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Edited by Chaouki Ghenai

SUSTAINABLE DEVELOPMENT – EDUCATION, BUSINESS AND MANAGEMENT – ARCHITECTURE AND BUILDING CONSTRUCTION – AGRICULTURE AND FOOD SECURITY

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Meet the editor

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Contents

Preface

The technological advancement of our civilization has created a consumer society expanding faster than the planet's resources allow, with our resource and energy needs rising exponentially in the past century. Securing the future of the human race will require an improved understanding of the environment as well as of technological solutions, mindsets and behaviors in line with modes of development that the ecosphere of our planet can support.

Some experts see the only solution in a global deflation of the currently unsustainable exploitation of resources. However, sustainable development offers an approach that would be practical to fuse with the managerial strategies and assessment tools for policy and decision makers at the regional planning level. Environmentalists, architects, engineers, policy makers and economists will have to work together in order to ensure that planning and development can meet our society's present needs without compromising the security of future generations. Better planning methods for urban and rural expansion could prevent environmental destruction and imminent crises. Energy, transport, water, environment and food production systems should aim for self-sufficiency and not the rapid depletion of natural resources. Planning for sustainable development must overcome many complex technical and social issues.

This sustainable development book is organized into the following four sections:

1. Sustainable Education
2. Sustainable Business and Management
3. Sustainable Building, Construction and Environment
4. Sustainable Agriculture and Food Security

The first Section of this book starts with a collection of articles about sustainable education or education for sustainable development. The papers present research and practices of teaching and education as essential tools for achieving sustainable development. Alternative perspective to funding public schools and Universities are also presented in this section. The goal is to foster the increased quality of teaching and learning and help countries make progress toward development. Papers presented in Section 2 of this book are about sustainable business and management: how to balance business considerations with environmental resources issues. The goal is to provide

tools for leaders to improve both the environmental performance and overall competiveness by reducing materials, energy and water utilization. Section 3 collects articles on buildings, architecture, construction and environment. These papers describe environmentally conscious design technique in the field on buildings and architecture: how to minimize the negative environmental impact of buildings by enhancing the energy efficiency, water efficiency, use sustainable (renewable or recyclables) materials of construction. Section 4 is a collection of articles related to sustainable agriculture and food security: systems of food production that provide secure supply to meet the world growing population. The papers analyze a range of subjects that includes the value of food and farming in the national economy, farming and the environment, and the strategies for food security.

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Part 1

Sustainable Education

1

Indigenous Epistemologies*, Sustainability and Schooling: The Case of South Africa

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1. Introduction

The concern I want to raise in this chapter is related to the relationship between indigenous identities, knowledge systems and indigenous values and world views compared to world views found in South Africa's new curricula after new dispensation. What are the values the indigenous pupils meet at home? Do they concur with those of the new curricula after 1994? The rationale for this focus is related to the question of whether the South African primary school is 'their school', i.e the school for the majority of South African children in terms of culture and knowledge. Moreover, does the epistemological basis of South African schools promote a sustainable future for the 'new' nation? The interest in and focus on indigenous identities and knowledge systems has been fuelled by the emergence of the African Renaissance rhetoric as proposed by Nelson Mandela and more consistently and frequently by former president Thabo Mbeki. Their focus is related to wishing to build a nation where African values, knowledges and African heritage are central. While the rhetoric around a new birth for Africa and African Renaissance is much older (Zeleza, 2009), in this chapter I am primarily concerned with the use of the concept in South Africa after the 'liberation' of South Africa in 1994. Already in 1994 Mandela referred to African renaissance at a summit of the Organization of African Unity in 1994: ''Africa cries out for a new birth. We must, in action, say that there is no obstacle big enough to stop us from bringing about a new African renaissance" (Mandela, 1994).

Former President Mbeki followed this up in 2002 by stressing the importance of self-construction.

We have a duty to define ourselves. We speak about the need for the African Renaissance in part so that we, ourselves, and not another, determine who we are, what we stand for, what our vision and hopes are, how we do things, what programmes we adopt to make our lives worth living, who we relate to and how (Mbeki, 2002).

While African renaissance takes a step back to focus on the past (as well as exploring the present) to construct an African identity/ identities based on African heritage and African values and indigenous epistemologies and knowledges the concept is also future- oriented 'who we should be': a new beginning for Africa yearning for a better future. The return to

* Epistemologies and knowledges are used in the plural to denote the multiplicity of indigenous epistemologies/knowledges

the past is a way of signaling that what was negated during the apartheid regime, the 'Africaness' of South Africa, the indigenous knowledge systems and values, also meant a negation of African identity which now needs to be restored to effect a viable future. African Renaissance, in Mbeki's rhetoric, means that (South) Africa and African identities are to be "shaped by African philosophies and not be limited by Western constructions"(Mbeki, in Kubow (2009), 47). African philosophy and indigenous knowledges seek to affirm core African values in the face of and as a response to globalization, and to establish an indigenous identity/indigenous identities for a sustainable future.

An African Renaissance which does not degenerate into essentialism has, according to Mbeki, the potential to change the lives of many Africans who have been ravaged by the continuing legacy of colonialism. African Renaissance thus embraces the view that Africa is destined to make considerable progress in economic, political and spiritual values by suggesting some sort of a rebirth where South Africa has a leading role to play.

It is this dialectics between African past/ presence including indigenous knowledges, identities and spiritual values on the one hand and the political, future –oriented world on the other that may seem to constitute this rebirth.

In this chapter I want to further explore the 'cultural world' of African Renaissance, i.e. African heritage/identity and African, indigenous knowledge systems as a constitutive element of Africa's 'rebirth' and a new, sustainable future. What are the characteristics of indigenous knowledges as found in the Black communities in South Africa? To what extent do they differ from the values and the knowledge production in the West? To what extent do they constitute a sustainable alternative or supplement to the West?

My own ethnographic research in South Africa was an exploration of the culture, cultural values and indigenous knowledges among the Xhosa in Western Cape and in Eastern Cape (see also Breidlid, 2002).

Qualitative data collection techniques were used and both community leaders, teachers, parents and parents in the communities in Cape Town and Eastern Cape were interviewed. Since the data used in this chapter are from the locations of our fieldwork, other Xhosa communities and people may have deviating cultural practices/world outlook. It must be said, though, that the findings of the research fit well with the literature in the field. While not a static or monolithic group there are certain basic features of Xhosa cultural values, indigenous knowledges and identity construction which reoccur and which seem to cut across location, age group and gender.

The results from the journey we undertook do not claim authenticity *per se* since any essentialisation of Xhosa culture and knowledge systems would be to deny their complex historicity. All notions of fixed or essentialist identities are problematic, also in the case of the Xhosa, not the least because not even the most traditional indigenous societies are static and are exposed to external influences. The focus in the following is on the religious and spiritual influence, not the least because it impacts heavily on the Xhosa identity construction and world outlook.

The journey underscored what Hunter (1979) claims is a difference between Bantu culture and European culture(s) where the Xhosa to a very large extent is born into traditional ties where choice and agency are limited, and where tradition and place are guarded. The post-

modernist insistence of identity as something always fluid, with hardly any boundaries, does not quite fit the terrain of our ethnographic research in Xhosa territories. While there are border crossings among the Xhosa in terms of identity construction there is also an anxiety "about the breakdown of barriers supposedly containing an identity?" (Massey, 1994: 122). It is also worth noting that the Xhosa does not constitute one group where all members were uniform in terms of beliefs, traditions, impact of foreign influence etc. Nevertheless there is a sense that the recovering of an African heritage is linked to tradition, not necessarily in terms of nostalgia for a utopian past, but in terms of the lived lives in the Xhosa communities.

In my research in the Xhosa communities two rural (Eastern Cape) and one urban community (township in Cape Town) were explored, with a particular focus on which elements constitute the identity construction of the Xhosa. Even though there are obvious differences between rural and urban Xhosa communities, certain fundamental issues seem to transcend the urban-rural divide, most notably linked to identity construction. I will first argue that the identity construction among the Xhosa is very much linked to the notion of place and territory. Then I move on to analyze the link between place and indigenous religious practices and identity construction. Finally I argue that despite what I call the Xhosa multiple identities, with their interplay and intertextuality between various cultural and religious practices, these identities are to a large extent defined in terms of an indigenous place or territorial specificity not worked over by modern values.

Place, defined as "the experience of, and from, a particular location with some sense of boundaries, grounds, and links to everyday practices" (Escobar 2001, 152) constitutes an important reference point in the construction of Xhosa identities, both in the rural and urban areas, most notably, but not exclusively in terms of indigenous, religious practices. The focus on the concreteness and territorialization of place, as opposed to the more abstract notion of space can be interpreted both as a defense of status quo and a way of sustaining or reconstructing alternative worlds. This tradition and place –related identity seems to represent resistance to the erasure of place and rootedness in (post-) modern thinking, and the conservation and protection of place and territory as something sacred.

Whatever the rationale, conscious or unconscious, the importance of place and boundaries as a sanctuary and a location of identity construction in the Xhosa world is unmistakable. It does not mean that the construction of identity is fixed or unchangeable, but it means, particularly among the rural Xhosa, that identity construction very often is also bound to a geographical place or location.

Place is both a physical location and a carrier of meaning which is, I argue, more prevalent in the Xhosa communities than in most Western societies. According to Giddens the emphasis on place indicates a culture bound up in tradition whereas modern societies transcend place and is more space oriented (Giddens, 1991). It follows from the space-orientation of modernity that place and territory do not carry a significant meaning as an identity marker, and are thus open to conquest and exploitation. While there are, as noted, border crossings by members of a more traditional society like the Xhosa the border crossings seem less frequent than in so-called modern societies.

While identity construction among the Xhosa is very much linked to place as a constitutive factor, place again is linked to indigenous epistemologies/worldviews realized in spiritual

and religious ceremonies, rituals and other practices. Even though there are aspects linked to indigenous cultural practices other than religion or spirituality, religion and spiritual practices are the *sine qua non* of Xhosa identity, thus underlining the sanctuary and sacredness of place and territory.

The holistic nature of the interrelationship between place/territory/nature, man and the supernatural is foundational in the Xhosa communities, and differs from the western perception of knowledge which separates people from place and nature physically and through the systems of knowledge, belief, politics and economics which it imposes.

In the indigenous religious system the ancestors stand out as probably the most important pillar. The informants underlined the importance of rituals in their veneration of the ancestors. As one informant told us:

In our tradition we worship the ancestors. That is our connection with God. We believe something is superior- ancestors. I must do things for the ancestors. Spiritually I have to go to church, but the traditions must also be there. If you don't do what you are supposed to do, bad things happen. (rural male teacher)'

The various types of rituals function as communication channels to the ancestors and takes place in the homestead where people also ask for advice on matters like marriage, jobs etc. The homesteads thus function as a site of negotiations between the living and the dead and are thus place not only of identity construction, but also of cohesion.

Clearly the ancestor cult is, as Hunter states, a sanction for the respect for seniors upon which the social and political system is based (Hunter,1979: 266), and indicates that this type of pervasiveness can be seen, paradoxically enough, as a logical or rational response to the insecurity that the Xhosa population faces in their daily lives.

While the overwhelming majority of our informants seemed to be most comfortable with their Xhosa religious identity they also confessed to be Christians. The strong influence of Christianity does not, paradoxically enough, seriously shake the place-boundedness of their belief system. These belief systems are not, according to the majority of our informants, mutually incompatible; on the contrary, there is an interplay or a dialogue which nourishes both systems.

There is a sense that despite the intertextuality and dialogic exchange between various value systems, the indigenous epistemological orientation is retained, not only as a means of social cohesion, but as a fundamental element of Xhosa indigenous identity construction. Our research findings go to show that the multiple identities among the Xhosa are a complex construct where border crossings are taking place, where identities are multiple due to the multiplicity of influential relations, but where these relations are located differently in terms of significance and where place, territory and home are in most cases the most important constitutive factor. To tamper with place is thus not only seen as a violation of ancestral land and the sacredness and spirits of nature, but as an obstacle to identity construction. It is in this perspective the 'cultural world' of African renaissance must be seen and which accounts for Hunter's statement that the Xhosa (Bantu) culture is widely different from European cultures.

The view in indigenous knowledges of the interrelationship between man, nature and supernatural and the perception of nature, place and territory as something sacred that is not

to be tampered with is a necessary corrective to rational science's excessive exploitation of nature and the contemporary ecological degradation of the planet with the accompanying global warming. Indigenous knowledge challenges the epitomisation of scientific truth and rationality that has excluded values which transcend the so-called rationality dogma of the West. This denial of epistemological diversity and the privileging of European epistemic monoculture is still hegemonic and perceived as a sign of development and modernity whereas it in reality upsets the relationship between man and nature through ecological degradation, seeking to possess the earth in the same way as a master exploits his slave. While colonialism and the capitalist world system have been beset with territorial, political and economic conquest Western science is based on the same idea of conquest, not respecting the earth's ecological limits. The unsustainability of such an epistemological perspective is challenged by the knowledge that the majority children bring from home in South Africa.

Since Xhosa pupils originate in an environment where knowledge is linked to spirituality, the encounter with modern schooling and the rationality of Western epistemic hegemony is often problematic. There is a tension here since, I will argue, the potential lack of recognition of their own epistemological and spiritual background impedes the development of the pupils' full potential. Taking cognizance of the indigenous pupils' spirituality Ver Beek points out that indigenous people's spirituality gives them "a sense of power and hope" (Ver Beek 2000 : 32).

In the next subsection I therefore focus on the new curricular situation after the 1994 revolution in South Africa and to what extent the curricula addresses epistemological issues related to the background of the majority of the children in the country.

Education and sustainability in South Africa

The introduction of Curriculum 2005 (C2005) in South African schools in 1997 (DoE 1997a and b) and the Revised National Curriculum Statement for GET (the General Education and Training Band (up to Grade 9)) in 2002 (DoE, 2002) was looked upon by the South African government as an important tool in the transformation of the South African society.

C2005 was well received, "falling on fertile ground ripe for alternatives to the divisive apartheid curriculum…Quite simply, the nation, particularly teachers and the media, embraced the story it told and the *ideological* (my italics) turn it promised" (DoE 2009, 12). Both versions of the curriculum (C2005 and the Revised National Curriculum Statement for GET) are clearly *in principle and rhetorically* ideologically counter-hegemonic to the dominant hegemony of the apartheid days. As we have seen this was stated quite explicitly in the preamble of C 2005. The apartheid hegemonic ideology and culture has been replaced by an anti-racist and anti-sexist curriculum.

The important question for the purposes of this chapter is however what happened to the African Renaissance rhetoric and Mbeki's focus on African heritage and local, indigenous knowledges? Has African Renaissance in any way functioned as an ideological compass for the curriculum writers? Is there an ideological difference between C2005 and the Revised Curriculum Statement in this respect?

In the South African context after 1994, and particularly in relation to C2005, the government interpellated the population into believing that the transformation of the educational system is under way by bombarding the people with important ideas like

democracy, social justice, equity and equality etc. Needless to say these were ideas or concepts which had to become part of the education system if the transformation of South Africa were to take place. But as will be documented later in this chapter, these ideas were situated in a context, both educationally, ideologically and macro-politically, which made the implementation of these principles into school reality difficult to envisage. Moreover, the ideological thrust of the government's school policy was so massive that both interrogations into the curriculum and any other counter-hegemonical interventions into the education policy were very difficult, if not impossible.

In the introduction to C2005 it is stated that, "The curriculum be restructured to reflect the values and principles of our new democratic society, (DoE, 1997a, 1). Such a statement is- probably intentionally- so vague and ambiguous that one wonders what is to be included and excluded from the variety of values, world views and knowledge systems in South Africa, with the exception of apartheid values. When C2005 proposes to establish "A shared understanding of a common South African culture," (DoE, 1997a, 16), the question arises if this is possible. What is a common South African culture? Since it is difficult to find a country, a nation with a clear-cut culture and since individuals, also in the South African context, construct, as has been noted in the first part of this chapter, multiple identities such a national identity has to be constructed. And if a common South African culture were to be constructed one would expect that the majority Black culture(s) to some extent would be prioritised since the Black population in South Africa constitutes approximately 80 per cent of the population.

On closer analysis of the two curricula, however, it is clear that this has not happened. The slogan: 'a common South African culture' does not mean that the cultures, world views and knowledge systems of the majority populations figure prominently in the new curricula. On the contrary, even though indigenous epistemology is referred to in the Revised National Curriculum (2002), the curriculum is modelled on a Western discourse, depending heavily on different international contexts, especially from New Zealand and Australia (DoE, 1995), suggestive of "what the African scholar Chinweizu describes as "Europhiliac Africans" (Chinweizu, 1970). Given this primary influence it is clear that the curricula and the education discourse of the new dispensation continue the epistemological hegemony of the West by marginalising indigenous epistemologies (see also Breidlid 2003).

The Revised National Curriculum (2002) touches upon the fact that people move between different worldviews and knowledge systems in a day:

… the existence of different world views is important for the Natural Science Curriculum…Several times a week they cross from the culture of home, over the border into the culture of science, and then back again (DoE, 2002, Natural Sciences: 12).

This epistemological movement is confirmed by for example Fakudze who states that "the African child finds him/herself having to cross the cultural border between his/her African worldview and that of school science as he/she learns scientific concepts presented to him/her in the science classroom" (Fakudze, 2003: 132).

This movement was also exposed in our field-work, where many teachers, like the pupils, cross cultural and epistemological borders on the same day, teaching Western science at school and taking part in traditional practices at home. The question then is how pupils and

even teachers cope with a knowledge system in school, which is alien to their home universe? And moreover, how can school construct a common South African culture when the majority cultures are sidelined?

The Revised National Curriculum senses a critical challenge here, asking:

…Is it a hindrance to teaching or is it an opportunity for more meaningful learning and a curriculum, which tries to understand both the culture of science and the cultures at home? (DoE, 2002, Natural Sciences: 12).

The cultural border crossings have been identified by Bernstein (1971) as a big problem for working class youths in middle class schools in England. These border crossings, however, important and difficult they may be, seem of a much more limited, cultural-linguistic character than what can be observed in South African schools. Among Xhosa children it is not only a matter of linguistic code switching, but of a collision of knowledge systems and world views which is of a far more serious and substantial character than class barriers in school in England. The Revised National Curriculum signals that these challenges will be dealt with in curriculum development:

Science curriculum development, which takes account of world-views and indigenous knowledge systems is in its early stages and will be addressed with enthusiasm by many educators. This Revised National Curriculum…is an enabling document rather than a prescriptive one (DoE, 2002, Natural Sciences: 12).

The crossing of epistemological borders to accommodate the so-called modern, rational world of science means that the pupil, according to Ogunniyi, is "involved in negotiating and navigating a complex array of conflicting mental states. He must synergize these conflicts into a more comprehensive world-view capable of accommodation of the new experience within the framework of intra/intersubjective life worlds, which provide him/her a sense of social identity" (Ogunniyi, 2003). The complexities of these negotiations and navigation should not be overlooked.

The revised curriculum is therefore, even though paying lip service to indigenous epistemology, firmly grounded in a modern, Western epistemology. Ntuli agrees:

Our education system seems to move farther and farther away from indigenous knowledge…There is no attempt at any level to examine the indigenous knowledge systems awareness of the essential interrelatedness of all phenomena - physical, biological, psychological, social and cultural (Ntuli, 2002: 64-65).

While we have seen that some attempts have been made in the Revised National Curriculum to include a discussion of indigenous knowledge systems, Ntuli is right in claiming that the influence of indigenous knowledge systems in education is marginal.

There is therefore, in South Africa as elsewhere in the South, an urgent need to address the issue of indigenous culture, sustainable development and education. When the thinking and acting of the majority of the people in a country, that is, their cultural expression and epistemology, are more or less excluded from the curriculum in the country, it does something to the self-confidence and self-esteem of those people, besides the obvious learning challenges it creates in school. What the curriculum should do "… is to help the people and their elite to capitalise and master the existing knowledge, whether indigenous

or not, and develop new knowledge in a continual process of uninterrupted creativity, while applying the findings in a systematic and responsible way to improve their quality of life." (Hountondji, 2002: 36).

Moreover, the lack of inclusion of indigenous epistemologies deprives not only the children of their own heritage, but also fails to make the new generations aware of alternative worlds and epistemologies that challenge the hegemonic knowledge production in the West and thus its unsustainability. The prioritisation of non-indigenous knowledge also means an underutilization of indigenous resources and knowledge in the development of a given society.

An exclusion such as that described above has major implications for the distribution of power in the country where those with non-indigenous cultural capital (including the Black elite who often do not identify with the African Renaissance rhetoric) are in the driving seat. The democratic problems of such a situation are obvious. A more comprehensive inclusion of indigenous knowledges may threaten power relationships based on Western knowledge, and possibly the reproduction of hierarchical structures benefitting those in power. As Silitoe states:" The privileging of some knowledge over others will extend a degree of power to those who hold that knowledge…"(Silitoe, 1998).

As has been noted above the African National Congress (ANC) has been reluctant to undertake a more radical reorientation in educational policies which includes innovative educational strategies to meet the needs of the majority of South Africans, and the South African society *in toto*. There seems to be a fear that such new strategies will leave South Africa out of the process of globalisation (see Crossman & Devisch, 2002). Moreover, the authorities may worry that a more contextualized and epistemologically more appropriate curriculum might leave the successful school leavers at a disadvantage internationally even though research has clearly shown that the present educational system under the ANC regime puts the majority of school children at a disadvantage. There is therefore reason to question the sustainability of the present system, not only in terms of academic success among the Black students, but also in terms of a future sustainable development in South Africa.

The incorporation of indigenous knowledge systems on its own terms also depends on the results of further research into the characteristic features of indigenous cultures and knowledge systems. While there is no doubt that this potential has been grossly under-utilised in the past, the potential and contributions of indigenous cultures and knowledge systems in relation to sustainability and sustainable development should not lead to the temptation, as Hountondji reminds us, "to overvalue our heritage", and we should bear in mind that indigenous knowledges "can be said to be less 'systematic' than scientific knowledge" (Hountondji, 2002: 25). This is in line with Silitoe's warning that "we need to guard against any romantic tendency to idealise it. " (Silitoe, 1998, 227).

There is, however, no doubt that there is an urgent need to address the world's poor health with alternative epistemologies that have a more non-exploitative view of land and nature. Indigenous knowledge's more harmonious relationship to nature is therefore vital in the struggle for a sustainable future.

The UN Decade of Education for Sustainable Development (UNESD, 2005) signals the important role education is supposed to play globally (see also Breidlid, 2009). According to

the UN, education is ''one of the most effective forces to bring about the changes in knowledge, values, behaviour and lifestyles required to achieve sustainability and stability within and among countries. . .'' (UNESCO Media, 2008, p. 39).

As has been suggested in this chapter, however, education's role in sustainable development is not unproblematic, since the hegemonic education discourse is more or less exclusively based on Western epistemology. This situation is a far cry from the ideas of African heritage and African culture and indigenous knowledges promoted by the African Renaissance rhetoric. Unfortunately it seems as if the re-launch of the concept (African Renaissance) was primarily rhetorical when the concept re-emerged after the new dispensation in 1994, and it still remains primarily rhetorical. As has been noted the global debate on education and sustainable development does not even pay lip service to the African Renaissance rhetoric or to indigenous knowledge systems. There is therefore an urgent need to interrogate the epistemological foundation of for example the UN Decade of Education for Sustainable Development. Such a UN decade is meaningless if it does not critique in a fundamental way the exploitative nature of the hegemonic Western epistemology and does not pick up and incorporate alternative voices and epistemologies, not only for the identity construction of those groups who have been marginalized over the centuries, like the Blacks in South Africa, but for the sustainability of Mother Earth. Educational institutions and educational actors in addition to the UN carry a huge responsibility as well in opening up the epistemological terrain for a more sustainable future. The formidable task has only just begun.

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2

Malaysian Primary Pre-Service Teachers' Understanding and Awareness of Environmental Knowledge

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1. Introduction

The quality of the environment is threatened by problems such as global warming, water pollution, fast decline of forests, and desertification (World Commission on Environment and Development (WCED, 1987). Global issues on environmental destruction have created space for more environmental related research to be conducted to overcome the notion that people's awareness over these issues is still at infancy. Due to this ignorance, human being continues to exploit the environment to an unprecedented scale to accommodate the expanding human needs and wants. According to the Millennium Ecosystem Assessment (MEA, 2005), over the past 50 years human activities have changed vital ecosystem services more rapidly extensively than in any comparable period of history. It is perceived that rapid growing demand for fuel, food, and water is likely to exacerbate the current problems. As the global population grows and standards of living improve, there will be increasing stress on the world's limited resources. Contemporary exponential increase in the price of crude oil further heightens this problem. Current degradation of natural environment has far-reaching consequences both to mankind and nature. This situation would require both present and future generations to use the earth's resources more efficiently and to produce less waste.

Education is recognized as one of the important tools to develop present and future citizens to live life in a sustainable manner. Education can illuminate incentives, showing people both how they could personally benefit from changing their behavior, and how they would suffer from a lack of change. Environmental Education (EE) is considered an essential component of the education for future citizens in order for them to be able to confront and deal with the current and emerging environmental issues. Through the process of EE, individuals obtain an understanding of the concepts of and knowledge about the environment. They also acquire experience, values, skills, understanding and the knowledge necessary to form judgments to participate in decision-making and to take appropriate action in addressing environmental issues and problems (Salequzzaman & Stocker, 2001; Bradley et al. 1999; Fien, 1997). This commitment to create awareness about the environment in the general population and changes in the human behavior must me be made in order for individual and social groups to be actively involved, at all levels in working towards resolution of environmental problems (UNESCO-UNEP, 1990).

Orr (1994) argued that in order to develop care for the Earth among future leaders the natural environment should be recognized as part of education. The education should reflect the interconnections between the knowledge and the design of nature: ecology, culture and economy. The knowledge system for sustainable development explicitly addresses the complex interactions between people, resources, environment and development (McKeown & Hopkins, 2002). Education for sustainable development is a process of learning how to make decisions that consider long-term future of the economy, ecology and social well-being of all communities (McKeown & Hopkins, 2002). Sustainable development knowledge cultivates decision making ability, critical thinking and problem solving skills. Learners are empowered to participate in decision making and ethically address the problems they might encounter in their daily life. Teaching and learning in line with sustainability emphasize holistic, multi disciplinary approach in order to develop knowledge and skills needed for sustainable future as well as changes in values, behavior and lifestyles.

Researchers in environmental psychology do believe that there is a strong correlation between environmental knowledge and attitudes. As Tikka, Kintnen and Tynys (2000) noted acquisition of nature related knowledge determines the attitudes and behavior of an individual. Lianne (2005) observed significant positive effect of students' awareness of the environment and their knowledge of environmental concepts in her study. Similarly, a study by Yencken et al., (2000) as well as by Barrasa and Walford (2002) also indicate the existence of strong relationship between environmental knowledge and environmental behavior. Although the relationship between the cognitive component (knowledge), affective (attitudes) and behavior is complex and necessarily linear, researchers have shown that increasing individual's knowledge via environmental studies resulted in more positive attitudes. Some researchers (Hungerford and Volk 1990) in the field of environmental education have indicated that an extensive level of knowledge about environmental issues does result in a greater awareness and sensitivity toward the environment which inevitably leads to environmentally friendly behaviors (Hungerford and Volk 1990). Hence, the importance of Environmental Education (EE) in enhancing awareness towards the environment is undeniable.

2. Environmental Education (EE) in Malaysia

The importance of EE in Malaysia is highlighted in the National Policy on the Environment 2002. One of the key areas of the Green Strategies outlined in the policy is 'Education and Awareness'. The emphasis on Education and Awareness is in line with the recommendations of Agenda 21 (MOSTE, 2002). Among the strategies for Education and Awareness are to devise and introduce comprehensive formal and informal EE and training strategies and information dissemination programs; to integrate environment and development into educational activities from school to tertiary institutions of which relevant method and materials will be developed, to establish national centers for excellence for inter-disciplinary research and education in environment and development; to review education curricula at all levels to ensure a multidisciplinary approach with environment and development issues; to actively promote non-formal education activities at local and national levels; and to strengthen the role of media in disseminating environmental information. Generally, the promotion of EE in Malaysia is focused towards addressing environmental challenges such as littering, water pollution, air pollution and the degradation of biodiversity.

In terms of formal education, the Ministry of Education has developed a curriculum for EE and has implemented various teaching and learning strategies to enhance environmental awareness and internalize values on the importance of environmental protection. In line with the National Education Policy, 'Environmental Education across the Curriculum' was introduced in both primary and secondary schools in 1990s. The goals are to educate children who will love and care for the environment so that they will think and act wisely to preserve it and to be aware of sustainable development. EE is infused in each subject in schools, rather than taught as a single subject. The school curriculum focuses on educating the society to be more sensitive and concerned about environmental issues, to be knowledgeable, skilled and committed to act individually or collectively to address environmental issues. Teachers are required to integrate the concepts and components of EE across the curriculum at all levels. To facilitate the task for teachers, EE Curriculum Guidelines that include specific objectives, components and implementation strategies of EE at pre-school, primary and secondary levels are provided.

After years of effort to integrate environmental education, studies keep revealing that Malaysians in general and students specifically have not reached a certain desired level of commitment towards the environment. The importance of EE is not given due emphasis and so students do not really see the need to practice an environmental-friendly lifestyle (Nadeson & Nor Shidawati, 2005). A study by Sharifah and Hashimah Yunus (2006) showed that there is still considerable apathy among Malaysian students to engage pro-actively in environmental behaviors due to 'the very low environmental awareness within society.' Kim and Fortner (2006) asserted that teachers do not teach environmental issues even though they acknowledged the importance of teaching such issues. Beside external and logistic barriers such as lack of time, the teachers are perceived to have internal and personal barriers. This includes attitudes toward teaching environmental issues, environment related content knowledge and how to teach environmental issues (pedagogical knowledge). These factors determine how often the teachers integrate environmental issues in their teaching.

In order for students to have sound knowledge and good values towards environment, the knowledge base of teachers themselves is of great importance as good subject knowledge is essential for best teaching. However, as Petergem et al. (2007) illustrated, teachers lack insight into the complexities of EE issues and how their teaching might contribute to productive EE. Previous researches also showed that most teachers are unaware of the underlying theoretical issues concerning EE and the concept of sustainable development (Cross, 1998; Summers, Kruger, and Childs, 2000). EE requires special training and commitment because it needs a different focus and outlook that many prospective teachers have not experienced in their own education (Tilbury, 1997). Teachers cannot effectively address the goals and aims of EE solely by acquiring information about environmental issues and concerns. It is unrealistic to expect teachers without expertise to explore environmental concepts with students to foster holistic, regional, and global thought about the environment, rather than treating each topic or idea as an isolated, discrete entity (Stables and Scott, 2002). Thoughtful integration of concepts, ideas, pedagogy, and skills for EE should reach beyond subject area barriers to include the rich scope of knowledge included in many areas of study (McDonald and Dominquez, 2010).

Teachers play a pivotal role in shaping the children's lives. This is so because in the course of their careers, they interact with and reach many pupils. In so doing, they "help shape

each pupil's worldview, economic potential, attitude toward others in the community, participation in community decision-making, and interactions with the environment" (McKeown & Hopkins, 2002, p. 252). In the context of EE, educator's role is further stressed as they are identified as key in transforming EE into practice (Petergem, Blieck and Pauw, 2007). Hence, the quality of teacher training is of critical importance. Faculties of education have the potential to bring about change through the teacher education curricula, training of new teachers and professional development for practicing teachers, consultations with local boards, and often have influence with ministries of education (UNESCO, 2006).

2.1 Sustainable Development

Sustainable development (SD) is a difficult concept to define (Hopkins & McKeown, 2001). The World Commission on Environment and Development (1987) defined sustainable development as the *development that meets the needs of the present without compromising the ability of future generations to meet their own needs.* SD reflects the relationship between the ecological environment and economic development process (Barbier, 1987). Economic development is the process where the needs of the people are fulfilled and sustained over time. SD according to McKeown et al. (2002) is a combination of three components: environment, economic and social. Accordingly, education that focuses on bringing SD into practice is ESD. ESD is a vision of education that seeks to balance human and economic well-being with cultural traditions and respect for the earth's natural resources. The ultimate target of education is to produce environmentally literate graduate, who is capable of evaluating thinking, make decisions, solve problems and take responsible actions accordingly.

SDCs are less discipline specific and more sustainable development related and reflect the interconnection between the subject matter with ecology, economy and society. It would be one possible way to have a holistic education which emphasizes connectivity and continuity among organism as articulated in Orr's ecology literacy.

Table 1 illustrates the 20 SDCs extracted from Yencken et al. (2000).

1	Carrying capacity	The capacity of ecosystems to support continued growth in population numbers, resource consumption, and waste production.
2	Steady-state economy	A non-growth economy in which the demands of resource consumption are in balance with resource supply and production.
3	Ecospace	The total amount of energy, land, water and other resources that can be used regionally or globally without environmental damage, disadvantaging the capacities of others to meet their basic needs or impinging on the rights of future generations.
4	Sustainable development	A process by which the needs of present generations can be satisfied without compromising the ability of future generations to satisfy their needs.
5	Ecological footprint	The area of land and water needed to support the total flow of energy and materials consumed by a community or population indefinitely.
6	Natural resource accounting	A strategy that helps a household, corporation or government calculate its real wealth, i.e. the value of total economic production minus the value of the natural and social capital consumed to achieve it.

7	Eco-efficiency	A strategy for maximizing the productivity of material and energy inputs to a production process whilst also reducing resource consumption and waste production and generating cost savings and competitive advantage.
8	Life Cycle Analysis	A management tool for identifying the net flows of resource and energy used in the production, consumption and disposal of a product or service in order to leverage eco-efficiency gains.
9	Sustainable consumption	The use of services and related products to satisfy basic human needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as emissions of waste and pollutants over the life cycle of the service or product.
10	The 5 Rs	Reduce, reuse, renew, recycle and rethink!
11	Local-global links	The recognition that the consumption of a product or service in one part of the world is dependent on flows of energy and materials in other parts of the world and that this creates potential opportunities and losses economically, socially and environmentally at all points in the local-global chain.
12	Inter-dependence	The relationships of mutual dependence between all elements and life forms, including humans, within natural systems.
13	Biodiversity	The diverse and interdependent composition of life forms in an ecosystem that is necessary for sustaining flows of energy and materials indefinitely.
14	Interspecies equity	A consideration of the need for humans to treat creatures decently, and protect them from cruelty and avoidable suffering.
15	Intragenerational equity	A consideration of the need to ensure that all individuals and societies have access to the resources required to satisfy basic human needs and rights
16	Intergenerational equity	A consideration of the need to live off net resource production rather than environmental capital in order to enable future generations access a world that is at least as diverse and productive as the one each generation inherits.
17	Human rights:	The fundamental freedoms of conscience and religion, expression, peaceful assembly and association, which ensure access to democratic participation and meeting basic human needs.
18	Basic human needs	The needs and right of all people and societies for fair and equitable access to flows of energy and materials for survival and a satisfying quality of life within the limits of the Earth.
19	Media literacy	An appreciation of the role of the public media and marketing and advertising industries in creating perceptions of needs and wants and the skill to identify the roles thee media may play in encouraging and undermining sustainable consumption.
20	Democracy	The right of all people to access channels for community decision-making.

Table 1. Sustainable Development Concepts (SDC) (adapted from Yencken et.al. 2000)

2.2 Theoretical underpinnings

This study is grounded on Orr's (1994) philosophical theory of ecological literary. Ecology literacy emphasizes the relations between ecology, economy, culture and human. It places humans as integral parts of ecosystem and recognizes the impacts of relations between human and other species and environment. Ecology literacy is holistic, emphasizing connectivity and continuity with fewer divisions and disciplines, recognizing commonalities among organisms and promoting the strength that exists in diversity. Hence, overemphasis on economic development could create a distance between the natural environment and human (Orr, 1994; 2006) whereby the environment is viewed as a separate entity resulting in exploitation of the environment to a point of no return. This further leads to a weakening of the social and cultural structures.

Through this theory Orr further asserts that interaction amongst humans as most important in the educational experience and stressed that natural environment is a part of education. Education should reflect the interconnections between ecology, culture and economy. Interwoven experiences in these three domains are essential to develop care for the environment and influences in making decision regarding the use of the environment. At the same time, this approach helps to overcome the notion that global environmental destruction is the result of the work of educated people and not the ignorant ones. This is due to the fact that current education emphasized theories instead of values, concepts rather than human beings, abstraction rather than consciousness, answers instead of questions, ideology and efficiency rather than conscience (Orr, 1994). Orr further noted that successful implementation of this theory is ascribed to be in the hands of the teachers. Teachers inherently shape the minds of the learners through setting appropriate learning environments.

3. Purpose of the study

This study was conducted to investigate the primary pre-service teachers' awareness and understanding of SDCs and TECs.

4. Methodology

4.1 Design of the study

Both questionnaire survey and qualitative interviews were employed. The quantitative survey was conducted to elucidate the pre-service teachers' understanding of SDCs and TECs using the Questionnaire on Environmental Knowledge. In order to get insights into the quantitative survey outcomes and to evaluate the student teachers' awareness of environmental concepts interviews involving 20 participants were conducted. Purposeful sampling approach was used to identify the interviewees. The interviews were conducted informally according to the students' convenience and the interview questions were semi structured. The interviews were conducted two weeks after the students answered the questionnaire. The questions asked during the interviews are as follows: Have you ever come across the term ecological footprint? Do you have any idea what it means? If you were given an opportunity to integrate this concept in your teaching, how will you do it?

4.2 Participants

A total of 153 primary pre-service teachers (71 male and 72 female) enrolled in a teacher education institute were involved in this study. Their ages ranged from 19-21 years old and majoring in the sciences, mathematics, social sciences and languages. Upon completing the course these teachers will be awarded with a Bachelor of Teaching, Primary Education and will be appointed as primary school teachers. Prior to entering the teacher education institute these students had undergone six years of primary education and five years of secondary education under the Malaysian education system.

4.3 Instrument

Data were collected using the Questionnaire on Environment Knowledge (QEK). QEK possesses high internal reliability with alpha Cronbach value reported as .89 and validated on the appropriateness of the content by two experts (Karpudewan et al. 2009). QEK was originally developed by Yencken et al. (2000) and contained 12 items: 8 items evaluated the understanding of TECs and 4 items on SDCs. The modified version contained 20 items. The first item focused on investigating the pre-service teachers' level of awareness of the environmental concepts, 12 items evaluated their understanding of TECs and 7 on SDCs. For the purpose this study, only items that evaluated the understanding of environmental concepts were included. Thus, there were a total of 19 multiple choice questions whereby the students were required to identify the most suitable answer for each item/question. The subjects took 40 minutes to complete the questionnaire. The students' level of understanding of the concepts was computed using percentage values. Comparisons between understanding of TECs and SDCs were conducted using descriptive statistics such as the mean scores and standard deviation.

5. Results

5.1 Questionnaire survey

The outcome of the questionnaire survey is presented in Table 2. The frequency indicates the number of students who answered the item on the understanding of a particular environmental concept correctly.

The majority of the students managed to answer the questions on TECs correctly. A total of 143 (93%) students answered the question on *water pollution* correctly. This is followed by *haze* (105, 69%), *ozone layer* (90, 59%), *ecology* (88, 58%), *greenhouse effect* (75, 49%) and *solid waste accumulation* (60, 40%). According to Yencken et al. (2000), these concepts are categorized as TECs. The outcome of this study is similar to the study conducted by the same authors involving secondary school pre-service teachers (Karpudewan et al. 2009). Students seemed to have a good grasp of the TECs which could be explained by their primary and secondary school experiences prior to entering higher learning institutions. According to Abdul Rashid (2006) and Sharifah & Hashimah Yunus (2006) the traditional concepts have been integrated into the existing curriculum and additionally co-curricular activities with environmental themes which embraced traditional concepts were also conducted in schools (Ministry of Education, 2004). Another possible reason for the high level of understanding of traditional environmental concepts could be due to the frequency

Concepts	Frequency (n)	Percentage (%)
Water pollution	143	93
Haze	105	69
Ozone layer	90	59
Ecology	88	58
Greenhouse effect	75	49
Solid waste accumulation	60	40
Renewable resources	36	24
Global warming	34	22
Biodiversity	32	21
Deforestation	31	20
Carbon cycle	28	18
Interdependence	15	10
Sustainable development	13	8
Eco-efficiency	6	4
Carrying capacity	5	3
Ecological footprint	4	2
Precautionary principle	1	0.01
Intergenerational equity	1	0.01

Table 2. Outcome of questionnaire survey

of appearance of these concepts in the daily newspaper and television. The general public is constantly reminded of the importance of recycling their waste, how and where to recycle through advertisements in newspapers and television. News on forest being destroyed (deforestation), open burning, illegal logging, flash flood and toxic waste being illegally discarded into the rivers by irresponsible parties were constantly broadcast. With Malaysia being one of the main producer of palm oil, the issues of using palm oil to produce biodiesel has been strongly argued. Subsequently, the term renewable resource was mentioned frequently. In sum all this could account for the students understanding of TECs.

However, results in table 2 also indicate that students' understanding of SDCs are far below average. For example only 15 students (10%) could give the correct answer for the concept *interdependence*. This is followed by *sustainable development* (13, 8%) *eco-efficiency* (6, 4%), *carrying capacity* (5, 3%), *ecological footprint* (4, 2%), *precautionary principle* (1, 0.01%), and *intergenerational equity* (1, 0.01%). According to Yencken et al., (2000) these concepts are known as SDCs. SDCs are foreign and not found in the primary and secondary school curriculum. The results of this study is similar with the findings of another study conducted by Karpudewan et al., (2009), Spiropoulpu, Antonakaki, Kontaxaki and Bouras (2007), Yang, Lam and Wong (2010) and Jucker (2002). Karpudewan et al. (2009) earlier study showed that the Malaysian secondary school pre-service teachers' understanding of SDCs generally appeared to be at the minimal level. Spiropoulpu et al., (2007) reported Greece's primary pre-service teachers' holds misconception of conceptual meaning of the term 'sustainability' and these teachers are not familiar with these concepts. Jucker's (2002) internet survey involving participants of all the humanities faculties in Germany, The Netherlands, UK and Switzerland also found some unsustainable core characteristics such as eco-illiteracy.

Concepts	N	Range of scores	Mean scores	Standard deviation
TECs	153	1-12	8.45	6.067
SDCs	153	1-7	1.09	2.075

Table 3. Comparison of pre-service teachers understanding of TECs and SDCs

Table 3 shows the range, mean scores and standard deviation for the entire TECs and SDCs. There are a total of 12 TECs and 7 SDCs in the questionnaire. The scores for TEC ranged from 1-12 with a mean of 8.45 and the scores for SDC ranged from 1-7 with a mean score of 1.09. Understanding of SDCs appears to be below the average of 3.5 while understanding of TECs is noticed to be above the average value of 6. Accordingly, findings from this study indicate that relatively, pre-service teacher's understanding of TECs is higher than SDCs.

5.2 Interview outcome

Interviews were conducted with 20 students in order to further enhance the outcome of the quantitative survey and to elaborate on the student teachers' awareness of environmental concepts. Similar to the findings from the quantitative survey, interview results indicate that the majority of the participants were familiar with TECs while SDCs appeared to be foreign to them. The majority of the participants were also noticed to have a better understanding of TECs while understanding of SDCs appeared to be minimal. The following excerpts illustrate one student's understanding of SDCs.

Interviewer: Have you heard about the term sustainable development?
Student A: Sometimes in the newspapers.
Interviewer: Do you have any idea of the meaning the word?
Student A: Not very sure. But I think it got something to do with sustaining the environment.
Interviewer: Can you elaborate on what you mean by sustaining the environment?
Student A: I think it is like preventing pollution and conserving the environment.

The above discourse indicates this particular student is aware of the term sustainable development. However, the understanding of the meaning of term appears to be superficial. The student could not enhance or elaborate on the concept.

Another student perceived the idea of SDCs as abstract and held the misconception that it is only appropriate for SDCs to be integrated into science lessons but not in other subjects.

Interviewer: Do have any idea what is the meaning of ecological footprint?
Student B: I don't know the meaning exactly. But I suppose I can guess from the word itself.
Interviewer: Oh…that's good. What do you think then?
Student B: I think how much your daily actions contribute to the pollution…..
Interviewer: Okay…let me explain the real meaning. *The interviewer starts to explain the meaning of ecological footprint. After explaining the meaning the interviewer asked …* now is it possible to tell how you can integrate this concept in your teaching?
Student B: I am not very sure. I think it best suits to be integrated in science teaching. It sounds very complex.

Student B indicated that he was not sure of the meaning and tried to guess the meaning from the words/terms. Even though he did not manage to arrive at a completely right answer, his answer reflected his idea of ecological footprint to a certain extent. To Student B, the term is complex and he had difficulties in understanding this concept. The vague understanding is further evidenced when he said that this concept is appropriate to be integrated only in the science curriculum.

6. Discussion

The results of the questionnaire survey showed that Malaysian primary pre-service teachers' understanding of SDCs is far lower than TECs. This is further supported by the interview findings which showed that not only did the pre-service teachers had a low understanding of SDCs some even stated that they were unaware of these concepts. On the contrary, the pre-service teachers' understandings of TECs were higher. A similar scenario has also been reported in other studies worldwide.

According to the theory of planned behavior, knowledge ultimately influences the intended behavior and final behavior to be performed (Ajzen and Fishbein, 1985). But why do global environmental problems persist when the level of understanding of environmental concepts exhibited by the pre-service teachers appeared to be high? This could probably be due to the fact that the knowledge that the students received has no influence on their attitudes and behaviors. The knowledge of TECs appeared to be proportional in nature rather than procedural, i.e., it is '*knowledge about the environment*' rather than '*knowledge on how to work for the environment*' (Fien and Tilbury, 2002). According to Fien and Tilbury (2002) proportional knowledge will not bring about behavioral change. Through this knowledge students learn about the environment. However, the holistic view of the environment relating to economy and society is not emphasized in the traditional environment concepts.

Improving understanding of SDCs which are more sustainable development related and less discipline specific would be a long term solution for the rising global environmental issues. Integration of SDCs into the subject matter will allow the learning to be extended beyond the four walls of the classroom. It provides an opportunity for the real world activities and scenario to be reflected in the teaching and learning process that takes place in the classroom. For example, when the primary school students were taught on the concept of living things in the science lessons an interdisciplinary approach would be appropriate for SDC to be integrated. The term *interdisciplinary* describes the interconnectivity of various living things in this world: animals, plants and humans. Integration of this term provides a platform for the teachers to discuss the importance of maintaining the interrelationships between the living things in sustaining the environment and preserving the social structure. Teachers could use examples of social structures being destroyed due to poverty, increased in population and also due to pollution.

The integration of SDCs is fundamentally grounded on David Orr's theory of ecology literacy (Orr 1994, 2006). Through this theory, Orr stressed the importance of considering natural environment as part of education. Education that reflects on natural environment inherently assists in restoring the social and cultural structure of a nation from being destroyed. According to Orr, the experiences from their own environment will shift from overemphasis of economic towards balance among economics, ecology and culture. Orr

further proposed that this could be implemented through outdoor activities and environmental education simultaneously suggesting that all education to be environmental education. Following Orr's suggestion, Mitchell and Mueller (2011) in their study have used outdoor learning environment to develop care and value towards nature and other living species.

In Malaysia, various federal and state government departments, the private sector, educational institutions and non-governmental organizations (NGOs) are actively promoting EE in both formal and non-formal arenas. The target groups are from all levels of society - teachers, students, government agencies, developers, restaurant operators, industries/factory owners and the general public. Non-formal EE activities planned and implemented includes environmental camps, talks, exhibitions, quizzes, workshops, seminars, tree-planting and radio shows. Environment-related events such as Malaysia Environment Week (21-27 October), Earth Day (22 April), World Environment Day (5 June), Wetlands Day (2 February) and Water Day (22 March) are also celebrated each year.

7. Conclusion

Global environmental crisis have created an expectation that improved understanding and awareness of ecological concepts would be one way of overcoming the growing crisis. This expectation is in parallel with the work of Hungerford and Volk (1990) and Hines, Hungerford, and Tomera (1987) whereby knowledge is perceived as antecedent towards environmentally responsible behavior. Paramount to this is the notion that school classes were found to be increasingly influential in the acquisition of knowledge about the environment (Fortner and Meyer, 1991). It is also suggested that simply relying on knowledge transfer will not bring about behavioral change (Frick, Kaiser and Wilson, 2004). According to Frick et al., (2004) it is essential to identify the types of knowledge that can promote behavioral change effectively and investigate the structure of this knowledge. The results of our study showed that the pre-service teachers have considerably high level of understanding and awareness of TECs but low on SDCs. SDCs provide a platform for the environment to be presented in a holistic manner. Teaching these concepts will allow for issues on the environment, economy and society to be appropriately integrated into the subject matter. This is in line with Orr's theory of ecology which emphasized the importance of natural environment to be embraced in education. The low/minimal level of understanding of SDCs by the students/preservice teachers suggest that it is timely appropriate to integrate these concepts into the teacher education curriculum.

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3

Alternative Perspective to Funding Public Universities in Nigeria

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1. Introduction

The funding model of university education in Nigeria is one of the control measures being utilized by the government as the proprietor of such institution. Such model of funding is determined by policies approved by the legislative and executive arms of the government. Currently, there is low-level of university education funding and it is often a recurrent debatable issue among stakeholders with its effects on quality of university education in Nigeria. The World Bank (2010) study reported that the problem of higher education financing, particularly university education is more acute in Africa than in the rest of the world. Apart from this low-level of funding in Nigeria for instance, this paper examines the funding policies of public universities owned by the Federal Government of Nigeria with a view to proposing an alternative funding policy.

Specifically, this paper draws on historical analysis of funds received by public universities owned and controlled by the Federal Government of Nigeria between the years 2000 and 2009 using the existing funding framework. The Hauptman's (2006) model of funding policies was utilized in order to argue for another funding policy in Nigeria. According to Hauptman, the funding policies are historical or political basis; funding formulas, policy-driven funding; performance-based funding; and categorical and competitive funds. I am of the opinion that the existing funding framework in Nigeria reflects a combination of historical basis, funding formulas, and policy-driven funding of the Hauptman's (2006) model. Therefore, this paper argues for performance-based funding policy in order to position public universities in a national and international competitive environment as a means of attaining sustainable and national development.

2. Background

The history of university education funding in Nigeria is as old as the establishment of universities. This dates back to 1948 when the University College Ibadan (UCI) was established following the Elliot Commission's recommendation in Nigeria. The Elliot Commission was set up in the year 1943 "to report on the organisation and facilities of the existing centres of higher education in British West Africa, and to make recommendations regarding future university development in that area" (Fafunwa, 1974, p. 144). Though UCI

was affiliated to University of London, it was accorded university status in 1962 and named as University of Ibadan (UI). Ukeje (2002) noted that UCI was funded from two main sources. The Nigerian government provided 70 per cent of the funds while the United Kingdom provided 30 per cent of the total recurrent cost.

Between the years 1960 and 1970, five more universities were established following Ashby Commission's report. The Ashby Commission was set up in the year 1959 "to conduct an investigation into Nigeria's needs in the field of Post-Secondary School Certificate and Higher Education over the next twenty years (1960 – 1980)" (Fafunwa, 1974, p. 152). The four of these five, were regional universities and their year of establishment: University of Nigeria in 1960, Ahmadu Bello University in 1962, University of Ife (now Obafemi Awolowo University) in 1962, and University of Benin in 1970. The fifth one was University of Lagos and was established in the year 1962 by the Federal Government of Nigeria. All these five universities plus UI made six universities in Nigeria as of the year 1975 and are regarded as first generation universities.

These first generation universities were well-funded until the year 1975 by their proprietors, that is, the Federal and Regional: Eastern, Mid-Western, Northern and Western Governments. Ukeje (2002) pointed out that in Ahmadu Bello University (ABU) for instance, from the years 1962 to 1975; there was no substantive difference each year between the amount requested by the University and the amount received from the Northern Regional Government. He further stated that there were years in which the amount received was slightly more than the amount requested. Perhaps, this could be attributed to what Yesufu (1985) stated that between 1950s and 1960s, Northern, Western, Mid-Western, and Eastern Regional Governments devoted from 25% to 30% of their annual budgets to education.

In the year 1975, the Federal Government of Nigeria established seven more universities and also took over the existing four regional universities. This announcement made the total number of universities under the Federal Government's control to be 13 universities. Hence, the Federal Government had the sole control of financing these 13 universities from the year 1975. Onyeonoru (2007) argued that the 1975 period marked the beginning of the problem of university funding in Nigeria. To corroborate his view, he cited Ukeje (2002) that after the 1975/ 1976 session at ABU for the first time, a recorded shortfall of 20 per cent in the amount requested was observed. This situation can be inferred that there is negative correlation between funding of university education and establishment of more universities in Nigeria. This inference can also be supported by the study of the World Bank (2010) on problem of financing university education in the whole of Africa. This means fewer resources competing for establishment and funding of more universities in order to make provision for access to university education.

As a result of an increasing demand for university education in Nigeria, the Federal Government of Nigeria established nine more universities between the years 1980 and 1990. And also between the years 1991 and 2009, five additional universities were established. Therefore, as of year 2009, the number of federally controlled universities in Nigeria was 27. One of the main arguments for increase in the number of universities is provision of access to qualified individuals. For instance, Okojie (2010) reported that degree student enrolment increased from 104 in 1948; 1 395 in 1960; 40 000 in 1976; 172 000 in 1988; 448 000 in year 2000; and to over 950 000 presently.

2.1 Funding framework

One of the recommendations of Ashby Commission set up by the Federal Government of Nigeria in 1959 was "a National Universities Commission should be set up to have undisputed control over the affairs of the universities, particularly in terms of finance, staff and courses" (Fafunwa, 1974, p. 155). In response to this Ashby Commission's recommendation, the National Universities Commission (NUC) was established in the year 1962 as an advisory agency to ensure adequate funding of universities in Nigeria.

Prior to taking over of existing regional universities in the year 1975, the NUC was reconstituted through Decree No.1 of 1974, as a statutory body for receiving block grants from the Federal Government and allocating them to federally controlled universities in accordance with such funding formula or parameters as may be laid down by the National Council of Ministers or Federal Executive Council, and performing other related functions. The block grants are separated into capital and recurrent grants. Comprehensively, the funding mandate of NUC is in three dimensions. The dimensions are:

- enquire into and advise the Federal Government on the funding needs, both recurrent and capital, of university education in Nigeria and in particular, to investigate and study the financial needs of universities in order to ensure adequate provision;
- receive block grants from the Federal Government and allocate them to federal universities in accordance with such formula as may be laid down by the Federal Executive Council; and
- to take into account in advising the Federal and State Governments on university finances, such as grants that may be made available to universities by corporate bodies or institutions and institutions both within and outside Nigeria. (NUC, 2011)

The funding parameters instituted by the Federal Government and directed to NUC for implementation can be viewed as a policy or control measure to direct the affairs of these federally controlled universities in terms of financial issues. This funding formula is usually initiated by the NUC in consultation with the universities based on financial needs assessment of universities and later being forwarded to the Federal Government for approval. This is in line with the funding mandate of NUC.

From the inception of NUC in 1974 as a statutory body, the funding formula for allocating funds to these federally controlled universities has consistently been reviewed based on several factors, such as generation of universities, that is, the year of establishment, number of degree students admitted, number of academic and non-academic staff, and ratio of science and humanities based disciplines. As a result of these factors, the funding formula keep on changing. For instance, Esenwa (2011) examined the role of NUC since inception and projected what the future is likely to be for NUC. He stated that one of the critical aspects of the funding mandate of NUC is to review the funding parameters for allocating funds to universities based on the approved funding policies by the Federal Government. For Esenwa, since the year 1974, the funding formula has been revisited twice, that is, in the year 1982 and also in the year 1989.

Okojie (2010) described the current approved funding criteria used by NUC to disburse funds to universities. These funding parameters or criteria according to Okojie are:

- capital grants on the basis of generation (year of establishment) of the university;

- ratio of personnel costs to overheads- 60:40;
- library 10%, research costs 5%, capacity building 1% of the total recurrent-minimum;
- academic to non-academic funding 60:40;
- expenditure on central administration- 25% maximum; and
- internally generated revenue- 10%.

A comprehensive interpretation of this formula for allocating funds to universities in Nigeria is stated in the World Bank (2010) study as normative input-based approach. Hartnett (2000) was cited in World Bank's study. According to the World Bank (2010),

> The National Universities Commission in Nigeria has long employed a normative approach to input-based budgeting for Nigeria's federal universities. In calculating an institution's budget recommendation, academic staff members are derived from student numbers using normative guidelines for student-staff ratios that vary by discipline. Likewise, administrative support staff numbers are determined from academic staff numbers using similar guidelines…. Additionally, 10 per cent of each university's recurrent grants is to be devoted to the development of that institution's library, and 5 percent is earmarked for research…" (World Bank, 2010, p. 44).

Based on the funding criteria, the funding trends received by NUC and to be disbursed to public universities controlled by the Federal Government of Nigeria between the years 2000 and 2009 were examined below. Okojie (2010) reported the trends of funds received by Federal Universities as shown in Table 1.

Year	Recurrent Grants (Naira)	Capital Grants (Naira)
2000	28 206 218 865. 91	1 936 785 632. 00
2001	28 419 719 502. 84	4 226 691 359. 00
2002	30 351 483 193. 00	
2003	34 203 050 936. 33	
2004	41 492 948 787. 01	11 973 338 699. 00
2005	49 453 098 168. 72	8 822 869 440. 00
2006	75 400 267 475. 00	6 976 416 815. 00
2007	81 757 053 487. 00	8 808 205 850. 00
2008	92 219 484 808. 00	14 414 135 937. 00
2009	98 028 449 198. 00	10 571 861 732. 00

Source: Okojie (2010)

Table 1. Trends of Funds received by Federal Universities in Nigeria

In Table 1, in the year 2000, 28 206 218 865. 91 Naira was received as recurrent grants and 1 936 785 632. 00 Naira was also received as capital grants for the entire 27 federally controlled universities as at that period. As of year 2009, 98 028 449 198. 00 Naira was received for recurrent grants and 10 571 861 732. 00 also received for capital grants for the entire 27 universities. The percentage increase in recurrent grants between the years 2000 and 2009 was 247. 54 per cent and for capital grants was 445. 85 per cent.

The increase in funding figures between the years 2000 and 2009 seems encouraging and impressive. However, universities operate as international institutions. This implies that Nigerian universities obtain both teaching and research inputs from not only the immediate environment, but also outside the shore of Nigeria. Therefore, the real value of these funds should be determined using US Dollars as a bench mark. As of the year 2000, the average exchange value of one US Dollar to one Nigerian Naira was 86 Naira. Based on this calculation, the recurrent grants received by the entire 27 federally controlled universities was USD 327 979 289. 14 and the value for capital grants was USD 22 520 763. 16. In the year 2009, the average exchange value of one US Dollar to one Nigerian Naira was 158 Naira. Therefore, the recurrent grants received by the entire 27 federally controlled universities was USD 620 433 222. 77 and the value for capital grants was USD 66 910 517. 29. The percentage increment in recurrent grants between the years 2000 and 2009 was 89. 17 per cent and for capital grants was 197. 11 per cent.

The implication of this funding analysis reflects the observation of the World Bank (2010) study that there is problem of financing qualitative university education in Africa. Apart from the low real value fund between the years 2000 and 2009, the upsurge in degree students' enrolment, that is, over 100 per cent as reported by Okojie (2010) is yet another dimension to compound the problem. The earlier study by Saint, Hartnett, and Strassner (2003) also found that between the years 1990 and 1997, the real value of government allocations for higher education declined by 27 per cent- even as enrolment grew by 79 per cent. Although there was slight increment between the years 2000 and 2009 in the real value of fund especially in capital grants, such increment seems to be incommensurable with the rise in degree students' enrolment for instance.

Okojie (2010) admitted that most federally controlled universities' administrators complain of inadequate funding and they are not allowed to charge undergraduate tuition fees. The effects of this funding problem could have resulted to some of Obanya's (2002) earlier observations on deterioration of physical facilities; internal and external brain drain among the intellectual class; and overstretching of teaching, research and managerial capacities in Nigerian university system. In relation to the university's mandate on research for instance, Olayiwola (2010) also claimed that,

> Since most research input and equipment are imported, the purchasing power of the naira has been weakening as a result of the devaluation of currency. Most of the input in the form of books, journals, and laboratory equipment could not be sustained for research activities. (Olayiwola, 2010, p. 152)

As a result of these daunting teaching and research situations, universities' administrators have consistently identified funding issues as a critical challenge in discharging their functions effectively.

The effort of the Federal Government of Nigeria to address the funding issue in not only the university sector, but the entire education system was demonstrated by the establishment of Education Trust Fund (ETF) in the year 1993. ETF was created via Education Tax Decree No. 7 of 1993, Laws of the Federation of Nigeria and amended by Education Tax Decree No. 40 of 1998. This body is saddled with the responsibility of administering the entire 2 per cent education tax on profit from every company registered in Nigeria. Specifically, the ETF Board of Trustees administers the tax revenue imposed by this Decree and disburses the

same amount or fund to federal, state, and local governments educational institutions in addressing the following areas:

- works centre and prototype development;
- staff development and conference attendance;
- library system at the different levels of education;
- research equipment procurement and maintenance;
- higher education book development fund;
- redressing any imbalance in enrolment tax mix as between the higher educational institutions; and
- execution of the 9-year compulsory education programme. (ETF, 2011)

Therefore, it could be concluded that ETF is established to assist or supplement in the execution of projects relating directly to the teaching, learning and research functions of public universities and other public educational institutions in Nigeria.

ETF as a body collaborates with relevant institutions such as NUC, States Universal Basic Education Boards (SUBEBs), and National Commission for Colleges of Education (NCCE). ETF also works directly with each university in the area of identification of projects to be executed and disbursement of funds. To disburse this tax revenue across all the levels of education, the sharing formula is:

- the higher education section receives 50 per cent;
- the primary education section receives 40 per cent; and
- the secondary education section receives 10 per cent. (ETF, 2011)

The distribution formula within the higher education section is in the ratio of 2: 1: 1 as between universities, polytechnics, and colleges of education respectively. Among the universities, Eze (2011) reported that all universities are funded equally irrespective of the duration or year of establishment.

The disbursement of funds by ETF started in the year 1999, that is, six years after its establishment. Table 2 presents the total amount of money disbursed across all the levels of education based on the executed intervention projects between the years 1999 and 2008.

Institutions	Total Allocation (Naira)	Disbursement (Naira)	Outstanding (Naira)
Universities	26 439 877 960. 12	15 705 503 511. 93	10 734 374 448. 19
Polytechnics	13 505 479 288. 00	9 169 512 231. 45	4 335 967 056. 55
Colleges of Education	13 786 121 431. 00	9 944 817 430. 00	3 841 304 000. 00
Monotechnics	4 205 350 000. 00	3 220 480 000. 00	984 870 000. 00
SSEs	16 608 299 569. 75	11 831 596 419. 65	4 776 703 150. 10
SPEBs	33 554 302 747. 90	22 165 386 610. 99	11 388 916 136. 91
Total	108 099 430 995. 77	72 037 296 204. 02	36 062 134 791. 75

Source: ETF (2009)

Table 2. ETF Intervention Projects in Institutions Nationwide from 1999 to 2008, Disbursement as at 30/6/2009 0:00

From Table 2, the total allocation for universities was 26 439 877 960. 12 Naira between the years 1999 and 2008. As of the year 2009, Nigeria had 58 public universities: 27 federal and 31 federally controlled universities. Out of the 27 federally controlled universities as at that period, National Open University of Nigeria, Lagos was excluded from the intervention project. Therefore, the entire allocation for 26 federally controlled universities intervention projects was about 12 060 295 209. 88 Naira based on equality formula among the entire 57 public universities. However, the rationale behind the exclusion of National Open University of Nigeria, Lagos was not reported by ETF (2009), this is subject to further investigation.

2.1.1 Implications of the existing funding framework

Saint, Hartnett, and Strassner (2003) conducted a wide study on higher education in Nigeria with particular reference to university education. They concluded that the present funding framework "does not serve the country's longer term development interests" (Saint et al., 2003, p. 17). In a broader report, they noted that, "Historically, university funding has been distributed in broadly equitable ways across both institutions and disciplines with little concern for their performance. The result has been to create a system of excessively homogenous institutions" (p. 16). This implies that consideration is given for geographical location of universities and possibly other historical factors in the allocation of funds. This could be informed by the view that growth and development of universities in Nigeria has been tailored towards correction of educational imbalance among the states and for promoting national development.

In the years following the study by Saint et al. (2003), the findings could be generalized to not only Nigeria, but most African nations. This is confirmed by the study of World Bank (2010) which claimed that, "African governments ought to consider the adoption of performance-based budget allocations in place of historically determined allocations" (p. 6). They observed that performance-based funding has been limited to South Africa alone in the whole of Africa; while countries such as Botswana, Ethiopia, Mozambique, and Tanzania are already considering its adoption (World Bank, 2010).

As regards the ETF sharing formula to public universities, Sams (2011) concluded that the ETF executive secretary admitted that misappropriation of funds is the major challenge to the implementation of education policies in Nigeria. This could be attributed to equality formula of allocating funds among the public universities. There is no room for healthy competition or allocation of funds based on outcomes or certain criteria. Heads of various institutions could perceive funding of such projects as compulsory with little responsibility or input.

2.1.2 Performance-based funding

As a result of not only dwindling funds received by universities in Nigeria, but also mismanagement of funds, it becomes important to amend the formula of allocating these funds for efficiency and effectiveness. The existing funding framework appears to be input-driven and consideration is not given to the outputs (Hartnett, 2000; World Bank, 2010). To minimize the wastage of available paucity funds allocated to federally controlled universities, there is need for incorporation of quality and relevant academic indicators and

research outcomes as predictors of allocating funds. This is because "performance-based allocations would encourage institutional autonomy as institutions must function under full management control" (World Bank, 2010, p. 6) of the available meager funds rather than being constrained by government bureaucracy that restrains universities to function effectively and efficiently.

Salmi and Hauptman (2006) mentioned how performance-based funding differs from other funding formulas in the following ways:

- they [performance-based funding] attempt to reward institutions for actual rather than promised performance;
- they use performance indicators that reflect public policy objectives rather than institutional needs; and
- they include incentives for institutional improvement, not just maintaining status quo. (Salmi & Hauptman, 2006, p. 64)

Based on these distinctions, research of Nigerian universities for instance, should be tailored to societal needs and ultimately for national development. Universities need to conduct relevant and quality researches and improve the quality of graduates because funding for the following year may be tied to quality and relevance. This refers to the observation of World Bank (2010) that universities "are to be judged on the basis of their performance" (p. 6) and contributions towards national development.

The outputs of universities in terms of research outcomes and quality of graduates are usually given prime places in terms of universities assessment globally and for sustainable development. The ranking of universities has mostly been focused on quality and relevant outputs of the universities. Take for instance, most of the purposes and goals of webometric rankings of universities have a focus on academic indicators and research outputs or outcomes of universities before making judgment. Therefore, efforts need to be made to address the low rankings of Nigerian universities both regionally and globally, poor quality of graduates, and irrelevant research outcomes to national development through the funding mechanisms as a critical factor.

Olayiwola (2010) argued for research outputs for allocating research funds in the dual support system of funding in Nigeria. These research outputs could be one of the indicators of performance in allocating funds to federally controlled universities. The suggestion of Olayiwola (2010) on the reports of Research and Development (R & D) fair or ranking of universities being done by NUC on yearly basis could be used as a tool for allocating funds to federal universities in Nigeria. More so, the World Bank (2010) study mentioned the common output indicators to be "number of graduates, the rate of student repetition, the number of minority, women, or regionally disadvantaged students who are admitted, and research productivity" (p. 45).

The Table 3 describes the features and impact of the potential progression of funding mechanisms from a combination of historical, input, and normative-based to performance-based funding on society.

From Table 3, it can be inferred that allocation of funds to federally controlled universities in Nigeria could progress from the combination of historical, input, and normative-based, which

Budgeting modality	Key feature	Requirements for data and technical expertise	Impact on sector performance
historically-based	rewards negotiation skills	minimal	maintain status quo
input-based	rewards expansion of inputs	moderate	encourages growth
normative	rewards adherence to defined norms	moderate	encourages uniformity
performance-based	rewards outcome achievements	considerable	encourages quality and relevance

Source: World Bank (2010)

Table 3. Funding Mechanisms

emphasized adherence to defined norms and inputs-oriented towards rewarding outcome or outputs, which encourages quality and relevance of such performance. Nigeria as one of the developing nations needs qualitative and relevant research to solve societal problems and also to reduce the already existing gap between developed and developing nations. Therefore, emphasis should be placed on performance-based funding mechanism in order to establish healthy competitions among Nigerian universities.

In performance-based funding as an outputs-driven approach to allocating funds to universities, emphasis should be placed on agreed or consistent indicators or outcomes for evaluating universities in order to allocate funds. Herbst (2007) stated that,

> The rationale of performance funding is that funds should flow to institutions where performance is manifest: "performing" institutions should receive more income than lesser performing institutions, which would provide performers with a competitive edge and would stimulate less performing institutions to perform. Output should be rewarded, not input. (Herbst, 2007, p. 90)

To ensure fair play among the universities based on Herbst's (2007) rationale, the agreed indicators ought to have been explicitly and unambiguously expressed to all the federally controlled universities at the outset. These indicators can also serve as a means of self-evaluation before the national evaluation for allocating funds. It is on this note that promotion of competitive trait among universities would be enhanced.

Salmi and Hauptman (2006) identified four types of allocation mechanisms that could be considered under performance-based funding. The four mechanisms are:

- performance-set asides: a portion of public funding for tertiary education is set aside to pay on the basis of various performance measures;
- performance contracts: governments enter into regulatory agreements with institutions to set mutual performance-based objectives;
- payments for results: output or outcome measures are used to determine all or a portion of the funding formula: for example, tertiary education institutions are paid for the number of students they graduate, sometimes with higher prices for graduates in certain fields of study or with specific skills; and

- competitive funds, which support peer-reviewed proposals designed to achieve institutional improvement objectives. (Salmi & Hauptman, 2006, p. 64)

Based on Salmi and Hauptman's (2006) classifications, I am of the view that a careful integration of performance set-asides and competitive funds allocation mechanisms could be utilized in Nigeria. This means that at least 50 per cent of the entire grants from the Federal Government should be put aside and allocated on a competitive means among the federally controlled universities. The quality and relevance of research outputs for instance to national development could be assessed through peer-review among the universities for allocating funds. Salmi and Hauptman (2006) pointed out that the number of academic indicators and research outputs could vary from one to as many as 12. These indicators should be decided collaboratively by universities, NUC, and other similar bodies or critical stakeholders of university education in Nigeria, such as Education Trust Fund (ETF), professional organizations, among others.

The remaining 50 per cent of the entire grants from the Federal Government could be allocated to federal universities based on other factors such as students and staff, programs, and facilities. This is to prevent low-performing universities from moving towards extinction as a result of non-availability of funds. This model of funding mechanism hopes to classify Nigerian universities into high-performing and low-performing universities within a given or specific period of time, rather than classification based on year of establishment or other geographical factors. The classification hopes to be on relevance or contributions to national development.

Nigeria should take a leaf out of South Africa's book on performance-based funding. Salmi and Hauptman's (2006) study also corroborated by the study of World Bank (2010) that South Africa is the only African nations which "has for a number of years set aside most of its core budget for teaching, research, and other services based on multiple performance measures" (Salmi & Hauptman, 2006, p. 65). For the past few years, South Africa has been leading the continent in terms of relevance and quality of research or outcomes from universities. Although, it can be argued that South Africa has invested more on university education than Nigeria. But, the little available funds provided by Federal Government can still be utilized efficiently and effectively among the federally controlled universities to a certain extent for ensuring national development, if the allocation of funds is based on output or performance.

3. Conclusion

Although I acknowledged the limitation of over-dependence on one source of funding universities, that is, the government. But, the little available funds by the government could still be used efficiently and effectively to a certain extent. Therefore, the current state of funding framework of federally controlled universities in Nigeria demands calls for a paradigm shift. The currently existing framework emphasizes input-driven policy without given any consideration to output-driven mechanisms. The argument of this paper is not in terms of quantity of universities, but the quality of universities in Nigeria. Performance-based funding policy based on certain outcomes or criteria for allocating both NUC and ETF grants can re-position federally controlled universities in Nigeria both nationally and internationally for sustainable development.

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Part 2

Sustainable Business and Management

4

Sustainable Business Development – A Case Study of the International Logistics Industry

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1. Introduction

Corporate responsibility is business' way of adhering to the concept of sustainable development as expressed in the 1987 Brundtland Report "*Our common future*" (World Commission on Environment and Development [WCED], 1987). It refers to re-thinking the corporate role in society in terms of stakeholders (who businesses have a responsibility towards) and models for creating value. The traditional corporate short term objective of maximizing profit (value) is replaced by a long term perspective of creating value in a "triple bottom line" framework. The principle of the triple bottom line, as stipulated by Elkington (1998), emphasises that the economic bottom line has to be complemented with social and environmental values and challenges. Major environmental challenges that society requires businesses to address include biodiversity loss, climate change, land use, freshwater consumption, chemical pollution and ocean acidification (Rockström *et al.*, 2009). The social challenges include issues related to air pollution, poverty, health and safety, equal opportunities and diversity, and skills and competence building (Visser & Tolhurst, 2010).

One might refer to the triple bottom line as a process of transition, from an old to a new paradigm, where each of the dimensions in this paradigm reflects implicit corporate ambitions. Stakeholders have a major role in this transition as they are increasingly asking for transparency and accountability. In this new environment companies cannot just talk about their intents, how they address social and environmental challenges, but they have to "walk their talk", i.e., to communicate their actions. It refers to providing stakeholders such as customers, employees, non-governmental organisations, regulatory agencies and investors, with information about corporate responsibility commitments and achievements. These commitments and achievements are revealing corporate strategies and systems for addressing environmental and social challenges in daily operations as well as in future aspirations (Walker *et al.,* 2007).

Communicating corporate responsibility strategies and actions serve as grounds for differentiation, where companies may create competitive advantage and serve as role models for other corporations (Heikkurinen, 2009). Some corporations will perceive

expectations of corporate responsibility as a threat to contemporary business practices, while others will look at it as new business opportunities. Depending on the perception of sustainable business development, corporations take on different strategic roles. These roles can be labelled as defensive, reactive or proactive strategies that are reflected in, for example, long term investments and daily operations such as management procedures and communicational efforts. A company's implementation of a corporate responsibility strategy may be explained by several factors, such as company size, management philosophy, corporate strategy and industry characteristics (Carroll, 1991). Industry characteristics represent an important factor, as different industries face various challenges to a varying degree (Heikkurinen, 2010; Laudal, 2010). Industries that are associated with a strong resource use and dependence, such as agriculture, forestry and transport, all depend on physical resources. Service production on the other hand, for example health care, is less exposed to challenges associated with sustainable resource use. The degree of corporate responsibility is determined by the structure of the supply chain, and by whether the customers are private consumers or other businesses (Roberts, 2003).

As an industry which faces a number of sustainable business development challenges (Rockström *et al.,* 2009) the transport and logistics industry is constantly under pressure to excel in terms of corporate responsibility. These challenges are associated with health related impacts (air and noise pollution), resource depletion (fossil fuels) and climate change as well as social challenges of trans-national management. Since the value in the production is context-bound it is also associated with social challenges, for example, human rights, labour rights and corrupt political systems. The aim of this chapter is to describe how three international corporations in the logistics industry deal with the traditional expectation of maximising the return on invested capital – and yet commit to sustainable business development addressing the challenges listed above. Questions of particular interest are:

- What are their challenges?
- Who are the key stakeholders for whom the shared value is created?
- How do they communicate their conduct?

The following pages present challenges in sustainable business development with cases from the logistics industry. These challenges are analysed in a framework that builds on the triple bottom line, assuming that shared value aimed at sustainable business conduct are desirable. The conclusions offer some key points of lessons learned from the comparative case study. It is clear that these corporations willingly share information about their efforts because they are aware of challenges and want to be active parts in finding solutions. Communication of strategic choices of each of these corporations is presented as various ways of being accountable.

1.1 Transport and logistics - the circulatory system of world economy

Globalisation and development of international trade depend on logistics that provides a set of measures for transportation, wholesaling, warehousing, inventory management and packaging (Lin & Ho, 2010; Organisation for Economic Co-operation and Development [OECD], 2002). According to OECD (2002) transport and logistics together with communication networks constitute a "circulatory system" of the world economy and is an important service provider for global trade. However, according to Lin and Ho (2010) little

attention has been given to environmental impacts within the service sector, as it is assumed to have little impact compared to the manufacturing sector. Yet, the authors point out that the logistics industry is an example of a service provider with large environmental impacts regarding emissions and use of natural resources.

The logistics industry relies to a large extent on carbon-based fuel that makes it vulnerable in the face of volatile prices for fossil fuels. Air and noise pollution draws attention to concerns about human health and negative impacts on ecosystems. Furthermore, despite technological innovations, the logistics businesses have to employ a high level of manual labour in such operations as vehicle driving, loading and discharging of goods. This aspect implies that an ongoing improvement of work safety is necessary. Major environmental impacts derived from freight transport therefore involve challenges of green house gases, acidification, negative effects on human health, land use and resource consumption (Bauer *et al.*, 2010). Given these problems faced by the logistics industry, corporate responsibility is going to be one of the main challenges for business management and logistics in the foreseeable future (Brewer, 2001; Murphy & Poist, 2003; Lin & Ho, 2010).

Environmentalism was introduced on the agenda of the logistics industry in the late 1980's and early 1990's as a response to the report *"Our common future"*, and issues such as acid rain, CFCs and global warming. Green logistics is a concept that can be defined as: "Producing and distributing goods in a sustainable way, taking account of environmental and social factors" (Sibihi & Eglese, 2009, p.159). This broad definition of green logistics is in line with the WCED (1987) definition of sustainable development and definitions of corporate responsibility (Lyon & Maxwell, 2008). According to Sibihi and Eglese (2009) activities within green logistics relate to measurement of environmental impact due to different distribution modes, reduction of energy consumption, and waste management.

2. Approach

This book chapter is empirically based on case studies of three corporations in the logistics industry, Posten Norden, FedEx and Thomas Nationwide Transport (TNT). It illustrates how these companies are working with sustainability in their business practices and how these commitments are communicated. Several choices related to method in this project were made along the way and the first was associated with the choice of industry. The logistics industry is a service industry with an important role in facilitating global trade. However, it is also a service industry that is facing major environmental and social challenges which makes it interesting to study from a sustainable business management perspective.

The next important choice was that of selecting units of analysis, in other words, case studies. A theoretical sampling (Eisenhardt, 1989) was made based on the common denominator that they all had a history of addressing corporate sustainability issues in their operations, which were externally communicated. Posten Norden, FedEx and TNT are all also working on an international market. Posten Norden is mainly operating on the Nordic market and is a smaller logistics company compared to FedEx and TNT. FedEx was founded in the United States but operates worldwide and TNT originates from Australia operating as a global actor (FedEx, 2009; Posten Norden, 2009; Thomas Nationwide Transport, 2009).

The purpose of this study was to gain an understanding of three companies within the logistics industry and describe how they have integrated social and environmental concerns

in their business practices to work towards corporate sustainable development. A qualitative, comparative case study provides a contextual understanding of the phenomenon but does not lend itself to draw general conclusions about the industry as such (Robson, 2002). Each case was based on secondary data in the form of sustainability and corporate citizenship reports issued in 2009, and were limited to the environmental and social aspects communicated. When possible, the empirical data has been validated in a process of triangulation, which refers to seeking information about the same aspect from different sources as a part of quality assurance in the research process (*Ibid.*).

Delimitations in the project are associated with methodological and theoretical choices. Even though our definition of corporate sustainable development is based on the triple bottom line, the analysis is focused on environmental and social aspects. When we discuss corporate shared values, both for the business and a broader range of stakeholders, the economic perspective has a major role. We are assuming that the economic bottom line is not neglected, only balanced with environmental and social aspects of corporate conduct. The recent data without a historical context serves as an empirical delimitation. Corporate sustainable development is a process, and as such we should ideally look at the corporations in longitudinal studies, to investigate the process of corporate responsibilities and challenges that each of these corporations handle. Some of the empirical facts reveal outcomes of processes (certifications, organisational collaboration arrangements, strategic investments etc.), which may serve as indicators aimed at corporate sustainable development. The analysis and synthesis of these findings, tools and initiatives, represent strategic choices made for each of these cases. Therefore, the results do not lend themselves to be generalised or de-contextualised

3. Sustainable business practices and shared value

The theoretical perspective in the case study takes its stances from sustainable business management as expressed in the triple bottom line (Elkington, 1998). he notion of sustainable business practices is a way of creating shared value, i.e., to establish practices that lead to long-term financial performances as well as positive societal outcomes (Epstein, 2008; Porter & Kramer, 2010). The theory departs from corporate responsibility as a general concept and then moves towards corporate responsibility as a corporate strategy, and the implementation of sustainable business practices. A model of tools and concepts within corporate responsibility and a model of companies' *"Corporate Social Responsibility Landscape"* (McElhaney, 2008) are presented as a framework. The tools and concepts are defined and explained and will, together with the *"Corporate Social Responsibility Landscape"* model, be used to facilitate the comparison of the communicated strategies and practices of Posten Norden, FedEx and TNT. Their communicated strategies for sustainable business practices serve as the focal point for the analysis with a particular interest in corporate tools and concepts to address environmental and social issues. Contextual factors, such as key geographical markets, location of head quarters and perceived internal motives are taken into account in the analysis of the communicated corporate responsibility efforts.

3.1 Corporate shared value

Businesses, regardless of industry and size, are active members of society, which is reflected by context-bound visions, social realities and operations in accordance with regulations. The

traditional view of the role of businesses, as argued by Friedman (1970), is to maximise the profit. This view assumes that increasing profit for shareholders is the sole responsibility of the corporation. Friedman argued that, by creating economic value (maximising return on investments) social wealth is provided. In this view, businesses generate more job opportunities, customer satisfaction, pay taxes and in the process contribute to societal values. Yet, business themselves have been changing and therefore their role has to be revised as well.

A more contemporary view of what corporate conduct is aimed at, and conditioned by, is outlined in the triple bottom line framework. In this framework, the strategic direction is aimed at value creation with corporate responsibility engagement (Charter & Polonsky, 1999). The creation of shared value is seen in various activities, ranging from money donations (philanthropic actions) to integration of new values and priorities (extended stakeholder dialogues, public-private partnerships, new product development with societal benefits in mind etc.). Integrating corporate responsibility as part of the core business, by for example developing new business models, is more likely to be sustained over time and lead to value for the business as well as for stakeholders compared to a philanthropic approach (Halme & Laurila, 2009; Porter & Kramer, 2011). A philanthropic approach might give more direct societal outcomes than the integration and innovation approaches, but might not lead to a sustained positive social outcome as it can easily be discontinued (Halme & Laurila, 2009).

Welford and Frost (2006) argue that corporate responsibility creates a competitive advantage for the corporation, and part of the value is associated to risk mitigation, cost savings and improved relationships with stakeholders. According to Porter and van der Linde (1995) eco-efficiency as a part of the triple bottom line improves the environmental performance by reducing costs for resource use and waste management. Additional advantages of corporate responsibility are associated with increased grounds for differentiation, enhanced employee motivation and customer loyalty (Charter & Polonsky, 1999; Heikkurinen, 2009).

3.2 Stakeholders and the corporate social responsibility landscape

In order to create shared value through sustainable business practices, corporations need to identify key stakeholders (Atkinson *et al.*, 1997). A stakeholder is defined by Freeman (1984, p.46) as "any group or individual who can affect or is affected by the achievements of the organisation's objective". Stakeholders are often divided in two groups, primary stakeholders that may influence the corporate activity and secondary stakeholders that are influenced by the corporate actions. In a triple bottom line this division is a bit blurred, since a larger number of stakeholders´ interests are taken into account. Stakeholders that traditionally would be regarded as secondary are included in a multi stakeholder analysis. In an extended stakeholder analysis we may find the traditional primary stakeholders: customers, employees, investors and owners. We will also find representatives of local communities, regulatory agencies, non-governmental organisations and even nature as key stakeholders that have interest and demands of how a business should operate.

The extended stakeholder concept vastly complicates the strategic choices for sustainable business practices since it needs to adhere to the demands of the broad spectra of stakeholders. Questions they may face include: How do employees perceive their workplace and what aspects are important for them in their relationship with the employer? Is the local

community in need of voluntary services or does the local school need funding for an environmental event? What expectations do investors have on the company's social and environmental management? What requirements do the local nature conservation group have on the business operations? These questions and values need to be balanced with the traditional (prevailing) economic bottom line view of what businesses are expected to do.

According to McElhaney (2008) corporate responsibility can take place at different geographical levels in what is called the "*Corporate Social Responsibility Landscape*" (Figure 1). These levels are company, community, industry and world.

- The *company level* refers to running a good business, for example adhering to the laws, having high employee retention, creating value for the customers and providing returns on invested capital for the stockholders.
- At a *community level*, the corporation is seen in its proximate geographical context. It refers to supporting the local community through philanthropy, efficient resource use and reducing waste.
- *Industrial level* implies how corporations take action towards other businesses in the same industry. It may imply serving as a good example, leading the way for innovative solutions and co-creation of value in alliances and partnerships.
- At the *world level,* corporations serve as pieces in a jig saw puzzle. Large corporations with strong positions in negotiations may lead the way for responsible conduct. International supply chains with operations worldwide serve as important carriers of information and practical understanding of shared value in different cultural contexts.

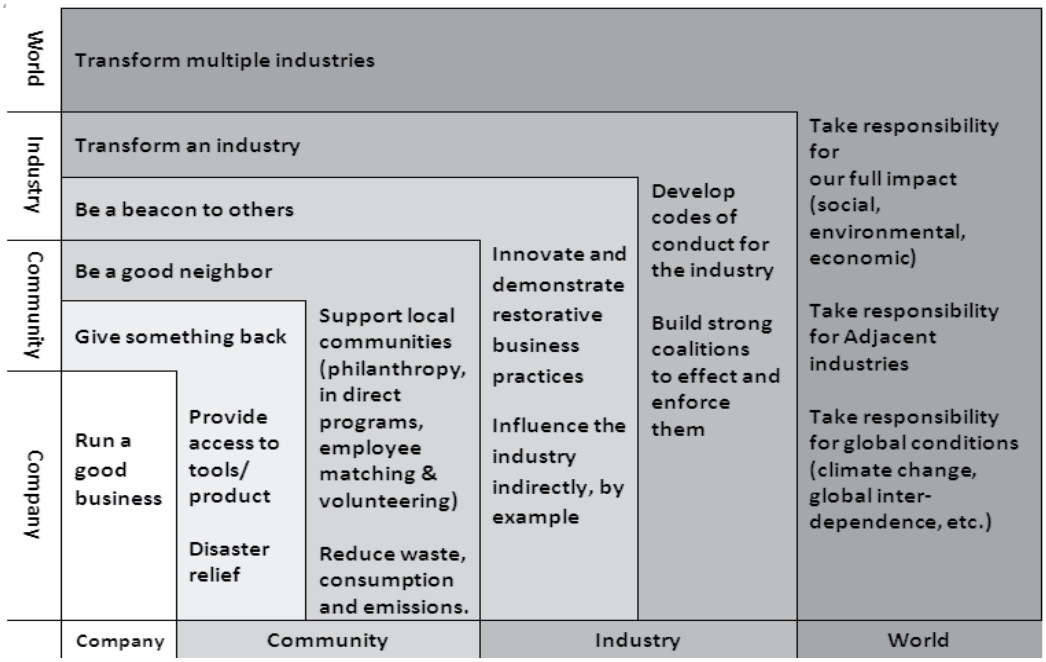

Fig. 1. The Corporate Social Responsibility Landscape (McElhaney, 2008, p.22).

Most corporate initiatives would be labelled as being a good neighbour, maintaining their license to operate or giving back something to society. A majority of companies can be said to engage on a community level, dealing with social and environmental challenges that are present at a nearby geographical location. In addition, businesses can influence the industry or as McElhaney (2008, p. 22) expresses it "to be a beacon to others". Corporate responsibility at this level involves taking a responsibility for not only impacting the industry, but also to acknowledge and address global environmental and social challenges, such as poverty and climate change. Hence, for corporations to develop business practices that lead to long-term financial performance as well as positive societal outcomes, sustainability has to be integrated in the core business and not be seen as an "ad-hoc" to regular business activities. A contemporary view of what corporate identity entails includes a vast number of objectives above and beyond that of making profit (Leipzinger, 2010):

- *Supplying* goods and services that customers need/want
- *Creating* jobs for customers, suppliers, distributors and employees
- *Continually* developing new goods, services and processes
- *Investing* in new technologies and in the skills of employees
- *Building* up and spreading international standards, e.g. for environmental practices
- *Spreading* "good practice" in different areas, such as environment and workplace safety

Corporate challenges are associated with taking on responsibilities beyond the financial bottom line with consideration taken to an extended stakeholder definition. In order to meet the increasing demands and yet be able to run the business in a competitive manner, businesses, international organisations and corporations have developed a number of tools and concepts to be able to create shared value. A selection of tools and initiatives available for sustainable business practices will be presented next.

3.3 Tools and concepts for sustainable business practices

A smorgasbord of tools and concepts has developed since the introduction of corporate responsibility in its contemporary form. In this study we have chosen to focus on a number of tools and concepts with different origins. The tools and concepts for sustainable business practices are summarised in Table 1.

The United Nations Global Compact, the Global Reporting Initiative and fundamental labour rights can be referred to as global agreements and guidelines for how organisations can adhere to and communicate corporate responsibility. Labour relations in this context refer to aspects regulated in international law, such as the "International Labour Organization Declaration on Fundamental Principles and Rights at Work" (ILO, 2010). The relationship between employer and employee can also involve voluntary initiatives, such as competence training and health care benefits.

A standard or a code of conduct has the function as a guiding document in the area of social and environmental responsibility. International and national standards are available in the area of work environment (OHSA 18000 and SA8000), environmental management (ISO 14001) and recently also in the area of social responsibility (ISO 26 000). A code of conduct is different from a standard in the sense that it normally is a document that is developed internally and functions as a guideline or standard in the relationship between two actors, e.g. between the employer and the employees or a buyer and its suppliers.

Green & social alliance	A form of collaboration aimed at achieving mutual benefits. Either in form of private-public partnership, private-non-governmental or business-to-business (Stafford & Hartman, 1996 & Charter & Polonsky, 1999).
Standard	A document of general advice offered to a large number of potential adopters, spread in written form and adopted on voluntary basis (Brunsson & Jacobsson, 2002).
Code of conduct	Documents regarding ethics used as guidelines for employees' or suppliers' conduct (Mamic, 2005; Wingborg, 2009).
Green services & products	Line-extensions, reformulation of existing products, a new product, eco-efficient products or services, and green premiums (Charter & Polonsky, 1999).
Labour relations	Fundamental and voluntary initiatives between employer and employee. Fundamental rights are based on the International Labour Organization Declaration on Fundamental Principles and Rights at Work (International Labour Organization [ILO], 2010). Voluntary initiatives refer for example to health care benefits and competence training (Visser & Tolhurst, 2010).
United Nations Global Compact	Policy platform and framework with universally accepted principles for human rights, labour, environment and anti-corruption (United Nations Global Compact, 2008)

Table 1. Tools and concepts of sustainable business practices.

Philanthropy, green services and products, and green and social alliances are concepts to describe initiatives taken to adhere to different stakeholder demands. An initiative of a company that involves supporting charitable organisations or local community projects financially or with knowledge and time, is referred to as philanthropy. Green services and products have developed as customers have become more aware of the negative environmental impacts from their consumption and their willingness to buy products or services with a green consciousness. The concept of green products and services is broad and can involve a product that is energy efficient, a service that involves climate compensation or a product that is labelled with a recognised environmental label.

Green and social alliances are rather recent initiatives to express corporate responsibility. An alliance or collaboration involves gaining mutual benefits between a corporation and a public organisation or a non-governmental organisation. The phenomenon of green and social alliances has developed as a way for businesses to gain knowledge within important fields and to gain legitimacy. The other partner in turn gets financial resources and exposure for the particular issue of interest, e.g. nature conservation or children's rights (Rotter *et al.*, 2011).

4. A case study of sustainable business practices

Posten Norden, FedEx and TNT are three corporations in the logistics industry that have adopted a corporate responsibility strategy and that are actively communicating their commitments to address corporate responsibility challenges. The following section aims at introducing the case companies and their views of corporate responsibility and sustainable business practices.

4.1 Posten Norden

Posten Norden provides communication and transportation solutions on the Nordic market and had an annual turnover of $6.4 billion in 2009. Key principles and results of its corporate responsibility strategy are reflected in its annual *"Sustainability Report"*, which is prepared separately from the financial reporting. The version of the report published in 2009 was designed in close accordance with the Global Reporting Initiative framework based upon a set of universal indicators that allows assessing business performance from economic, environmental and social perspectives. Out of the 79 indicators offered, Posten Norden prepared full reporting on 19 indicators, while nine indicators were partly covered. Commitment to establishing long standing relationships with various stakeholders is expressed in the company's vision. It is declared that partnerships and collaborations play important roles in development of profitable international logistics operations. In this sense, primary focus is placed on strengthening ties with owners, society, customers, employees, and suppliers and their partners (Posten Norden, 2009).

4.2 FedEx

FedEx is an American based company with operations in transportation and logistics worldwide. The company operates in more than 200 countries and the reported turnover was approximately $35 billion in 2009. To describe its efforts in the domain of corporate responsibility, FedEx introduces the concept of corporate citizenship which combines measures that facilitate access of people to goods and information through the lowering of distance related barriers. Strategies that fit in the framework of this concept are annually conveyed in the *"Corporate Citizenship Report"* set to be published as a supplement to the annual report. The corporate citizenship of FedEx is based on four focus areas: people and workplace, economics and access, environment and efficiency, and community and disaster relief. Practical implementation of actions within the corporate citizenship strategy is carried out through the special program *"EarthSmart"*. The programme is realised in three main directions: solutions (services and physical assets, including transport), work (participation of employees in sustainability efforts) and outreach (philanthropic and volunteer initiatives). Stakeholders frequently mentioned by the company in its report include employees, customers, shareholders and communities where it operates (FedEx, 2009).

4.3 Thomas Nationwide Transport

TNT provides express delivery services; logistics supply chain solutions and mail services globally. By the end of 2009 TNT had operations in more than 200 countries and reported $12.5 billion in revenues. Compared to Posten Norden and FedEx, TNT does not have a separated report intended to communicate its strategy of corporate responsibility, but instead TNT reflects this information as a special section of the annual report where other key data including financial statements is presented.

Overall, in 2009 TNT managed to single out ten focus areas within its strategy. Engagement of multiple stakeholders is crucial in shaping the corporate responsibility strategy. TNT initiated a stakeholder dialogue that enabled determining key parties involved in or affected by TNT's operations. This initiative helped to clarify the main directions for activities with a high stakeholder concern. The list of stakeholder groups that took part in the dialogue comprises employees, customers, subcontractors, suppliers, investors and civil society (TNT, 2009).

Table 2 summarises a number of the tools and concepts within corporate responsibility used by Posten Norden, FedEx and TNT.

Tools and concepts	Posten Norden	FedEx	TNT
Global Compact	• Member (world)	• Not a member, but belongs to the Global Environmental Management Initiative (world)	• Member (world)
Global Reporting Initiative	• Member (world, industry)	• Member (world, industry)	• Member (world, industry)
Labour relations	• Works with the equality and diversity project "Similar Unique" • OH-SAS 18001 certification (company) • Training and workshops (company)	• Corporate diversity council to ensure representative culture (company) • Affinity groups to promote diversity (company)	• Member of North Star Alliance to address health issues among truck drivers (community) • Encourages open dialogue with employees (company) • Adaptation for the layoff (community) • Developed "Choose Orange" to train drivers to increase fuel efficiency & reduce accidents (company) • OH-SA 18001 certification (company)
Philan-thropy	• Supports Denmark Cycle Union & Swedish Football Association (community) • Sponsors the children's project "Post-Pal" (Community) • Supports the exhibition for children (community)	• Provides disaster relief (world) • Offers school scholarships (company) • Collaborates with Key Stone Science School to educate young people about environmental conservation (community)	• Participates in the Wooden Spoon charity (community) • Participates in the Joop Swart Masterclass (community)
Green & social alliances	• International Post Corporation (world) • Participates in the project Climate Neutral Freight Transportation to reduce climate impact of road-based freight (Industry)	• Founded Carex to improve fuel efficiency (community) • Public-private partnership with EMBARQ, a network for sustainable transport solutions (community)	• Initiated "Code Orange" to increase emission efficiency (industry) • Involved in the Jathropa project to combat poverty and provide biofuel (industry) • North Start Alliance,

Tools and concepts	Posten Norden	FedEx	TNT
		• Recycling projects (company) • Alternative means of transport (industry) • Participated with stakeholders to produce "Hush Kit" for reducing aircraft noise (community)	public-private partnership to provide sustainable road side clinics
Green services & products	• Special stamps to highlight environmental issues (community) • Climate compensation/ calculations (community)	• Does not communicate any green services or products	• Reveals CO2 emissions generated by customers' shipments (community)
Standards	• Goal to have all departments ISO 14001 certified • OH-SAS 18001 certified (company, community, world)	• Has embraced fuel efficiency standards through the "Smart Way Transport Initiative" (industry, community, world)	• ISO 14001, SA 8000 & OH-SA 18001 certifications (company, community, world)
Code of conduct	• Has a code of conduct (company, industry)	• Has a code of conduct (company)	• No code of conduct is communicated
Labour relations	• Equality & diversity projects (company) • OH-SAS 18001 (company) • Training & workshops (company)	• Corporate Diversity Council (company) • Affinity groups (company)	• North Star Alliance (community) • Open dialogue with employees (company) • Adaptation of laid-off (community) • Choose Orange, employee project for sustainable lifestyles (community) OH-SAS 18001 (company)

Table 2. Summary of tools and concepts for Posten Norden, FedEx and TNT to express corporate responsibility

The tools and concepts illustrated in Table 2 highlight the importance the three companies attach to corporate responsibility as part of corporate strategy. It is also evident that these initiatives are diverse with each of the three companies involved in several of them. Posten Norden's, Fedex's and TNT's corporate responsibility initiatives are further analysed in the next section.

4.4 Sustainable business practices of Posten Norden, FedEx and TNT

Businesses realise many benefits when they integrate a strategy for corporate responsibility (Sharma & Greenburg, 1998; Charter & Polonsky, 1999). According to McElhaney (2008), it is crucial that the message communicated is also reflected in the corporation's actions, i.e., that companies "walk their talk". This section discusses the differences and similarities between the case companies' use of corporate responsibility strategy and sustainable business practices to achieve sustainable business development. In addition, by using the various tools that were identified in Table 2, this section analyses the extent to which sustainable business practices live up to stakeholder demands on different geographical locations based on the "*Corporate Social Responsibility Landscape*" model (McElhaney, 2008).

Posten Norden and TNT are members of the United Nations Global Compact, which contains globally recognised principles for business to acknowledge. FedEx is not listed as a member of the Global Compact but belongs to the Global Environmental Management Initiative, which promotes responsible corporate citizenship. By working with players on a global level, and acknowledging stakeholders worldwide, the three companies have taken steps to meet the requirements of a world level of engagement (McElhaney, 2008). Additionally, all the three companies work within the framework of the Global Reporting Initiative by subscribing to the triple bottom line reporting approach. Since this is a global initiative which has been embraced by many companies within and outside the logistics industry, it is clear that through this, the companies are aiming at providing a variety of stakeholders with transparent and comparable information about corporate commitments and achievements, on both an industry and world level (McElhaney, 2008).

Market and internal factors can motivate companies to adopt certain standards (Jones *et al.*, 1997; Brunsson & Jacobsson, 2000). Posten Norden and TNT work according to standards within the areas of environmental management (ISO 14001), labour rights and work environment (OH-SAS18001). In addition, TNT works with SA8000 and has initiatives that extend its labour practices outside the physical work place, such as supporting drivers outside the company and supporting employees that have been laid off. FedEx does not communicate that they are working in accordance with any internationally recognised standard. However, FedEx has publicly called for fuel efficiency standards for commercial and heavy-duty trucks in the United States. By undertaking these measures, the companies are further displaying their desire to fulfil company and community levels of engagement (McElhaney, 2008). Since industry engagement can lead to the standards being embraced by other companies and suppliers (Porter & van der Linde, 1995) this exemplifies attempts by the companies to leverage their level of engagement to industry level to improve environmental performance and work environment within the industry and ultimately at a world level.

The standards focusing on work environment is also a way of expressing an extended responsibility and willingness in the area of labour relations, in addition to what is regulated by national laws and the International Labour Organization. Initiatives for equality and diversity are required in international law, while training programmes and workshops are voluntary initiatives to improve job satisfaction and the competence level among employees. All these initiatives focus on the company level, i.e., they are initiatives mainly addressing internal challenges of labour relations. However, TNT has a number of

programmes with a further reach. The North Star Alliance project for example, addresses social issues at a world level, by building up and sponsoring road hospitals in developing countries together with other actors. The Choose Orange project also has a further reach than employees at work as it aims at making employees bringing home the lessons learned about energy efficiency at work.

While a standard is developed by a third-party, Posten Norden and FedEx have developed internal guidelines in the form of code of conducts to guide employee conduct and communicate that they act according to their respective code of conduct. FedEx describes in detail what areas the code of conduct covers, while Posten Norden does not emphasise the particular areas the code of conduct relates to. Posten Norden communicates that they incorporate the code of conduct in their supplier contracts, which is a way of spreading good management practices in the value and supply chain. Undoubtedly, Posten Norden and FedEx, by putting in place codes of conducts to regulate internal behaviour of employees, and for Posten Norden requiring their suppliers to adhere to their code of conduct, are attempting to meet the company and industry level of engagement respectively (McElhaney, 2008).

Partnerships and alliances between businesses and environmental or other groups can be used to effectively integrate goals and market objectives for sustainable business development (Hartman & Stafford, 1997). This ability by companies to pool resources "across profit/non profit boundaries" is one of the prerequisites that companies should meet in order to realise shared value (Porter & Kramer, 2011, p.64). The three companies are involved in different green alliances in the areas of emission reduction, energy conservation, and application of alternative means of transport and fuels. TNT produces bio-fuel within the Jatropha project, which can be seen as a mixed approach of sustainable business practices. The project is a form of philanthropy, an environmental project and a green alliance. FedEx is the only company that communicates that they have recycling projects on a business to business level. Analysed in accordance to the "*Corporate Social Responsibility Landscape*" model (McElhaney, 2008), TNT's Jatropha project and FedEx's recycling program could have the potential to transform multiple industries as they can be applied to other sectors. Besides this, these programs also serve to illustrate that these are responsible companies that engage with their communities on issues of global concern. Posten Norden on the other hand, reports that they are mostly involved through memberships in different councils and organisations related to global issues, such as the project Climate Neutral Freight Transportation and the International Post Corporation.

Posten Norden, FedEx and TNT are all involved in some form of philanthropic activity, as referred to by Carroll (1991). Their charitable engagements include engagement with young people and cultural and sport activities in different geographical areas. FedEx reports undertaking disaster relief on a world level, while the philanthropic activities of Posten Norden and TNT can be characterised as being at community level. Overall, by undertaking philanthropic activities, the three companies show that they are committed to being engaged on community levels all around the world (McElhaney, 2008).

With regard to green services and products, Posten Norden and TNT provide their customers with climate compensation and emission calculation services. Posten Norden also uses specially designed stamps for charity and as a channel of information in the area of

sustainable development. The stamp collections of Posten Norden can, just like the Jatropha project of TNT, be seen as a mixed approach. It can be seen both as charity and a green alliance with the World Wide Fund for Nature. According to McElhaney (2008) a company that supplies its customers with green products or services, shows engagement on a community level. Moreover, as Porter and Kramer (2011) state, by supplying green products and services these companies are moving away from the traditional product mindset, a development that is aligned to the notion of creating shared value.

Green products and services can also be seen as a way for Posten Norden and TNT to differentiate themselves within the logistics market (Hartman & Stafford, 1997; Heikkurinen, 2009). However, from a critical perspective the green services and products offered by these logistics companies are rather reactive solutions than proactive ways of decreasing the negative environmental impacts from transportation. Services and products with a shared value should include a re-thinking of the contemporary business models and involve alternative means of transport or alternative fuels, rather than climate compensation. These are the solutions that have a real chance of providing shared value in a long-term perspective.

5. Industry characteristics and green logistics

Posten Norden, FedEx and TNT are communicating a number of sustainable business practices ranging from initiatives promoting diversity and equality, standards for work environment, disaster relief, industry projects, climate compensation, charity stamps, fuel efficiency standards and environmental management systems. These initiatives can all be labelled as practices for green logistics (Sibihi & Eglese, 2009) and are designed to address the major environmental and social challenges facing the industry. The wide variety of initiatives, both in the area of social and environmental challenges, shows that several stakeholder demands are adhered to, from the acknowledgement of international initiatives and standards, to supporting local communities and offering climate compensated services and charity stamps both to private customers and business partners.

According to Li and Ho (2010) company size and an uncertain business environment can have impacts on the implementation of green practices. Other business characteristics such as whether the products or services are sold to private consumers or business-to-business can influence a company's implementation of a strategy for corporate responsibility (Carroll, 1991; Heikkurinen, 2009; Laudal, 2010). Posten Norden, FedEx and TNT are all relatively large and established on their respective markets, which could serve as an explanation to why they have what can be considered a proactive approach to sustainable business practices.

As previously discussed, the logistics industry is facing large corporate responsibility challenges, not least within the area of natural resources usage. Industries with large challenges have larger pressure from stakeholders than less polluting industries. However, an analysis of the structure of the logistics industry reveals that logistics providers mainly work with other businesses than with private consumers. Hence, logistics businesses have less pressure from consumers than say, an airline business which meets its customers more directly. This study reveals that even though the logistics industry is mainly based on business to business contracts, sustainable business practices seem to be an important aspect

also in the relationship with other businesses. This situation can be attributed to the fact that major corporations such as Posten Norden, FedEx and TNT, meet high demands from major customers, which in turn are required by their customers to improve the social and environmental conditions of the value chain.

5.1 The environmental and social pillars of the triple bottom line

Regarding the environmental issues in this study, the initiatives communicated by Posten Norden, FedEx and TNT are similar, both regarding the actions (philanthropy, green alliances, standards and industry projects) and the levels of engagement (company, community, industry and world level). A close scrutiny of the sustainability and global citizenship reports showed that initiatives related to reducing carbon dioxide emissions is a top priority for the companies. This implies that this is acknowledged as a major environmental challenge closely related to the companies' core business. This understanding from the companies is crucial to be able to create long-term shared value for the business and the various stakeholders (Porter & Kramer, 2011). However, the usage of fossil fuels is not only an environmental issue but also has economic implications due to the costs involved in cleaning up air pollution in major cities. Moreover, the unstable political environment in oil producing countries has led to the escalation of costs of fuel. Therefore, initiating projects for fuel efficiency does not only create legitimacy among stakeholders, but also leads to positive impacts on the economic bottom line (Porter & van der Linde, 1995).

To understand the social aspects of a business there is need to appreciate both the industry context and the national and cultural contexts. In Scandinavia and Europe, where Posten Norden and TNT have their origins, there is a long tradition of adhering to workers' rights and to initiate voluntary actions to improve the working conditions for employees (Visser & Tolhurst, 2010). In the national and cultural context of FedEx, an American based company, businesses have a large role in supporting employees with health care benefits and pensions. In comparison to environmental challenges, which are highly dependent on what business operations that take place, most companies meet similar basic challenges regarding workers' rights and other social aspects of corporate conduct. Posten Norden, FedEx and TNT have a wide variety of initiatives addressing social aspects. The companies originate from countries with strong traditions of pro-actively working with labour relations both from regulatory agencies and from society in general. This gives these companies, when operating on markets where labour conditions are not as prioritised, the possibility of transferring norms, values and management practices of appropriate labour standards to other cultural and national contexts. By transferring values from one business culture to a national context, social challenges of transnational management are addressed.

Philanthropic projects initiated by the companies mainly have a social focus, such as supporting sport events for children, international projects for cultural interactions, disaster relief, scholarships and education programmes. Working with established and internationally recognised standards for work environment and labour relations, and as well support projects in the local communities where the companies operate, can create both employee motivation and customer loyalty (Banjeree, 1999; Heikkurinen, 2009).

The logistics providers are also important actors in the value chain of most other industries as logistics providers serve as facilitators of global trade. Logistics providers are used to

transport raw materials, finished products, deliver advertisement material and is in many ways a link between the different actors in global supply chains. As more environmental and social demands are put on several actors in the value and supply chains (suppliers, subcontractors, logistics providers, retailers and so on), it enables sustainable business practices to spread in the value chains. The sustainable business practices are hence not limited to a few actors, but can be present throughout the whole value chain. When Posten Norden, FedEx and TNT are proactively working with addressing sustainability issues they also have the possibility of "transforming multiple industries" (McElhaney, 2008), i.e., the industries they are providing services for. Other actors in the value and supply chains also have the possibility to put demands on less proactive actors leading to a knock-on effect, which will have positive effects on working towards sustainable business development.

5.2 Transparency – A prerequisite for trust and value creation

There are many factors that can affect the communication of corporate responsibility in the sustainability and global corporate citizenship reports. A critical perspective on corporate responsibility communication is that it is rather part of marketing than being a responsible business. Communication of corporate conduct can be seen as a tool for risk mitigation (Welford & Frost, 2006; Arvidsson, 2010). However, communicating commitments and achievements can also be seen as stakeholder dialogue and as crucial for trust and value creation (Kotonen, 2009). Some even argue that corporate responsibility has become a hygiene factor for many medium and large sized companies (Ihrén, 2011). Posten Norden, FedEx and TNT are all using sustainability reporting and corporate information on websites as stakeholder dialogue and are transparent about the projects they are engaged in. To some extent, for example in line with the Global Reporting Initiative, they also report on their performances in a number of areas.

The environmental aspect is a main area of reporting. A possible factor to explain this can be that the companies consciously chose to communicate the values that they judge as being most important for the stakeholders and the company's "green image". Green issues have been highlighted the last ten years on the global business agenda. Pushing green issues can also be a more direct way of gaining competitive advantage than dealing with social issues. The logistics companies are service providers and might not meet the same harsh labour conditions as the manufacturing sector; instead focus has been on transportation providers' responsibility to decrease emissions of carbon dioxide to address climate change. The social aspect of sustainable business practices are in some contexts also taken for granted. In Europe and Scandinavia employers are expected to treat their employees with respect and undertake voluntary initiatives that motivate employees. This might be another explanation to why environmental issues have a major focus in the communication of Posten Norden, FedEx and TNT.

Just like sustainable business practices can be spread through the value chain when demand is transferred from one actor to another, communicating responsible business conduct can also inspire other actors in the industry and leading the way for innovative solutions. Posten Norden, FedEx and TNT can by being transparent and openly communicate what they do to contribute to sustainable development become role models for other actors in the industry who also realise the value of engaging in sustainable business development (Walker *et al.*, 2007).

6. Conclusion

This chapter seeks to elucidate how three international corporations in the transport and logistics industry deal with the traditional expectation of maximizing the return on invested capital, and yet commit to sustainable business development. In this regard we highlighted Posten Norden's, FedEx's and TNT's strategies for sustainable business practices and the initiatives developed to address challenges of natural resource use, human health and work safety.

The study revealed that the companies communicate transparency and accountability in similar ways and to a large extent have adopted similar sustainable business practices. Sustainable business practices were identified in a number of areas, including social and environmental aspects as pointed out in the triple bottom line (Elkington, 1998) and the WCED (1987) definition of sustainable development. Initiatives promoting diversity and equality, standards for work environment, disaster relief, industry projects, climate compensation, charity stamps, fuel efficiency standards and environmental management systems are different approaches to create shared value among the case companies and their stakeholders. However, some of the initiatives will have a greater chance of creating shared value than others. Initiatives for sustainable business practices range from philanthropic approaches to initiatives that to a high degree are related to the core business. Porter and Kramer (2010) argue that the time of corporate responsibility expressed as philanthropy is obsolete. To be able to create shared value corporate responsibility has to be integrated in the core business. The logistics industry with large challenges regarding natural resource use, human health and work environment need to focus its sustainability efforts on an industry level with initiatives aimed to "be a beacon to others" and "transform the industry" (McElhaney, 2008, p.22).

A number of the initiatives in this case study focus on change of the industry, such as Climate Neutral Freight Transportation, Code Orange and the Jatropha project. As an important facilitator of global trade the logistics providers also have important roles in the value chain of other industries and are in different ways a link between the actors in global supply chains. As a business that is part of most other businesses value and supply chains, a proactive logistics industry has a position of influencing social and environmental practices on the corporate level. As more demands are put on several actors in the value and supply chains it enables sustainable business practices to spread. Hence, it is not limited to a few actors, but are present throughout the whole value chain.

Communicating a strategy for corporate responsibility objectives and implementation of sustainable business practices are important aspects of influencing other actors in the logistics industry as well as other industries. The communicative aspects are also crucial for a broad stakeholder dialogue. Stakeholders are increasingly demanding transparency regarding business practices. Posten Norden, FedEx and TNT communicate and address issues as expressed by different stakeholders. By doing this they can both comply to stakeholder demands and needs, and also be able to influence other businesses that have not yet proactively implemented sustainable business practices in their business operations.

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5

The Obligation of Sustainable Fisheries Management: Review of Endured Failures and Challenges in Exploitation of the Living Sea

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1. Introduction

Fishing is defined as a specific use of our living environment, the extensive or intensive activity to hunt or collect aquatic species for a huge variety of motivations related to leisure, nutrition or profit. More generally interpreted, the term can also be applied as a metaphor for any passive and active advantage taking from our surroundings, from "fishing" for monetary values to compliments. So we (creatures) and many of our actions are concerned.

The world's confined biosphere is composed of living and non-living constituents, which are interlinked by a complex web of relations at different levels and with different intensities. We subdivide the various constituents and their effects into ecosystems. Their common and main feature appears to be a dynamic change at all scales in time and space, which provokes the vital evolution through everlasting mutation and adaptation (Pickett *et al.*, 2007). We need to realize that the non-equilibrium is a major feature of ecology and widely accepted as paradigm (Lévêque, 2003). Humanity, as highly developed constituent, intensively exploits living and non-living resources with high impacts (footprints), and thus highly depends on stability and resilience when optimizing its exploitation strategies over short or medium term, i.e. periods of generations or beyond with increasing ethical concerns. The initiation of the concept of sustainability in the 20th century reflects the increasing global awareness of the threat posed by the human-induced effects and thus can be interpreted as a logical consequence by defining limits to achieve a stable and optimized use of any sort of common or private goods.

While such conceptual thinking is not new and appears easily comprehendible, the reality largely differs regarding both common property (Hardin, 1968) as well as private property (common experiences, I guess). Despite sufficient knowledge leading to various definitions and requests of precautionary approaches, principles and time frames towards sustainability, human management normally fails and results in crisis management to minimize damages at all levels, from personal to international dimensions. The desperate

try to constrain climate changes and mitigate their consequences are an impressive example. Fisheries do not represent an exemption (Cochrane *et al*., 2009), and different arguments are used driven by multifaceted objectives of various interest groups, such as non-governmental organizations, stakeholders, politicians and their international frameworks, and even scientists.

2. Overfishing as ecological footprint: The facts and definitions

Historically, hunting of whales was among the first human activities which proved that marine resources are limited. Commercial bowhead (*Balaena mysticetus*) whaling began in the 1840s, and within two decades caught over 60 percent of the bowheads (Braham, 1984). It's noteworthy that the populations appear still not fully recovered as the International Union for Conservation of Nature (IUCN) assigns their status still as 'lower risk' to 'critically endangered'. More than 100 years ago, Garstang (1900) demonstrated that increased fishing could reduce fish abundance, which is seen as the basis for Graham's (1943) fishing law (Hart & Reynolds, 2002). Schaefer (1954) formulated the first general production model to be applied to fisheries data for the quantification of the surplus, which is still interpreted as the sustainable yield from a given living resource. Further milestones with increased understanding and precision were the growth modeling (v. Bertalanffy, 1938) and the development of age structured dynamic pool models (Gulland, 1965; Pope, 1972) to estimate the past and future stock production (Beverton & Holt, 1957; Ricker, 1975).

The drastic short term changes in the ecosystems and their components is reflected in the relative high amount of energy many marine species invest for reproduction, i.e. the amount of eggs and prolonged reproductive seasons in tropical, boreal and polar regions. The species are classified based on the number and quality of offsprings (MacArthur & Wilson, 1967) into the so-called r-strategists (high number of eggs and short lived) versus the k-strategists (low number of eggs and long lived). Higher variability is expected and can be seen in the fisheries targeting the r-strategists of the pelagic habitats. Taking this into account, the recent scientific challenge is characterized by the move from the individual stocks to the ecosystem approach (Jennings, 2001) to fisheries management, which shall provide a wider understanding of the human impact through exploitation of living marine resources. Hilborn (2010) defines the most important elements of ecosystem based fisheries management as keeping fishing mortality rates low enough to prevent ecosystem-wide overfishing, reducing or eliminating by-catch and avoiding habitat-destroying fishing methods.

The recent state of the marine ecosystems has been continuously assessed by many authors and institutions. The largely biased general public opinion is that the sea is empty, the food webs are fished down to small species and there is a general loss in biodiversity impairing the oceans' capacity to provide food, maintain water quality, and recover from perturbations (Pauly *et al*., 1998; Pauly & Palomares, 2005; Worm *et al*., 2006). But the facts prove that the oceans are surprisingly resistant, despite the destructive and ongoing illegal, unreported and unregulated fishing practices (IUU fishing), which are officially condemned and combated as a serious global problem regarding habitat destruction and fish stock depletion. The destructive and incidental catch of sharks, seabirds, turtles and marine mammals has to be avoided by selective devices (FAO, 2008). However, the latest assessment of the Food and Agriculture Organization of the United Nations (FAO, 2010 a)

concludes that global production of marine capture fisheries reached a peak of 86.3 million tons in 1996 and then declined slightly to 79.5 million tons in 2008, with high annual fluctuations and changes in contributions of the major species. While there are severe concerns regarding the human impacts through capture fisheries on marine ecosystems, we may realize that 63% of assessed fish stocks worldwide still require rebuilding to optimize the productivity, and even lower exploitation rates are needed to reverse the collapse of vulnerable species (Worm *et al.*, 2009). In summary, overfishing is an ecological footprint of our recent society but we are far from the apocalypse of collapsed world's fisheries (Hilborn, 2011).

After having assessed the world's fishing resource situation, we now need to define sustainability and then review the development of recent management reference points consistent with sustainability. In accordance with the definition by Costanza & Patten (1995) sustainability is generally interpreted as the capacity of ecological, economic or social systems to endure under stress, e.g. exploitation. However, it appears clearer when sustainability is compared with resilience (Ludwig *et al.*, 1997). Sustainability encompasses resilience but also requires a predefined goal in addition. Sustainable goals or reference points are commonly set at high or optimized levels. However, in order for sustainability to be a useful criterion for guiding changes, its characterization should be literal, system-oriented, quantitative, predictive, stochastic and diagnostic (Hansen, 1996).

The international requirement for marine protection is stipulated in the Treaty on the Convention on the Law of the Sea (UN, 1982), where all States enjoy the traditional freedoms of navigation, overflight, scientific research and fishing on the high seas and they are obliged to adopt, or cooperate with other States in adopting, measures to manage and conserve living resources. Coastal States are granted sovereign rights in a 200-nautical mile exclusive economic zone (EEZ) with respect to natural resources and certain economic activities, and exercise jurisdiction over marine science research and environmental protection.

During the Earth Summit held in Rio de Janerio, Brazil, 3 to 14 June 1992, the Agenda 21, the Rio Declaration on Environment and Development, and the Statement of principles for the Sustainable Management of Forests were adopted by more than 178 governments. The "Rio Principles" represent the international guidelines calling specifically for the reduction of unsustainable patterns of production and consumption and capacity building for sustainable development (UN, 1992). In 1995, the United Nations agreed upon the implementation of the provisions of the convention on the Law of the Sea of 10 December 1982 relating to the conservation and management of straddling fish stocks and highly migratory fish stocks. The implementation of limit reference points was requested, which are intended to constrain harvesting within safe biological limits within which the stocks can produce maximum sustainable yield (MSY), while target reference points are intended to meet management objectives (UN, 1995). Assigning the maximum yield a long term perspective immediately turns the underlying intention towards maximum conservation, as only well protected stocks can produce high yields over a long time. However, any stock size status indicator shall gain less weight in comparison with the exploitation indicator in the decision making progress as the actual stock size underlies and is considered the outcome of many ecological effects in addition to the human impacts through fishing. In the same year the idea of such reference levels for the fisheries management was more widely

applied in the Code of Conduct for Responsible Fisheries by the FAO (1995). The sustainability goal for fisheries management was re-confirmed during the Sustainability Summit in Johannesburg (UN, 2002), interpreted as the core publication. The MSY of all exploited stocks has now to be implemented by the specific date of the year 2015, a clear ecological target. Undoubtedly such ratified political design, which is based on the principle of short term losses in the view of long term gains, requires major and continued efforts towards transparent information and protection against the unsustainable solution of short term gains versus long term losses.

The internationally agreed fishing mortality F_{MSY} that produces MSY is defined as

$$F_{MSY} = r/2\,, \tag{1}$$

where r is intrinsic rate of population growth in the logistic population growth model (Prager, 1994),

$$dB_t/dt = rB_t - (r/K)B_t^2, \tag{2}$$

in which the change in stock biomass over time (dB_t/dt) is a quadratic function of biomass (B) and K is defined as the carrying capacity.

After all these considerations we are in the position to defend the conclusion that the world fisheries do unsustainably exploit many of the living marine resources, and have a long history and prominent examples to do so with disastrous socio-economic consequences. In particular, the hardly or non-reversible damages caused by fishery effects in the deep sea or hard substrate habitats (coral reefs) have to be avoided by all means (FAO, 2008). Discarding, throwing back into the sea the whole or selected parts of the unwanted catch, appears an unacceptable performance, recognizing the ethical concerns regarding the waste if biological resources through discards in the magnitude of 7 million tons in the world's fisheries (FAO, 2010 a). In addition, unknown and thus unaccounted discarding implies increased uncertainty in assessments of exploited stocks, scientific advice and fisheries management. However, a discard ban or landing obligation is already implemented in national fisheries regimes but unsurprisingly appears difficult to control after all. While the best practice is to avoid discarding by not catching the potentially unwanted fish, a discard ban might incentivize improved technical selection through appropriate gear specifications or closing of sensitive areas.

Probably the most impressive relation between humans and fish is the story of Atantic cod (*Gadus morhua*) fisheries which spans a thousand years and four continents (Kurlansky, 1997). Before the 1970s, the annual capture production exceeded 3 million tons and rapidly fell below 1 million tons at the beginning of the millennium 30 years later. We could continue with many examples, e.g. collapsed and recovered herring (*Clupea harengus*) fisheries or the recent annual bluefin tuna (*Thunnus thynnus*) battles heavily debated in the international press.

Europe ranges among the poor regions when it comes to the status of its common fishery resources as the great majority of the European fish stocks (88%) remain overexploited with regard to high long term yields (EU, 2009). The deep-rooted problem of overcapacity and imprecise policy objectives and will are identified as the main structural failings, in particular at the operative level of individual fishermen and their fishing strategies. The joint exploitation of fish and shell fish stocks in European marine waters underlie the

Common Fisheries Policy (CFP; EU, 2002), which apparently lacks a specific definition of the sustainability. The European Parliament acts as co-legislator under the Lisbon Treaty (EU, 2007a), with the exception of measures on fixing prices, levies, aid and quantitative limitations and on the fixing and allocation of fishing opportunities, that will remain as in the EC Treaty, where they have to be adopted by the European Council on a proposal from the European Commission. However, the CFP is due to a reform by 2012, after a standard 10 years interval. The management goals of the reformed CFP requires consistency with the European Marine Strategy Framework Directive (MSFD; EU, 2008a) and its focus on good environmental status of all exploited fish and shellfish stocks in all European regions including the EEZs and territorial waters by 2020 (Rätz *et al.*, 2010). The complementary decision by the European Commission (EU, 2010) identified the so-called fishing mortality F to generate MSY as primary indicator of sustainability. F is defined as the famous coefficient of the annual rate of dead or removed fish caused by fishing as a function of the annual rate of dead fish caused by natural reasons (see following section). Such stock specific level of exploitation needs to be identified and set considering all ecological effects, as the sustainable production differs not only among species but also among stocks. Rätz & Lloret (2003) demonstrated that the cod stocks in the warm regions of the Northeast Atlantic are more productive in terms of growth and recruitment and can sustain higher fishing rates as compared with the stocks inhabiting the colder Northwest Atlantic, which appear more vulnerable through lower productivity.

3. Less is more: We know enough to move towards it!

The major challenge of the modern fisheries management is not any longer to define sustainable exploitation levels and to best approach them but to correct the errors made in the past decades, mainly related to the reduction of fishing power accounting for increased efficiency and technological creep, which can reach 2% per year (Rijnsdorp *et al.*, 2006). Whatever kind of regulations are chosen, ranging from the suite of technical measures (e.g. closures, gear configurations) and direct fishing restrictions (total allowable catches TAC or total allowable fishing effort TAE), they shall effectively control the fisheries induced mortality and shall consider of potential future effects based on experience.

By fishing less the expected yields from an overexploited resource will be increasing as can be seen from the classical yield curve of the prominent and continuously overfished North Sea cod stock (including Skagerrak and Eastern Channel, Fig. 1). It must be acknowledged that there exists no experience in stock dynamics during sustainable exploitation at the maximum sustainable term yield or below it, even after 50 years of data. Therefore, the estimation of the maximum sustainable yield of 700,000 tons per year at a stock weight of all spawning fish around 800,000 tons is a result of an extrapolation and thus appears quite hypothetical. These high values can be considered overestimated if under such favorable conditions the ecological processes gain a more dominant role, i.e. intra-specific (cannibalism) and inter-specific consumption (predation by other species).

In the cases of heavy overfishing and depleted stocks it may be advisable to search agreement among interested parties by designing multi-annual plans considering an adaptive stepwise mitigation process rather than the short term solution with drastic consequences for all involved parties. However, the mitigation process should be significant enough to ensure a transparent monitoring in order to justify the measures taken. This can

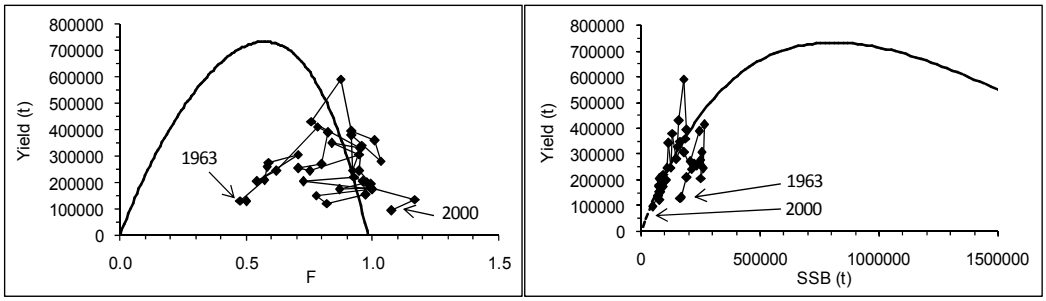


Fig. 1. North Sea cod stock. Potential annual yield as a function of fishing induced mortality F and the weight of all spawning fish (spawning stock size SSB) as estimated by means of a non-equilibrium model using data 1963-2000 from ICES North Sea working group (ICES, 2010).

be achieved even if the scientific advice regarding the final goal is imprecise but clearly quantifies the problem and the direction to solve it (Patterson *et al.*, 2001).

Single stock fisheries, the easy case: Sustainable fisheries management requires the pre-agreed biological limit exploitation level based on the above outlined policies. Given that the stock of a target species can be fished without significant by-catch of other species and impact on its habitat, a simple TAC including potential discards of the target species can be used to effectively control the single species fishery induced mortality and keep it below the a-priori set limit accounting for stock specific conservation requirements. This recommendation applies to both passive gears, i.e. longlines, nets and traps, as well as actively moved gears such as seines and trawls. However, fully implemented and effective scientific monitoring and advisory as well as fishery control and enforcement systems must be in place. If the exploited stock is considered a shared resource among nations and their various fisheries, a complex framework of political commissions will be active to decide on access rights, probably to the level of individual fishermen, defined as individually transferable quotas (ITQ) and recently favored to strengthen stakeholder involvement through increased responsibility (Hauge & Wilson, 2009). Often the access rights are based on historic records on contributions of each fishery and nation to the overall exploitation. However, the prominent example of the Mediterranean blue fin tuna fisheries already demonstrates the many potential management failures starting from biased scientific knowledge and advice based on wrong catch records due to ineffective control. The simplicity of single stock/species fisheries management through catch constraints to achieve sustainable levels is enough reason to incentivize fishing industries to conduct so-called "clean" fisheries without by-catches where- and whenever possible. The incentives should force fisherman to stop effectively fishing once their allowance is exhausted. In particular, this recommendation regards fisheries for pelagic stocks/species, such as the tunas, herring, mackerel, anchovy and sardine fisheries. The pronounced schooling and migratory behavior of pelagic species over continued periods prevents relatively small areal closures or direct effort limitations being effective and safe. "Clean" catches can also be achieved by advanced selective trawl devices (Valentinsson & Ulmestrand, 2008).

Mixed fisheries, the difficult cases: We have to realize that sustainable fisheries management can be much more complex and difficult. The great majority of stocks are exploited by

multi-species (mixed) fisheries, particularly the near bottom and bottom dwelling species due to their coexistence in diverse communities (Caddy & Seijo, 2005) and the poor selectivity of many gears used. Fisheries using bottom trawls and seines might severely impact the structure of the sea bottom (Kaiser & Spencer, 1996). Still, the variety of exploited stocks in mixed fisheries requires specific conservation needs based on the specific ecological role and stock status. In addition, the selection of the various mixed fisheries involved in the exploitation of certain stocks varies significantly with the gears and the fishing strategies. It is argued that the mixed fisheries are best managed by fishing effort (Kell *et al*., 2005; Schwach *et al*., 2007), if they deploy trawled (active) gears. This can be done by settings of effort constraints (TAE) in units of days at sea or the product of kilo Watt times days at sea to account for engine power (Cotter, 2010). It's noteworthy that such effort measure can be easily controlled. However, the effectiveness of such effort measures regarding passive gears has still to be proven. Fishing grounds with high stratification, e.g. along continental shelves, may force certain stocks or parts of them to occur highly aggregated and thus make pure effort measures ineffective to control fishing mortality, like in the example of pelagic fisheries (see above). However, catch constraints (TAC) estimated and set consistently with effort constraints (TAE) will help to communicate foreseen fishing possibilities to the involved stakeholders.

Now, since we've learnt that many stocks are exploited simultaneously by various mixed fisheries, we may understand that, under such circumstances, fisheries management can be very complex. While the agreed stock specific conservation requirements can be defined as F_{MSY} (1), the way towards it appears less clear when simultaneously considering all jointly exploited stocks by a variety of fisheries characterized by different selection patterns. A stochastic medium term forecast model for North Sea demersal fisheries (7 stocks, 9 fisheries) based on data from ICES (2010) and STECF (2011) provides some robust conclusions on future catch and biomass trends under various management scenarios. The major underlying dynamic concept is defined as

$$N_{y+1,a+1} = N_{y,a} \exp(-(M_{y,a} + F_{y,a})), \tag{3}$$

where N denotes stock size in numbers in given year y at age a, M equals natural mortality and F fishing mortality (Beverton & Holt, 1957).

The most important stock productivity parameter is the recruitment to the stock expressed as

$$R = \alpha S \exp(-\beta S), \tag{4}$$

where R denotes the recruitment to the stock, S the parental stock size with α and β as stock specific parameters (Ricker, 1975).

Finally, the catch equation links the observed catches taken from a given stock with the stock size and the two components of mortality, i.e. the natural and the fishing mortality as

$$C_{y,a} = F_{y,a} N_{y,a} ((1-\exp(-(F_{y,a} + M_{y,a}))) / (F_{y,a} + M_{y,a})) \tag{5}$$

where C denotes catch in numbers in a given year y at age a (Beverton & Holt, 1957).

Stock specific production parameters required and the limit reference levels of exploitation of seven stocks are listed in Table 1 defining all stock areas as being consistent with the joint

demersal fisheries management area of the Skagerrak, North Sea and Eastern Channel. It has to be noted that the stock dynamics of Norway lobster in the North Sea are largely unknown and they are assumed to be a short lived species with one age group only during its exploitation phase. The matrix of actual contributions in terms of fishing mortalities by stock for each of the nine fisheries is given in Table 2. The fisheries definitions are in accordance with the fleets defined in the cod management plans (EU, 2008b), one of the major concerns in European fisheries management. It can be taken from Table 2 that each of the nine defined fisheries contributes to the exploitation of each of the seven stocks with different intensity. While the trawlers are catching all gadoids, Norway lobster and flatfishes except sole, the beam trawlers are mainly targeting the flatfish plaice and sole. The major interest of the passive gillnets and trammel nets focuses on sole with some cod shares of gillnets as well. Longlines do not play an important role in the evaluated system at all and other fisheries catch a rather small share of cod and whiting.

	COD 3an47d	HAD 3an4	WHG 47d	POK 3a46	PLE 4	SOL 4	NEP 3a4
Ricker coefficient a	3.5	20	17	1.5	9	6	77
Ricker coefficient k (t)	1700000	300000	300000	300000	290000	50000	250000
first age group	1	1	1	3	1	1	1
last age group	7	7	8	8	9	9	1
recruitment relative variation CV	0.8	0.9	0.4	0.5	0.7	0.9	0.1
precautionary biomass Bpa (t)	150000	140000	200000	200000	230000	35000	150000
Fref range (fishing mortality)	age 2-4	age 2-4	age 2-6	age 3-6	age 2-6	age 2-6	age 1
F in 2010 (fishing mortality)	0.86	0.25	0.35	0.30	0.25	0.37	0.17
F limit or FMSY proxy (fishing mortality)	0.40	0.30	n.a.	0.30	0.20	0.22	n.a.
relative max. annual change Fref	0.1	0.1	0.1	0.1	0.1	0.1	0.1
relative max. annual change TAC +-	100	100	100	100	100	100	100

Table 1. Stock specific parameters of seven stocks as used in the stochastic medium term forecast model of catch and biomass under various management scenarios. Cod in ICES divisions 3an, 4 and 7d (*Gadus morhua*, COD 3an47d), haddock in ICES divisions 3an and 4 (*Melanogrammus aeglefinus*, HAD 3an4), whiting in ICES divisions 4 and 7d (*Merlangius merlangus* WHG 47d), saithe in ICES divisions 3a, 4 and 6 (*Pollachius virens*, POL 3a46), plaice in ICES division 4 (*Pleronectes platessa*, PLE 4), common sole in ICES division 4 (*Solea solea*, SOL 4) and Norway lobster in ICES divisions 3a and 4 (*Nephrops norvegicus*, NEP 3a4). Note that n.a. assigns not available.

As we start from an overexploited situation for some stocks, the overarching rule applied is an annual reduction in fishing mortality by 10% for each stock whenever the exploitation exceeds the pre-agreed reference point. This appears close to the existing multi-annual plans for the North Sea stocks (EU, 2007b; EU, 2008b). A limitation regarding the annual variation of TACs as often requested by the fishing industry and implemented in the stock specific multiannual plans is not considered in the following simulations as such rules imply conflicts among the plans in the likely case that the stock dynamics differ. Let's start with the current situation in European mixed fisheries management, i.e. only the exploitation status of one individual stock is decisive for the regulation of the fishing mortalities induced by multi-species fisheries. There is a good chance that any time one of the exploited stocks is in a good environmental status, and this becomes the decisive stock for the management and the fisheries continue until their last quota shares are exhausted. All other by-caught

stocks, for which the limit exploitations and the respective TACs are exceeded through ongoing fisheries, have then to be discarded. Often such catches are black landed due to their economic value and ineffective control. In cases that discarding of marketable fish is not prohibited, high-grading of the landed catch proportions is a common response by the fishing industry. This strategy intends to maximize the economic value of the catches by means of discarding of low-priced catch components while keeping the landing and revenue option valid throughout the management periods.

Gear	Mesh size (mm)	Fishery code	COD 3an47d	HAD 3an4	WHG 47d	POK 3a46	PLE 4	SOL 4	NEP 3a4
Trawls other than beam trawls	≥100	TR1	0.496	0.15	0.173	0.253	0.031	0.002	0.002
Trawls other than beam trawls	≥70 <100	TR2	0.192	0.076	0.057	0.033	0.021	0.006	0.151
Trawls other than beam trawls	≥16 <32	TR3	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Beam trawl	≥120	BT1	0.005	0.002	0.002	0.002	0.006	0.001	0.002
Beam trawl	≥80 <120	BT2	0.012	0.002	0.002	0.002	0.177	0.299	0.002
Gillnets	all	GN1	0.048	0.002	0.002	0.002	0.003	0.018	0.002
Trammel nets	all	GT1	0.01	0.002	0.002	0.002	0.004	0.033	0.002
Bottom longline	n.a.	LL1	0.003	0.002	0.002	0.002	0.002	0.002	0.002
OTHER	n.a.	OTHER	0.095	0.009	0.103	0.002	0.002	0.002	0.002

Table 2. Nine European fisheries active in the Skagerrak, North Sea and Eastern Channel and their contributions to the overall stock specific exploitation rates expressed as partial fishing mortalities. Data are adopted from ICES (2010) and STECF (2011).

The consequences of the management of mixed fisheries based on only one decisive stock are illustrated in Figure 2. While the exploitation of the most productive stock in the system, in this case the North Sea cod, is reduced stepwise towards the limit management reference with the logic and positive recovery of its stock size, the exploitation rates of the other stocks increase rapidly as their stock sizes diminish to very unproductive levels, in particular plaice and saithe. Only the stock size of Norway lobster remains without feedback to increased exploitation as the stock dynamics are specified as unknown in the model. As mentioned above, the simulated management scenario will allow major discarding of haddock, plaice and saithe while the discarding of cod is declining. All fleets except the trawlers with a mesh size of 70-99 mm will increase their efforts based on opportunistic catch possibilities. In summary, the effort management of mixed fisheries based on a single stock's reference point puts the goal of a sustainable exploitation at an unacceptable level of risk. The high amount of catches exceeding the TACs (overquota catches) contributes significantly to the management risk.

There will be immediate agreement among the conservative interests in the prescribed goal of the MSFD that not one but all exploited stocks shall be in a good environmental state, at least as far as the fisheries impact is concerned. Such conditioned simulations are illustrated in Figure 3, with the same annual reduction in fishing mortality by 10% if the exploitation exceeds the any of the limit reference points set. Under such circumstances all the stocks are quickly recovering to highly productive states and their exploitation rates are consistently reduced. Maintaining at and below or reaching such goals simultaneously for all exploited stocks implies renouncement of catches in short term from more productive stocks which are by-caught in the various fisheries. However, the previous overall catch reduction will be compensated after about 6 years with some changes in the contributions by the various stocks, there will be more cod and saithe while sole landings will remain unchanged.

Haddock and plaice landings will be significantly reduced. The projection of increased Norway lobster landings must be interpreted with care due to the largely unknown stock dynamics. Discarding will be largely reduced after a short period of few years, as all catches can be landed without further restrictions and minimum landing sizes will have a reduced effect on the amount discarded as higher individual survival will result in higher abundance of large fish. As such this management scenario supports the idea of a discard ban. The results of the management scenario suggest that all fisheries will reduce their effort proportionally by more than 60%. Although this reduction across the board offers a huge potential to economically safe investments and thus increase the economic viability of the fisheries, it equally requires the need to adequately cover the social consequences of such a drastic effort reduction. However, the winning argument for a similar management of mixed fisheries is the gain in stock size with the related high security against fisheries collapses.

Mixed fisheries management based on specific limit reference points of all stocks may require the option of disproportional weighing of specific fisheries, e.g. by favoring fisheries avoiding overfished stocks or selecting less stocks from the ecosystem (Rätz *et al.*, 2007). In this way fisheries management can adaptively benefit from stock specific fishing possibilities. Focusing exclusively on the exerted fleet specific impact expressed as the ratio between fishing mortality in relation to the sustainable management limit on a stock by stock basis one could assign the fisheries a specific relative factor according to the formula

$$fac_{fishery} = (P / \Sigma (F_{fishery} / F_{MSY})) / (\Sigma (P / \Sigma (F_{fishery} / F_{MSY})) / L), \quad (6)$$

where $fac_{fishery}$ denotes a fisheries specific weighing factor, P the number of stocks caught by a given fishery and L the number of fisheries. $F_{fishery}$ quantifies the fishing mortality exerted by specific fishery, known as the partial fishing mortality. Such factor $fac_{fishery}$ would be relatively low if a given fishery contributes more to overfishing than other fisheries. Contrarily, fisheries contributing less to the risk of overfishing would be assigned a relatively high factor which could be then applied to allow for an increased impact of such fisheries, i.e. their partial fishing mortality determining the specific fishing possibilities of future years.

The fisheries specific management scenario applying the above outlined algorithm of a specific factor to consistently estimate landings, discards, fishing mortality and specific relative fishing effort is illustrated in Figure 4. In comparison with the proportional fisheries management scenario illustrated in the preceding Figure 3, the arbitrary choice to privilege certain fisheries at the expenses of more problematic ones results in almost unchanged stock dynamics but increased landings, which are still taken consistently with the sustainable management goals. The possibility of continued and incentivized fishing strategies if considered less problematic is demonstrated by their relative effort trends in Figure 4, i.e. constant or increasing trends. Such potential solutions for conflicting interests among various fisheries and the predefined regulatory frameworks shall be discussed and agreed among stakeholders and managers in advance and be implemented in multi-annual plans of the fisheries.

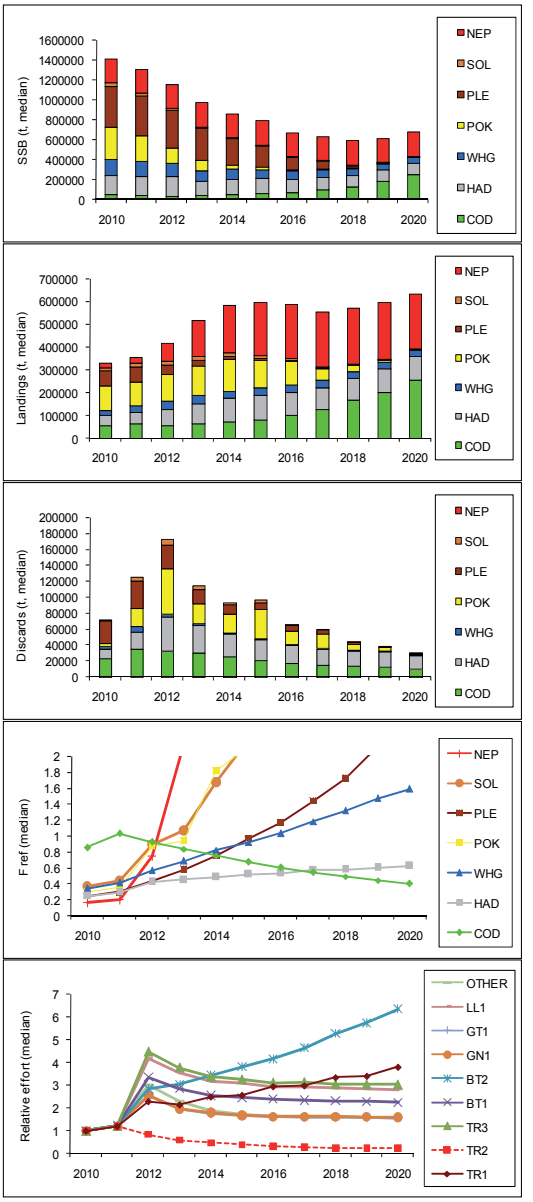
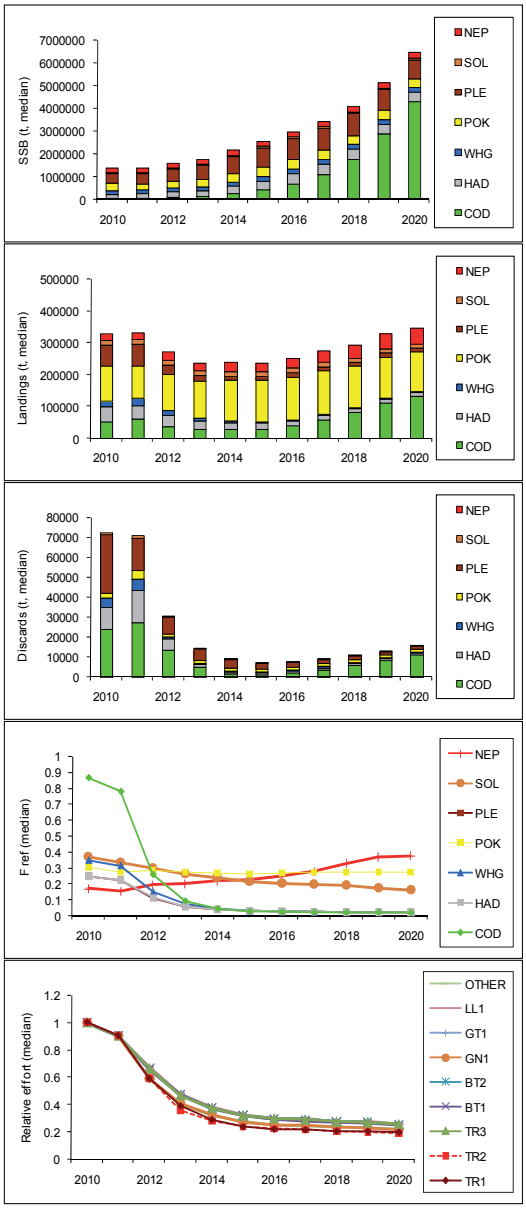


Fig. 2. Decadal trends of median stock (SSB=spawning stock biomass, Fref=fishing mortality) and fisheries parameters (landings, discards and relative fishing effort) based on 100 iterations obtained from a stochastic forecast model to simulate mixed fisheries effects for 7 stocks and 9 fisheries in the Skagerrak, North Sea and Eastern Channel. Stocks and fisheries are defined in Tables 1 and 2, respectively. A harvest control rule to reduce exploitation below or to maintain exploitation at the agreed limit reference point (Table 1) by means of an annual variation in fishing mortality constrained to a maximum of 10% is applied. Only one (the highest) stock specific and sustainable limit reference point is decisive for the control of fishing mortality.



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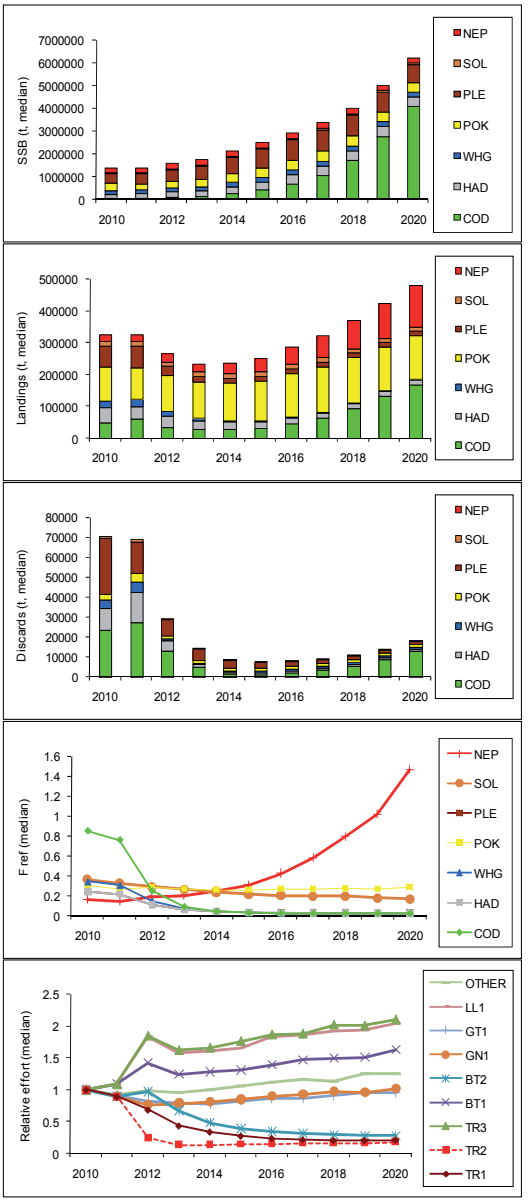

Fig. 4. Decadal trends of median stock (SSB=spawning stock biomass, Fref=fishing mortality) and fisheries parameters (landings, discards and relative fishing effort) based on 100 iterations obtained from a stochastic forecast model to simulate mixed fisheries effects for 7 stocks and 9 fisheries in the Skagerrak, North Sea and Eastern Channel. Stocks and fisheries are defined in Tables 1 and 2, respectively. A harvest control rule to reduce exploitation below or to maintain exploitation at the agreed limit reference point (Table 1) by means of an annual variation in fishing mortality constrained to a maximum of 10% is applied. All defined stock specific and sustainable limit reference points are simultaneously decisive for the control of fishing mortality with a non-proportional fisheries specific management scheme.

4. Money doesn't make the fisheries go-round: Sustainable nutrition and ethical responsibility to the benefits of all!

We have realized that the oceans are not empty but overfishing occurs frequently at an unacceptable level with significant disadvantages for the entire society including industry and consumers. While the objectives of sustainable fisheries management are internationally agreed (UN indicators for exploitation of marine stocks defined as F_{MSY}), the road to implement them remains long and bumpy, also because coastal nations of a marine region have to be consulted, come to an agreement, implement it to their national legislation, enforce and finally control it. Given the improved information available from scientific assessments of exploited stocks and their fisheries impacts and in line with the responsible fisheries management, there shall be no further reason to postpone necessary actions regarding evaluations, decisions and measures implemented to achieve high long term yields at reduced ecological and economic risk within a reasonable time (OECD, 2011). Unfortunately, slow decision-making and implementation has been identified to delay or even prevent a sustainable approach – once decided lately, many decisions appear outdated and their implementation often turn counterproductive. As a consequence, lost value through forgone future opportunities caused by depleted and non-rebuilt fisheries are seldom accurately accounted for in arguing to delay implementation of sustainable fisheries management (Shelton, 2009). The responsible parties shall immediately develop policies aimed at sustainable stewardship of the biosphere; in easy words: how our oceans shall look like in 50 years and how Neptune's garden shall be used. By doing this, the human role needs to be re-identified and respected; yet we are players in and not controlling managers of the ecosystems. Although the global modeling including climate and other ecological effects are rapidly improving and leading to a better understanding, the sustainable management of ecosystems appears rather ideological and shall be approached by adaptive regional steps while considering the existing gaps in knowledge and political power (Norton, 2005). Gladwin *et al*. (1995) were calling for re-integration of humanity into nature and truth to morality.

The policy makers already raised the need for economic information to assess and consider the socio-economic consequences and the potential conflict with confidentiality of individual data. Socio-economic consequences are commonly presented in so-called "impact assessments" to verify the social welfare. However, it is of vital importance that ecological and economic goals are harmonized as functional ecosystems are seen as the natural capital, i.e. there must first be something you can harvest, and secondly the economy deals with the strategy of the investments and revenues. The evolution of ecological economics as an extended "ecological regime" is both qualitatively and quantitatively dependent on an adequate understanding of the behavior of living systems (Jansson et *al*., 1994). Economists have long argued that a fishery that maximizes its economic potential usually will also satisfy its conservation objectives. To add, it is well acknowledged that subsidies to fisheries that contribute to overcapacity and overfishing will turn the effectively strong relation between ecology and economy to perversity (Meyers & Kent, 2001). Recently, maximum economic yield (MEY) has been identified as a primary management objective for Australian fisheries and is under consideration elsewhere. However, the avoidance of significant trade-offs is complex and to develop an implementable management strategy in an adaptive management framework, a set of assumptions must be agreed among scientists, economists, and industry and managers, indicating strong industry commitment and involvement

(Dichmont *et al*., 2010). The optimum structure of regional decisive power and whether the fishing industry is willing and able to assume greater responsibility for its actions remain key questions (Lassen *et al*., 2008). We conclude that fisheries management has to be fisheries specific to be acceptable and effective. Furthermore, it is obvious that smaller systems are easier to manage than starting top down on large and complex fisheries at a global or continental scale.

The mutual educational processes between scientists and decision makers, from scientific monitoring, modeling, understanding to the complementary advisory role of global political frameworks, is exemplarily documented for air quality targets by Hordijk & Amann (2007). However, such demanding process will certainly benefit if the various parties involved keep their cooperation strictly constrained towards exchange of relevant information and their mandates, i.e. scientists shall undertake accurate science and advice and policy makers shall undertake and defend the sustainable decisions. Given the global poor status of many exploited stocks and their fisheries, which appear depleted in many cases, the realization of the political goal towards sustainable fisheries would require stringent or even brutal management actions. For obvious reasons, multi-annual management plans accompanied by impact assessments offer preferable solutions to avoid irrational responses (Symes & Hoefnagel, 2010). Needless to emphasize that specific multi-annual management plans and their outcomes depend on a full implementation into the fisheries management schemes including monitoring, enforcement and control without any tolerance against violations. The vision is that once fishing capacity and deployed fishing effort are adapted to the production of the exploited marine stocks, the required investments into control and enforcement could be minimized.

Fisheries science is to support the achievement of the sustainable use of the oceans by sound scientific advice based on accurate data from monitoring, and in close relation with economy and social sciences (Symes & Hoefnagel, 2010). Nature is everything else but stable, instead high and increasing variability appears the normal under the climate changes we are recently facing (Walther *et al*., 2002). Fish production is considered highly variable even without fishing. However, status classification of exploited marine stocks and ecosystems requires more consistent frameworks worldwide to further develop and review integrated scientific advice to sustainable fisheries management considering also economic impacts in the format of an integrated advice. Many of the regional fishery organizations need to consider such needs and their advisory bodies need to be reformed regarding their structure and mandate towards integrated advice.

In particular, sustainable fisheries shall support the food production from sustainable aqua- and agriculture. The aquaculture, as closest sector to fisheries, is boosting as it maintained an average annual growth rate of 8.3 percent worldwide between 1970 and 2008 (FAO, 2010 a), peaking at 52.5 million tons reported for 2008. In common with all other food production practices, aquaculture is facing challenges for sustainable development, including genetic conservation and environmental risk of genetically altered aquatic organisms (NACA/FAO, 2001). The continued efforts in optimizing production practices, including food supply and pollution, have to be assessed, regulated and controlled to avoid environmental problems. Like capture fisheries, aquaculture will contribute to food security only after full compliance with long term sustainability criteria.

But do we need all this fish and shellfish that can potentially be produced once we are fishing and rearing sustainably? Annual per capita fish consumption grew from an average of 9.9 kg in the 1960s to 11.5 kg in the 1970s, 12.6 kg in the 1980s, 14.4 kg in the 1990s and reached 17.0 kg in 2007. In 2007, fish accounted for 15.7 percent of the global population's intake of animal protein (FAO, 2010 a). There is of course significant regional variation in the dietary. Given the recent status of marine fisheries and resources, their relevance in protein supply has to be significantly improved, which is considered necessary to effectively increase food security and thus combat world's hunger. The world population is expected to grow from the present 6.8 billion people to about 9 billion by 2050. The growing need for nutritious and healthy food will increase the demand for fisheries products from marine sources, whose productivity is already highly stressed by excessive fishing pressure, growing organic pollution, toxic contamination, coastal degradation and climate change (Garcia & Rosenberg, 2010). The number and the proportion of undernourished people have declined, but they remain unacceptably high. Although the number and proportion of hungry people have declined in 2010 as the global economy recovers and food prices remain below their peak levels, hunger remains higher than before (FAO, 2010 b). Fisheries and their management shall adopt the challenge of sustainable food production and adjust their goals and actions at global as well as regional scales in accordance with the view to safeguard biodiversity, bio-production and thus increase livelihood of humanity.

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6

Modelling for Sustainable Development: Inundation Risk Management and Decision Making in Water Sector

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1. Introduction

Actually, for all the world, at different levels and scales (international, national, regional, local, zone) there is an urgent request suggested by scientific experts, environmentalists, academicians, decision makers, policy makers, economists, sociologists consisting to propose models and tools based on mathematical formulations using new technology in the purpose to study the physics phenomenon behind floods in order to give solutions minimising their effects and to make the right decision concerning the water sector (resources, adduction network and distribution network) for all human usages: domestic, services, agricultural, industrial.

In fact, climatic change, short violent precipitation, inundation risk management, protecting infrastructures and agriculture fields from water streaming, diminution of water resources, rehabilitation of the water networks either for the resources, adduction or distribution, long drought, soil erosion and degradation, diminution of plant productivity, high price of agronomic product, research of new water resources, economical management of the existing ones, new and adaptable techniques for hydro-agricultural management, soil type and soil occupation cartography, biodiversity conservation are subjects that we hear every time in our days and that exhaust all the rings of the economic chain from the farmer, through the consumer and citizens, to the decision maker at the planet level.

How the scientific research can contribute to give responses to those occupations and avoid the dangers that menace the humanity? Which outlooks it can propose and models it can develop to encourage the farmer and the consumer, to secure citizens and to orient decision makers about flood management and water sector protecting and renewing?.

In this chapter I will raise the basic equations to use in order to formulate the physics phenomenon linked to flood management and water sector protecting. Many reflections points will be revolted in the purpose to develop models in the service of the environment enhancement and to participate in the resolution of the problems suggested above. Results

from experimental study done at laboratory level to estimate the effect of streaming through planes liable to flooding will be mentioned. A first application of a model established using the geographic information system to analyse the water sector for all usages to a region in the North-east of Tunisia (Siliana) would be detailed.

2. Calculus for floods monitoring and their risk management

Monitoring floods and managing their risks necessitate first methods and tools to foresee the instant of averse happening, their intensities and the geographical positions of their descents (Martin 2010,Nor Azliza 2006, Plate 2002). Which means to formulate the transport phenomenon at the atmosphere level. Second we have to follow the streaming on the ground by detecting their geographical directions, estimating the debit of the flows and quantifying their energies. Which signify to calculate the water height, water velocity in all directions and the pressure exerted by the streams. We can then make maps for vulnerable zones the most menaced by inundation and classify the other by priority linked to a degree of averse danger (Martin 2010, Li B et al 2006, Evan et al 2006). Also, on the ground we can evaluate the resistance level against streaming for human infrastructure either in urban or rural regions, for soils and for vegetation canopies. Which make us capable to propose the adequate technical solutions for protecting human properties, to envisage the ideal places for implanting new projects (buildings, infrastructures, agriculture fields…) and finally to reserve the suitable budget for planes liable to flooding (United States Department of Agriculture. Natural Resources Conservation Service (USDANRCS) 2010, 2011, Nor Azliza 2006).

2.1 Formulating atmospheric water circulation to localise the precipitation

In plus of the water evaporated from soils, lakes, oceans, the amount of water transpired by plant canopies constitutes a mass of humid air that will absorbs and emits energy, losses or gains material, moves up, and participates with the action of earth rotation (coriolis force) and atmospheric vapour pressure difference in the formation of wind, cloud displacement and giving out precipitation. The mass of air has tendency to displace vertically from position of high pressure to another characterised by a weak pressure value. The effect of earth rotation will generate the displacement of that mass in different directions. The direction of motion of the air mass represents the wind direction and the speed of its displacement is exactly the wind velocity (Sellami 2011). Localising the geographic position of averse and pelting rains and determining their intensities consist in fact to map the atmospheric water pressure and to estimate the wind velocity for all directions. The most used equations formulating the problem suggested above are the atmospheric primitive equations. They are well used in meteorology and oceanography for numerical models of time forecasting and when simulating the future behaviour of the atmosphere (Edward 2010, Firth Robert 2006, Beniston 1998, Pielke Roger A 1984,).

A general analytical solution of the primitive equations that consider the latitude and the altitude and formulating wind velocities in all directions and the potential pressure is (Sellami 2011, Edwards 2010, Comolet R. 1963):

$$\left[u, v, \Phi\right] = \left[\hat{u}, \hat{v}, \hat{\Phi}\right] e^{i(s\lambda + \sigma t)} \tag{1}$$

u, v : Coordinates of the wind speed, respectively zonal and meridional
Φ : geo-potential for the pressure difference

Knowing the fact that the air pressure at a point in the atmosphere is defined as the weight of air column above that point per surface unity we can deduce clearly the close link between the repartition of air pressure in the atmosphere, wind velocities and precipitation. We can then present a more explicit formula as relationship between air atmospheric pressure and wind velocity (Edward 2010, Comolet R. 1963):

$$V = \|\vec{V}\| = \frac{1}{\rho f}\sqrt{\left(\frac{\partial P}{\partial x}\right)^2 + \left(\frac{\partial P}{\partial y}\right)^2} \tag{2}$$

f : Coriolis parameter proportional to the earth rotation
P: Water vapour pressure at a designed point in the atmosphere
x, y: Coordinate of a point in atmosphere
$\vec{V}$: Velocity vector
ρ : Volumic mass

The vertical direction is not considered because in the hypothesis adopted we have neglected the vertical variation on behalf of the horizontal ones.

So we can say that estimating the wind speed in all positions of the atmosphere, monitoring its variation over time permit to localise the zone of low pressure, indicator of minimum local pressure and precipitation, the zone of high pressure, indicator of maximum local pressure, fine weather and absence of precipitation.

2.2 Formulating the streaming after precipitation

In the case of inundation, the flowing of the free water on the planes liable to flooding, either for urban or rural zones, obeys the fact that the scales for the vertical variation of motion are neglected in front of those horizontals and that the representation of all phenomenon by surface coordinates (not on the space) is well sufficient. With those considerations, the Navier Stockes equations (combination between the equation of mass conservation, equation of energy conservation and equations of motion conservation) are transformed to the Saint Venant equations also said « shallow water equations » which are the most used for modelling the fluvial flowing (Pascal 2009, Brett et al 2008, Lorenzo et al. 2008, Aldrighetti 2007, Berreksi et al 2006, Li B et al 2006. Hostache 2006, Ranjit and Steven 1995, Comolet R. 1963). They are represented by the following system:

$$\frac{\partial h}{\partial t} + \frac{\partial (uh)}{\partial x} + \frac{\partial (vh)}{\partial y} = 0 \tag{3}$$

$$\frac{\partial}{\partial t}(uh) + \frac{\partial}{\partial x}(u^2 h + g\frac{h^2}{2}) + \frac{\partial}{\partial y}(uvh) = gh(S_{0x} - S_{fx}) \tag{4}$$

$$\frac{\partial}{\partial t}(vh) + \frac{\partial}{\partial x}(uvh) + \frac{\partial}{\partial y}(v^2 h + g\frac{h^2}{2}) = gh(S_{0y} - S_{fy}) \tag{5}$$

S_{0x} : Slope of the planes liable to flooding bottom's according to x direction

S_{0y} : Slope of the planes liable to flooding bottom's according to x direction

S_{fx} : Friction slope according to x direction

S_{fy} : Friction slope according to y direction

h : Water height on the plane
u: Water longitudinal speed for x direction
v: Water transversal speed for y direction
g : Gravity acceleration

The friction slopes can be expressed as follow (Pascal 2009, Berreksi et al 2006):

$$S_{fx} = \frac{n^2 u\sqrt{u^2+v^2}}{h}\left[\frac{B(x)+h}{bh}\right]^{\frac{1}{3}} \tag{6}$$

$$S_{fy} = \frac{n^2 v\sqrt{u^2+v^2}}{h}\left[\frac{B(x)+h}{bh}\right]^{\frac{1}{3}} \tag{7}$$

n: Maning Coefficient
B: Width of the streaming water layer
x: Coordinate x representing the direction of the water flow

The Width of the streaming water layer is expressed by:

$$\frac{B(x)}{b_1} = \frac{1}{2}\left[1+\left(\frac{x}{b_1 F_1}\right)^{3/2}\right] \tag{8}$$

B(x) : Width of the streaming water layer at the longitudinal coordinate x from a zero point
b_1 : Width at the upstream
F_1 : Incident Froude Number

The resolution of those equations either numerically or analytically permits to determine the streaming water height and the streaming water speed at every point on the plane liable to inundation by considering the ground topography (Syme 2008, Smith et al. 2006, Huthoff and Augustijn 2006). Then we can calculate the energy accompanying the flow for every position by (Moghadam 2010, Davide et al. 2009, Lorenzo et al. 2008, Yen Ben Chie 2002, Arcement and Schneider 1981):

$$E_{flow} = \rho g z + P_r + \frac{1}{2}\rho U^2 \tag{9}$$

E_{flow}: Energy accompanying the flow of water
P_r: Pressure
U: Water speed
Z: Height
ρ : Water density

The power that accompanies the water running is known by stream power and represents a measure of energy transfer. It can be computed by (Davide et al. 2009, Arcement and Schneider 1981):

$$W_{str-p} = \omega R_h S_{ws} U \tag{10}$$

W_{str-p}: water stream power
ω : Water specific weight
R_h: Hydraulic radius
S_{ws}: Water surface slope
U: Water velocity

So we can evaluate if human properties (houses, buildings, ponds, vegetation canopies…) can resist to that energy also we can propose the appropriate techniques and fences capable to absorb that energy and protect our constructions (Bewsher Consulting 2009, Syme 2008, Hilary and James 2007, Zhang et al 2005). Finally we can say that the equations proposed and that we will detailed later could be bases to establish tools for economic flood damage assessment and after reserving the adequate budget (United States Department of Agriculture. Natural Resources Conservation Service (USDANRCS) 2010, Bewsher Consulting 2009, Nor Azliza 2006, Zhang et al 2005). We will in the following paragraphs formulate the resistance of obstacles to water flowing in order to test if they can dissipate the flow power and after to foresee the risk of damage.

2.3 Formulating the resistance of obstacle to water streaming

In the case of inundation, the flow of water streaming through plains either in rural or urban zones will suffer resistance from all existing obstacles on its scheme. Those obstacles can be plant canopies (grass, single separated trees, agriculture fields, forests, wetlands) or buildings, houses, and infrastructures (hydraulic constructers, barrages, bridges, roads…)(Bewsher Consulting 2009, Lorenzo et al. 2008, Syme 2008). Modelling the force of resistance of every obstacle to the effect of water streaming after averse permits to evaluate the risk of damage in every region or zone, to diagnose the resistance situation of all installed projects, to propose technical solutions ameliorating the toughness for the different components of new projects (emplacement, specie of vegetation for agriculture projects, material of construction and architecture for infrastructure, buildings and houses) so we minimise the risk of losses after floods, to size up tools and techniques absorbing the power of water flow and protecting human properties (USDANRCS 2011, Roca and Davison 2010, Bewsher Consulting 2009, Hilary and James 2007, Moghadam 2007, Nor Azliza 2006, Zhang et al 2005, Plate 2002, Martin 2001). To do so we will try in this part to give a general formulation of obstacle resistance.

2.3.1 Resistance Force of vegetation to water streams

Modelling for hydrological or agriculture studies, at regional scale or at vegetation field scale, necessitates to express the phenomenon of water flowing and streaming by considering the effects of roughness, shear, friction and drag for both soil type and vegetation specie (Sadeghi et al 2010, Mauro 2009, Baptist et al 2007, Austin 2007, Huthoff and Augustijn 2006, Arcement and Schneider 1981). Those effects intervene, generally, in the

expression of the bulk energy losses coefficients and every kind of vegetation canopy could be considered as a type of superficial roughness. Depending on its height, density, flexibility, distribution and species, it can significantly decrease the capacity of river or waterway, extending flow resistance; alter backwater profiles and exchange sediment transport and deposition. (Roca and Davison 2010, Yen Chang Chen et al 2009, Yen Ben Chie 2002). To investigate the resistance effect of vegetation we must differentiate between the flexible vegetation like grass plants and less flexible vegetation (bushes, trees), and we have to consider the cases when the plants are partially or totally submerged (Mauro 2009, Moghadam 2007, Maarten et al 2005, Yen 2002, Juha 2004). We will try in the following reasoning to give a general formulation for the problem.

In order to propose an expression for the drag force taking in account the physical effect of vegetation, we apply force balance between gravitational force, drag force and friction force for a uniform flow in the direction of vegetation.

The drag force for submerged vegetation can be expressed by (Mauro N. 2009, Fredrik et al 2007, Juha 2004, Ranjit and Steven 1995, Arcement and Schneider 1981):

$$F_{drag}^{sub,v_i} = \rho \frac{U_{sub,v_i}^2}{2} \chi_{dc}^{sub} C_{veg}^{sub} \tag{11}$$

$F_{drag,i}^{sub}$: Drag force for the submerged vegetation inside a limited volume v_i
ρ : Water specific density
χ_{dc}^{sub} : Drag coefficient for submerged vegetation
$U_{sub,vi}$: Velocity averaged over time for the submerged vegetation inside the limited volume v_i
C_{veg}^{sub} : Vegetation area coefficient for submerged vegetation

For partially submerged vegetation we give the following expression:

$$F_{drag}^{p-sub,v_i} = \rho \frac{U_{p-sub,v_i}^2}{2} \chi_{dc}^{p-sub} C_{veg}^{p-sub} \tag{12}$$

F_{drag}^{p-sub,v_i} : Drag force for the partially submerged vegetation inside a limited volume v_i
$U_{p-sub,vi}$: Velocity averaged over time for the partially submerged vegetation inside the limited volume v_i
C_{veg}^{p-sub} : Vegetation area coefficient for partially submerged vegetation
χ_{dc}^{p-sub} : Drag coefficient for partially submerged vegetation

The mean velocity of flow through emergent vegetation can be expressed by (Fredrik et al 2007, Baptist et al 2007, Ranjit and Steven 1995)

$$U_{p-sub} = \sqrt{\frac{\dfrac{2gS_0}{\chi_{dc}^{p-sub} m_{sd} D}}{1 + \dfrac{2}{h \chi_{dc}^{p-sub} m_{sd} D} f}} \tag{13}$$

The mean velocity of water flow through submergent vegetation is:

$$U_{sub} = \sqrt{\frac{\frac{2gS_0}{\chi_{dc}^{sub} m_{sd} D}}{1 + \frac{2}{k\chi_{dc}^{sub} m_{sd} D} f}} \tag{14}$$

h: Height of water
k: Height of the resistance layer function of vegetation height
m_{bsd}: Bed surface density
S_0: Bed slope
D: Diameter of plant stem
f: Friction coefficient

The drag coefficients for the submerged and partially submerged vegetation are generally calculated by (Davide et al. 2009, Baptist et al 2007, Maarten et al 2005, Ranjit and Steven 1995):

$$\chi_{dc}^{sub} = C_{veg}^{sub} \left(\frac{h}{h_{veg}}\right) \frac{2gS_{wa}}{U_{sub}^2} \tag{15}$$

$$\chi_{dc}^{p-sub} = C_{veg}^{p-sub} \frac{2gS_0}{U_{p-sub}^2} \tag{16}$$

h: Water height
h_{veg}: Vegetation height
B: Water stream width
S_0: Longitudinal slope of the bed
S_{wa}: Wetted area

A general formulation of the vegetation area coefficient can be given by:

$$C_{veg} = \frac{2\beta}{d_s} \tag{17}$$

β : Aerial coefficient of plant depending on vegetation type and configuration
d_s: Distance between stems

The roughness coefficients for both submerged and partially submerged vegetation are (Davide et al. 2009, Baptist et al 2007, Maarten et al 2005, Ranjit and Steven 1995):

$$C_{rough}^{sub} = \left(\frac{h^{\frac{1}{6}} h_{veg}^{\frac{1}{2}}}{\sqrt{2g}}\right) \sqrt{\chi_{dc}^{sub}} \tag{18}$$

$$C_{rough}^{p-sub} = \left(\frac{h^{\frac{2}{3}}}{\sqrt{2g}}\right) \sqrt{\chi_{dc}^{p-sub}} \tag{19}$$

C_{rough}^{sub} : Roughness coefficient for the submerged vegetation

C_{rough}^{p-sub} : Roughness coefficient for the partially submerged vegetation

A general formulation of the friction coefficient for a densely vegetated flood plain can be expressed by (Arcement and Schneider 1981):

$$f = n_0 \sqrt{1 + (\frac{\chi_{edc} A_{fav}^{tot}}{2gA_{sa}^{cr-fl} L_{ch}})(\frac{1}{n_0})^2 R_h^{\frac{4}{3}}} \quad (20)$$

χ_{edc} : Effectif drag coefficient

A_{fav}^{tot} : Total frontal area of vegetation blocking the flow in square meter

A_{sa}^{cr-fl} : Cross sectional area of flow

n_0: Maning's boundary roughness coefficient

L_{ch}: Length of the channel in meter

R_h: Hydraulic radius in meter

2.3.2 Modelling overland flooding of urban areas: Resistance Force of urban obstacle to water streams

For the urban zone, where the obstacles resisting to flow are not flexible, the water flowing between houses and buildings, through roads and fences suffered a lost of load as results of the roughness effect exerted by every obstacle (Syme 2008). This roughness effect is generally expressed by a friction coefficient depending on the size of the obstacle (height, width, length, weight…) and the area it occupies (Peng and Athol 2004, Martin 2001). The physics signification of the friction coefficient is that it translates the roughness degree and the resistance power to water flow of obstacles and their retardance effects (Brett et al 2008, Hilary and James 2007, Yu D. and Lane 2006). To make empirical formulas for the friction factor based on global experimental studies that could be extrapolated at large scale for flood management, many researchers, on behalf of a dimensional analysis, suggested that the friction factor could be formulated as function of the following parameters (Yen Chang Chen et al 2009, Nian-sheng. 2008, Juha 2004, Kidson et et al. 2002, Yen Ben Chie 2002:

$$f = F(N_{fr}, P_{og}, P_{ofl}, P_{orsub}, P_{od}) \quad (21)$$

N_{fr}: Froude number ($= \frac{U}{\sqrt{gD_h}}$)

U: Water velocity

g: Gravity acceleration

D_h: Hydraulic diameter for the open channel

P_{og}: Parameter characterising the obstacle geometry

P_{ofl}: Parameter characterising the obstacle flexibility

P_{orsub}: Parameter characterising the obstacle relative submergence

P_{od}: Parameter characterising the obstacle density

A general expression for friction factor that can be used for all flowing regimes is (Nian-Sheng.C. 2008):

$$\frac{1}{f}=\left(\frac{Uh}{24\nu}\right)^{\alpha}\left(1.8\log\frac{Uh}{2.1\nu}\right)^{2(1-\alpha)\beta}\left(2\log\frac{11.8h}{k_s}\right)^{2(1-\alpha)(1-\beta)} \tag{22}$$

k_s: Roughness size depending on the type of obstacle
h: Water height in a determined position
U: Water speed
ν : Cinematic viscosity
α, β : Coefficients characterising the type of micro- flowing

They are expressed empirically as follow:

$$\alpha=\frac{1}{1+\left(\frac{Uh}{\nu 850}\right)^{9}} \text{ and } \beta=\frac{1}{1+\left[\frac{Uh}{\nu}\times\frac{160h}{k_s}\right]^{2}} \tag{23}$$

A general expression of the drag force corresponding to urban obstacles (house, building, fences, cars, …) can be given by (Brett et al 2008, Juha J.A. 2004):

$$F_d^i=\frac{1}{2}\rho C_d^i A_r^i U^2 \tag{24}$$

F_d^i : Drag force for the obstacle i
C_d^i : Drag coefficient for the obstacle i
A_r^i : Reference area for the obstacle i
U : Water speed
ρ : Water specific density

A relationship between the drag coefficient and the friction factor can be expressed by (Brett et al 2008, Juha 2004, Yen Ben Chie 2002)

$$f^i=4C_d^i\frac{A_r^i}{A_b^i} \tag{25}$$

f^i : Friction factor for the obstacle i
A_b^i : Bottom area for the obstacle i

Flooding in urban areas presents a range of challenges to the modellers due to the complexity of the flow patterns and paths that occur (Syme 2008, Smith et al. 2006). In fact the major problems signalled are how to give a drag coefficient or friction factor the most appropriate to every kind of building, house, fence... ? How considering the storage effect?, how to represent the blockage of interior and exterior walls?, if to model the buildings as porous?. The additional complexity that occurs due to fence collapses, debris blockages, and the displacement of cars and other obstructions how to calculate their effects? Actually, the global tendency of many researchers is to determine the drag coefficient by kind of obstacle from experimental data at laboratory level and to extrapolate the results for real cases (Sadeghi et al 2010, Mauro 2009, Nian-Sheng. 2008, Fredirik et al 2007, Ranjit and Steven 1995, Julien 2002, Kidson et al. 2002, Martin 2001, Guellouz and Tavoularis 2000, Julien and Wargadalam 1995). It is the objective of the following paragraph.

2.4 Experimental study at laboratory level

We will erect in this part the first results from an experimental protocol we have realised at laboratory level to determine the effect of obstacles on water flowing through an open canal. The system is composed from a storage tank linked to a pump, which aspires and delivers water to a second tank occupied with a filter installed at the upstream of the canal. On the exhaust pipe of the pump there is a control weir permitting to fix the discharge debit. The driven water crosses the canal, reaches the down river, and falls in the storage tank to be forced again toward the up river. Between the down stream and the storage tank we have installed a water balance to measure the repressed debit. The study consists to measure, every 0.5 m inside the canal, the water height and the water speed for different obstacle positioning scenarios 's and many discharge debits. The scenarios are when the canal is without obstacles (S_0), canal with one rectangular obstacle placed one meter from the upstream (S_1), canal with two rectangular obstacles the second is at four meters from the upstream (S_2) and canal with three obstacles the third has a convex form and is placed at the middle of the rectangular ones which means at 2.5 m from the upstream (S_3). The extrapolation of the results to real scale can be easily done when considering the size of the obstacle, the geometry of its form and the values of the debit which are analogous to the streaming flow for the floods (Sadeghi et al 2010, Moghadam et al. 2010, Pascal 2009, Limantara 2009, Yen Chang Chen et al 2009, Davide et al. 2009, Lorenzo et al. 2008, Chao and Peifang 2007, Berreksi et al 2006, Peng and Athol 2004, Kidson et al. 2002, Guellouz and Tavoularis 2000). The results from measurement of the water height for the four scenarios and for one discharge debit (Q_1 = 6.9767 10^{-3} m^3/s) are presented in the following figure.

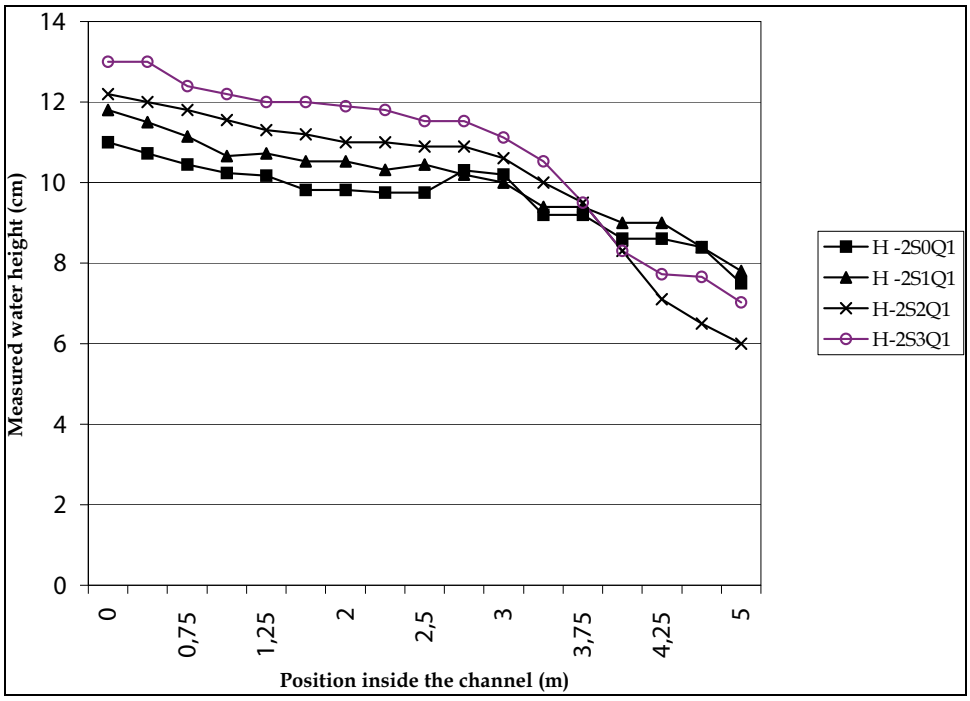

Fig. 1. Variation of water height inside an experimental channel for four scenarios of obstacle positioning

We note clearly that the water height decreases from the upstream to the downstream of the canal for all the scenarios. We notice also that between the upstream of the canal tell the position 4 m inside, the height of water is the most important for the scenario three obstacles, followed by the scenario tow obstacles, one obstacle and finally canal without obstacles. Which revolt the effect of obstacle number on the flowing. At the down stream we remark that water height for the four scenarios are very closes to each other and that the height is the most important for the scenarios canal without obstacle and canal with one obstacle. Compared to results from other experimental studies, our work is promising (Pascal 2009, Berreksi et al 2006). The importance of this experimental study is that the correspondent results could be used to validate an eventual resolution of the shallow water equations either analytically or numerically and also to determine the drag coefficients associated to each obstacles which can be extrapolated for real cases (Andrew et al 2006). It's the purpose of a future work in preparation.

3. Calculus for the decision making in the water sector

Knowing the fact that floods on urban or rural zones affect directly the water circuit by two contradictories phenomenon. The first is the risk to damage the hydraulic infrastructures, forages, pumping stations, pipes, adduction/distribution networks…(USDANRCS 2010, 2011). The second is that the surplus water that accompanied inundation can enhance our water resources for the surface ones or the groundwater. So proposing model for completely managing the inundation risk must necessarily be done by revolting the necessaries equations formulating the water circuit monitoring (Martin 2010, Yangwen et al 2007, Chao and Peifang 2007, Evan et al 2006, Li B et al 2006).

As consequence, we will put in at this part, the different steps to follow, the mathematical equations/models and the necessary materials that can be used to control, to monitor and to evaluate, by geographical position, the actual and future situation of water circuit: water availability at the resources level, the state of the adduction/distribution networks, the consumer requirements (agricultural sector, industrial sector, service sector). So we can after evaluate if the existing resources and water networks could satisfy all consumers categories and for what time, to propose solutions of rehabilitation, to install new schemes of water networks for the consumers not yet connected or for those whose the existing network could not assume their water need in the future

3.1 Calculus for water resources

Generally there are two classes of resources: the surface resources and the ground water resources. The amount of water available is generally linked to climatic conditions: precipitation, temperature, and evaporation. The prediction of resources efficiencies can be done easily for any region by applying this reasoning: After limiting the different surface lakes, all waterways, the different water sheets (water table and deep water sheet) in every region, we consider every one of them as a closed system for which we apply the balance equation. This later is presented as the equilibrium between the inflow, out flow, income and lost of water for every system defined. It can be written in global form as follow (Mauro 2009, Sellami 2008, Yangwen et al 2007, Chao and Peifang 2007]:

$$\Delta V_w = V_{i,w} + (P + Q_{l,in}) - (Q_e + Q_{l,out}) \tag{26}$$

ΔV_w: variation of water volume in the defined system
$V_{i,w}$: initial water volume in the defined system
P: precipitation
$Q_{l,in}$: the lateral inflow for the defined system from all the directions
Q_e: water lost by evaporation from the defined system
$Q_{l,out}$: the lateral outflow for the defined system from all the directions

So then we can formulate the fictive water debit at a determined time for the defined system by:

$$Q_f = \frac{\Delta V_w}{\Delta t} \tag{27}$$

Q_f: fictitious water flux
ΔV_w: variation of water volume in the defined system for the desired period
Δt: variation of time in the defined system for the desired period

The determination of every term in the balance equation depends on the climatic conditions, soil structure, soil occupation and the geologic characteristics in the region studied. We can measure them directly by using the necessary apparatus and methods (piezometric and geological mapping, hydrological measurements, meteorological measurements).

If we consider the system occupied by water as a reservoir, its volume is calculated by the following relationship (Yangwen et al 2007):

$$V_r = A_{occ} \times H_{tot} \tag{28}$$

V_r: Total volume of the reservoir
A_{occ}: Area or extent occupied by the water
H_{tot}: Total height of the reservoir (distance between the bottom and the top for the considered system)

The volume of water continued in the reservoir is defined by:

$$V_w = A_{occ} \times H_w \tag{29}$$

V_w: Water volume in the reservoir
H_w: Water height inside the reservoir (distance between the bottom and the surface of water sheet)

For the surface resource, they are formed from the hydrographical networks (rivers), natural lakes, barrages lakes', and natural water sources. Their localisations are possible by establishing numerical maps and land numerical models using land altimetry measures, thematic maps and aerial photos (satellite and planes). We must limit the fluvial network (length and capacity of the primary line water, secondary line water, tertiary line water…) and we have to determine the capacities of the existing lakes (geographical localisation, extent and water height).

The water volume existing in a river can be calculated by (Yangwen et al 2007):

$$V_{river} = L_{river} A_{sriver}^{\sec} \tag{30}$$

$A_{sriver}^{\sec}$: Area of the river lateral section (wet surface of a river)
L_{river}: Length of the river
V_{river}: Water volume of a river

The debit through a river can be expressed as follow (Comolet 1963):

$$Q_v = S_m C \sqrt{R_H i} \tag{31}$$

S_m : Wet surface of the river
R_H : Hydraulic radius of the river
i: Slope of the river
C: Friction coefficient

For the ground water and table water resources, they are considered, generally, as non-renewable resources. They don't depend largely on climatic parameters but they are sustained our days to an overexploitation. Determining the amount of water that exists, for how time it can assume our needs and the possibility of their artificial recharges are questions that we can model (Younes et al 2010; Mauro N. 2009). So we must make a geological sweeping, a piezometric scanning and mapping and we have to make many types of forage for testing and controlling the existing sheets and to discover if possible the new ones. Then by using thematic maps and models for underground hydraulic we can elaborate equations for water sheet folding, expanse, height and volume. By utilising the statistical studies, land use plan, agricultural maps, economic plans, directing plans for development by region we can propose mathematically relationships for the evolution of water consumption by sector and by region. We can then determine the life duration of the ground water and the amount of water to add when thinking to their recharge. The most used equations formulating the debit of their exploitation are (Comolet 1963):

For the table water:

$$Q_v = \pi k \frac{(h_1^2 - h_2^2)}{\ln \frac{R}{r_0}} \tag{32}$$

Q_v : Pumped debit
h_1: Piezometric height at the position of action radius (R)
h_2 : Water height in the pumping well
r_0 : Radius of the pumping well
k : Hydraulic conductivity
R: Action radius of the pumping well

For a captive ground water we write:

$$Q_v = 2\pi h_0 k \frac{h_1 - h_2}{\ln\left(\frac{R}{r_0}\right)} \tag{33}$$

Q_v : Pumped debit

h_1 : Piezometric height at the position of action radius (R)
h_2 : Water height in the pumping well
r_0 : Radius of the pumping well
k: Hydraulic conductivity
R: Action radius of the pumping well
h_0 : Distance between the two substratums

3.2 Calculus for the adduction/distribution water networks

The adduction/distribution networks are defined as the course that the water flow follows from the source to the consumer. Our days, in rural or urban zones, to assume the water needed at time and to avoid its loss in route there is tendency to conduct the water by special canalisations (pipes, conduits), hydraulic accessories and apparatus (pump, tanks, treatment stations, floodgates, bends, diaphragm...). The differentiation between adduction and distribution is arbitrary. It depends on the sector to supply with water and is only to facilitate the conception of the network when making hydraulic studies. Generally, the adduction part is that from the sources to the tank or to the series of tanks for water storage and treatment. The distribution is that from the tanks to the consumer: fields and plants for agricultural sector, houses for potable sector (service sector) and factories for the industrial sector. Calculating a water network signifies determining the length of pipes, their diameters, nature or material of fabrication, number of conduits sections', types and number of hydraulic accessories, their capacities (surface, volume, power, energy…) and finally the cost. There are many mathematical relationships, formulas and models that are used to make the hydraulic calculus. They are based on the energy balance between the initial points of the network (resource) to the end point of the network (entrance to the consumer property). This energetic balance is formulated by the theorem of Bernoulli expressed as follow:

$$H_{initial} = H_{final} + J_{initial\text{-}final} \tag{34}$$

$H_{initial}$ is the energy at the initial point of network
H_{final} is the energy at the final point of the network
$J_{initial\text{-}final}$ is the total lost of energy between the initial point and the final point of the network

Generally, between the initial and final points of a water line, and because of topographical problems, we have to consider many particular points where there is change of slope, change of direction and/or obstacles. They are called knots. The distance between two successive particular points (knots) defines the length of a pipe section. If we note A and B the two successive knots, we can, by applying the Bernoulli theorem to the pipe section AB, write (Sellami and Trabelsi 2009, Sellami2008, Comolet 1963):

$$H_A = H_B + J_{A\text{-}B} \tag{35}$$

$$H_A = z_A + \frac{P_A}{\rho g} + \frac{V_A^2}{2g} + J_A \tag{36}$$

$$H_B = z_B + \frac{P_B}{\rho g} + \frac{V_B^2}{2g} + J_B \tag{37}$$

$$J_{A\text{-}B} = j_{A\text{-}B}\, L_{A\text{-}B} + J_A + J_B \tag{38}$$

H_A, H_B: are the energy at, respectively, point A and point B
z_A, z_B: are the altitudes of, respectively, point A and point B
$J_{A\text{-}B}$: is the total lost of energy in the pipe section AB
$j_{A\text{-}B}$: Linear lost of energy in the pipe
J_A, J_B: are the singulars lost of energy due to contact with hydraulic accessory at, respectively, the points A and B
$L_{A\text{-}B}$: Length of the pipe section AB
P_A, P_B: are the pressures at, respectively, point A and point B
V_A, V_B are the water velocities at the knots A and B

The total lost of energy $J_{A\text{-}B}$, is defined as the sum of the singular energy lost (J_A and J_B) and the linear energy lost between A and B ($j_{A\text{-}B}$).

For every hydraulic accessory in the network corresponds a particular singular energy lost (floodgates, bends, diaphragm, change of section…). We give the general formula:

$$J_A = \alpha_A \frac{V_A^2}{2g} \tag{39}$$

J_A : Singular energy lost for the knot A
g: Gravity
V_A: Water velocity at the knot A
α_A : Coefficient of singularity for the knot A

While for the linear energy lost there are many empirical formulas. They express generally the linear energy lost by the water inside the pipes as function of the diameter, the water flow, the conduit roughness and the nature of fabrication material. We can give here as example the following (Sellami and Trabelsi 2009, Ennabli 2001, Punmia and Ashok, 1998):

Blasius formula: $$j = 7.77\ 10^{-4}\ Q^{1.75}\ D^{4.75} \tag{40}$$

Scimemi formula: $$Q = 48.8\ D^{2.68}\ j^{0.56} \tag{41}$$

Bresse formula : $$D = 0.32\ Q^{0.4}\ j^{-0.2} + 0.005 \tag{42}$$

Formule de Colebrook : $$V = 61.5 D^{0.68} j^{0.56} \tag{43}$$

Formule de Hazen-William: $$V = 0.355 C D^{0.63} j^{0.54} \tag{44}$$

Formule de Darcy : $$j = \frac{\lambda}{D}\ \frac{V^2}{2g} \tag{45}$$

Formule de Flamant Masoni : $$j = k \frac{V^{\frac{7}{4}}}{D^{\frac{5}{4}}} \tag{46}$$

Formule de Maning : $$j \times 10^6 = 3120 \frac{V^2}{D^{1.5}} \quad (47)$$

Formule de Maurice Levy: $$V = 36.4\sqrt{\frac{D}{2} j(1+\sqrt{\frac{D}{2}})} \quad (48)$$

Where Q is the debit (m^3/s), j is the linear lost of energy (m/m), D is the pipe diameters (m), V water velocity (m/s), λ coefficient for energy lost

So we have to know the altitude of the particular points (from topographical measurements and level curves maps) and the pressure needed to assume the distribution of water to all the consumers which must be superior to the highest manometeric level at the streamside. By applying the Bernoulli theorem for every pipe section we can deduce all the needed parameters for the hydraulic network conception. I must signal here that there are many models and soft wares that can be used and that they are established from the precedent reasoning and formulas (Sellami & Trabelsi 2009, Sellami 2008).

3.3 Calculus for the consumer level

In the conception of a hydraulic network, we must begin by defining the consumers. This means calculating the amount of water they need and the minimum pressure permitting to lead water to the consumer at the highest manometeric level now and in the future.

As said above, there are three categories of consumers depending on their activities: agricultural activities, industrial activities and services activities.

3.3.1 For the agricultural activities

The amount of water to lead is that needed by the plants in the field and by field in the region for all vegetal speculations that exist. There are many models permitting to estimate the water needed by plants as function of the physiological characteristics of every specie (leaf area index, sap flow, stomata resistance…), soils types (texture, structure, permeability, porosity…), climatic parameters (solar radiation, temperature, precipitation, evaporation, transpiration, heat…) and the economical and demographic evolution by region. Their use is possible and it depends on the precision asked. We present here a simple and general formula permitting to calculate the amount of water needed by plants in the field (Sellami 2011, Sellami 2008, Sellami and Sifaoui 2008, Battaglia and Sands 1997, Tournebize and Sinoquet, 1995):

$$Q = K_c * ETP \quad (49)$$

Q : amount of water needed
K_c: cultural coefficient that depends on the types of plants and soils
ETP: potential evapotranspiration

For the water needed by plants in the future, it can be evaluated as function of demographic evolution, the sort of tolerant vegetation to install as food, the type of industrial culture to implant, the evolution of the agro-alimentary industry and the climatic change. So we must know the economical and political orientations for the durable development by region and

we have to utilize the agricultural maps, land-use plan, the data basis for vegetations characteristics, the gene banks, climatic data basis, models for plants transpiration, biosphere models, circulation and climatic models. (Ciret and Henderson-Sellers, 1997b, Sellers et al 1986).

3.3.2 For the industrial activities

The amount of water needed depends on the type of product and the different process used inside the industry. So we must do multi audit studies to evaluate the real need by process for every product. A general formulation of the water needed by type of industry can be formulated as follow (Sellami 2011):

$$Q_{ind,k} = \sum_{j} \left(\sum_{i} Q_{prd,i}^{proc,j} \times N_{prd,i}^{j-k}\right) \tag{50}$$

For a zone where there is many industry the total water needed by a defined unity can be expressed globally by:

$$Q_{ind-zone} = \sum_{k} Q_{ind,k} \tag{51}$$

$Q_{ind,k}$: Amount of water needed by a defined unity for the industry k

$Q_{prd,i}^{proc,j}$: Amount of water needed by a defined unity for the product i in the process j

$Q_{ind-zone}$: The amount of water needed by a defined unity for an industrial zone

$N_{prd,i}^{j-k}$: Defined unity for the product i in the process j for the industry k

The defined unity can be a linear meter unity from the occupied surface, m² unity from the occupied area, m³ unity from the occupied volume, unity of mass (kg), number of product….

We can give here some examples of water needed by sort of industry: for the textile industry (cotton tissue) we need 4500 l/kg (the defined unity is a kg of product), for dairy industry we need 10 l/l milk (the defined unity is a litre of product), for the paper industry we need 222 – 330 m³ /t, for the sugar industry we need 1929 m3 /t (the defined unity is a tonne of product), For bovine, mutton and goat meat we need 13 500 m3/t, for poultry meat we need 4100 m3/t, for eggs we need 2700 m3/t, for olive oil industry we need 11350 m3/t, for soybean oil industry we need 5405 m3/t, for sunflower seed oil we need we need 7550 m3/t, for palm oil we need 5500 m3/t, dates industry we need 1660 m3/t, Apples 387m3/t, Bananas 499m3/t oranges and citrus we need 378 m3/t, onions we need 168 m3/t, tomatoes 130 m3/t, coffee 5790 m3/t, for the cotton 496 m3/t (Chapagain et al 2006, Zimmer and Renault 2000).

For the future, the water needed is evaluated as function of the orientation of the durable development axis by region, census studies, economic plan, the technology evolution and the market demand. We can intervene here to advice about what industry to install in what region after studying the water circuits (Sellami 20111, Sellami and Trabelsi 2009).

3.3.3 For the service activities

The amount of water needed here is that to consume as potable water. It depends on the number of residents by region, their requirement in comfort, their evolution in the future. We have to use the census studies and the statistical models to evaluate the change in the future. They are generally based on the following equations (Sellami et Trabelsi 2009, Sellami 2008, Baroudi et al 2006, Ennabli 2001):

For the demographic evolution we have:

$$P_y = P_{y0} (1 + \tau)^{y - y_0} \quad (52)$$

P_y: is the population number for the year (y)
P_{y0} : is the population number for the reference year (y_0)
τ: is the population evolution rate

For the consumption evolution we have:

$$C_y = C_{y-1} (1 + \Gamma)^n \quad (53)$$

C_y : is the water consumption for the year (y)
C_{y-1}: is the water consumption for the year (y-1)
n: number of years for which we estimate the consumption
Γ : consumption evolution rate

4. Representation of data on numerical support

We will identify here the data processing support to use in order to make the link between data bases, maps, models and equations established and to show the results in maps, graphics, tables formats and files. So we can evaluate the actual situation, take decision and intervene at moment. Also, we can foresee the future state for the resources, networks and consumers, propose the adequate scenarios for management, rehabilitation and development. After propounding the necessaries equations, mathematical models, software and maps to use, we can organize the data we dispose in the form of a data conceptual model, data logical model data physical model and land numerical model. The GIS tools' to utilize are (Sellami and Trabelsi 2009):

- The equations presented above for the direct calculation for the two parts
- Epanet 2.0 for hydraulic calculus and pressure verification
- ENVI 4.2: The environment for visualizing image to elaborate the land numerical model
- ArcView GIS 3.2 to digitalize the information layers from maps, to organise the data tables and to make the link with mathematical models and software of calculus
- Power AMC Designor 6.0 for data arrangement
- Hydrogen as interface of link with hydraulic calculus
- 3D Analyst and Spatial Analyst for spatial and 3 D analysis and representation

Depending on the quantity of items and data basis we dispose (input), the thematic maps/plans to realise (output) are those representing the different information layers needed in decision making (proposing a solution scenario). We list here the following: geologic maps, hydrographic network maps (primer, secondary, tertiary rivers), topographic maps for the land numerical model, soil type maps, land use maps, lakes and table water maps, grounds waters maps, adduction and distribution network maps, hydraulic accessories maps, knots

maps. After, we have to make the hydraulic calculus for the proposed scenario in order to accept or refuse it. Here with a block diagram for the modelling approach:

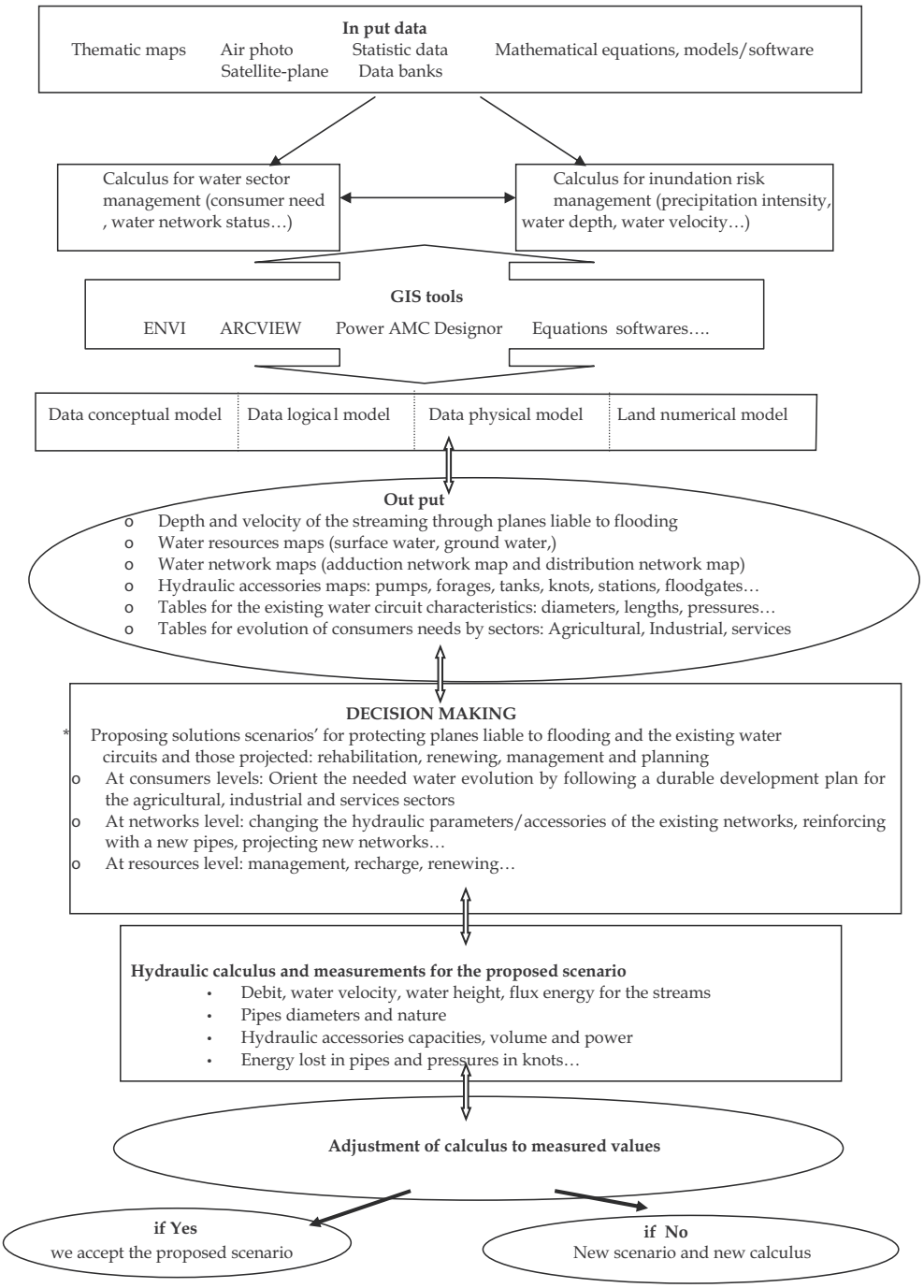

Fig. 2. Block diagram for the modelling approach functioning

The same reasoning and the same tools were used for the region of SILIANA as we will present later.

5. Results from partially validation of the modelling approach

A first application of the model has been done to the region of SILIANA in the West-North of Tunisia (Sellami and Trabelsi 2009). At the beginning we have identified, limited and evaluated the water resources available (surfaces resources, ground water resources, artificial resources…). After, by using the necessaries equations, we have diagnosed the different adduction/distribution networks that exist and calculated their hydraulic parameters: the lengths of pipes, diameters, pressures and debit at different positions, types and capacities of hydraulic accessories, risk of conduits corrosions and filling, risks of pipe damage and water leak. Experimental verification of calculus has been done by measurement of pressure and water flow at different positions (GPS, pressure captors, debit captors). Finally we have distinguished all types of water consumers in the region, calculated their water needs and determined those connected to the water network and those who are not yet connected.

By using the GIS tools and the brut data we dispose, we have established the multi-layers information map'. It is presented in figure 3. It comports the following items: Topographic layer (level curves), hydrographic networks layer (first, secondary and tertiary river lines), geologic layer, forages for ground water resources layer, adduction network layer, hydraulic accessories layers.

After using the necessary calculus and the existing databases we have numerated the actual water distribution network. We have deduced the next results:

- Geographical situation:

The zone studied is referenced by these coordinates: Longitude 2° 27′ 33″; Latitude: 71° 18′ 16″, Altitude: 400 and 460 m NGT

- Water resources:

Because the flow in the rivers networks is irregular, the region is supplied by water only from ground water sheet via 4 forages. Here with their characteristics (table n°1):

Forages	Altitude (mNGT)	Static level (mTN)	Debit (l/s)
Ramlia	438	-17.1	16
Siliana II Bis	457	-19	26
SI 14	438.62	-25	20
Elguabel	449.4	-20	25

Table 1. Characteristics of the water resources

- Adduction and distribution water networks:

We have verified the hydraulic calculus for the existing adduction/distribution networks and we have measured at different points of the network the pressures, debits and conduits diameters for the adjustment. Table n°2 offers the main features:

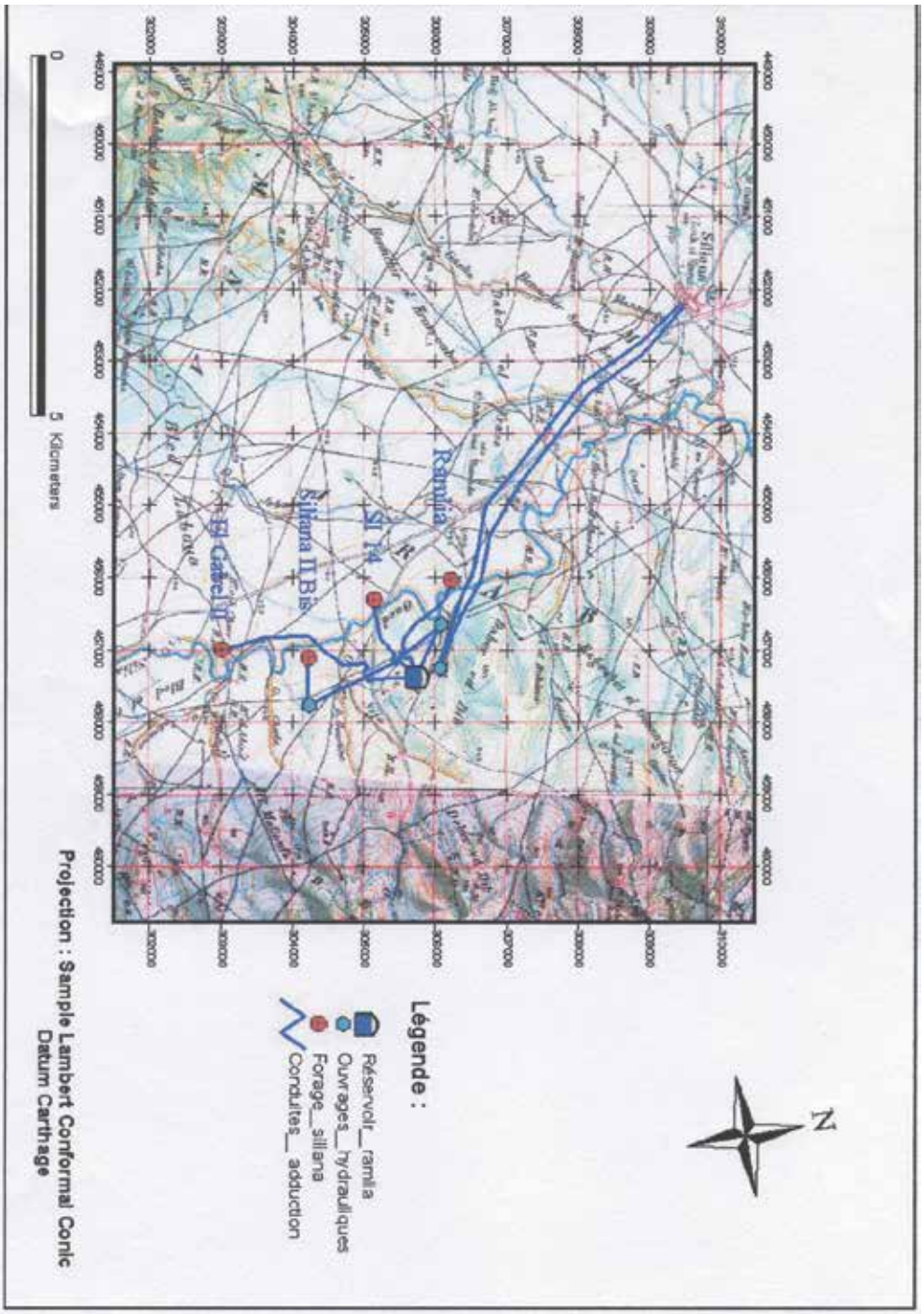

Fig. 3. A thematic maps representing the superposition of the following information layers: topographic maps, geologic map, rivers network map, adduction network map, hydraulic accessories map, water resources map (forages)

	Sections number	Nature	Mean diameter	Total mean length
Adduction network	7	AC, PE, Fonte	200 – 315 mm	25189 m
Distribution network	718	AC, PE, PVC	80 – 250 mm	248038 m

Table 2. Characteristics of the adduction/distribution networks

- For the consumer:

We have evaluated the amount of water needed by the consumers actually and in the future, those who are connected and those who are not yet connected. The principal results for the evolution of the daily volume for consumption and resources from 2006 to 2030 are propounded in table n°3.

year	2006	2010	2015	2020	2025	2030
Water needed	3964 m^3/day	4401 m^3/day	5022 m^3/day	5738 m^3/day	6563 m^3/day	7515 m^3/day
Resources	7517 m^3/day	7517 m^3/day	7517 m^3/day	7517 m^3/day	7517 m^3/day	7517 m^3/day

Table 3. Evolution of the daily water volume for the consumptions and resources

We can say that the existing resources assume the needed water until the year 2030. So we must think to a new resource or to a technical solution like recharging the existing resources or installing a new storage tank.

After modelling the water network functioning situation for the year 2007, we have remarked that there is five pressure levels in the network: less than 20 m, between 20 and 40 m, between 40 and 50 and more than 60m (Sellami and Trabelsi 2009). But for the majority of knots, the pressure is between 20 and 40 m which is a threshold fixed by the Tunisian National Society of Water Distribution for each subscriber. The singular knots for which we have recorded feeble pressures are between 10 and 20 m and those for which we have registered high pressures are not too distant from 50 m and for both the problem is due to the subscriber altitude. So there is no real problems of pressure for the year 2007.

Figure 4 shows the calculated prevention of the pressure and the energy lost for the year 2030 in the adduction and distribution networks.

We notice a high pressures (much more than 50 m) and an important lost of energy (more than 3 m/km) in the pipes of the high zone. We can suggest here many scenarios of rehabilitation. After hydraulic modelling, we have proposed to replace many conduits sections by others with a diameter varying between 400 and 500 mm. The new pressure and energy lost repartitions for the year 2030 appears in figure 5.

For all the pipes, we notice a net amelioration for the pressure (between 20 and 50 m) and for the energy lost (between 1 and 2 m/km). The same reasoning and simulation could be effectuated for different paces of time (daily, monthly, yearly…) in order to take the appropriate decision at time.

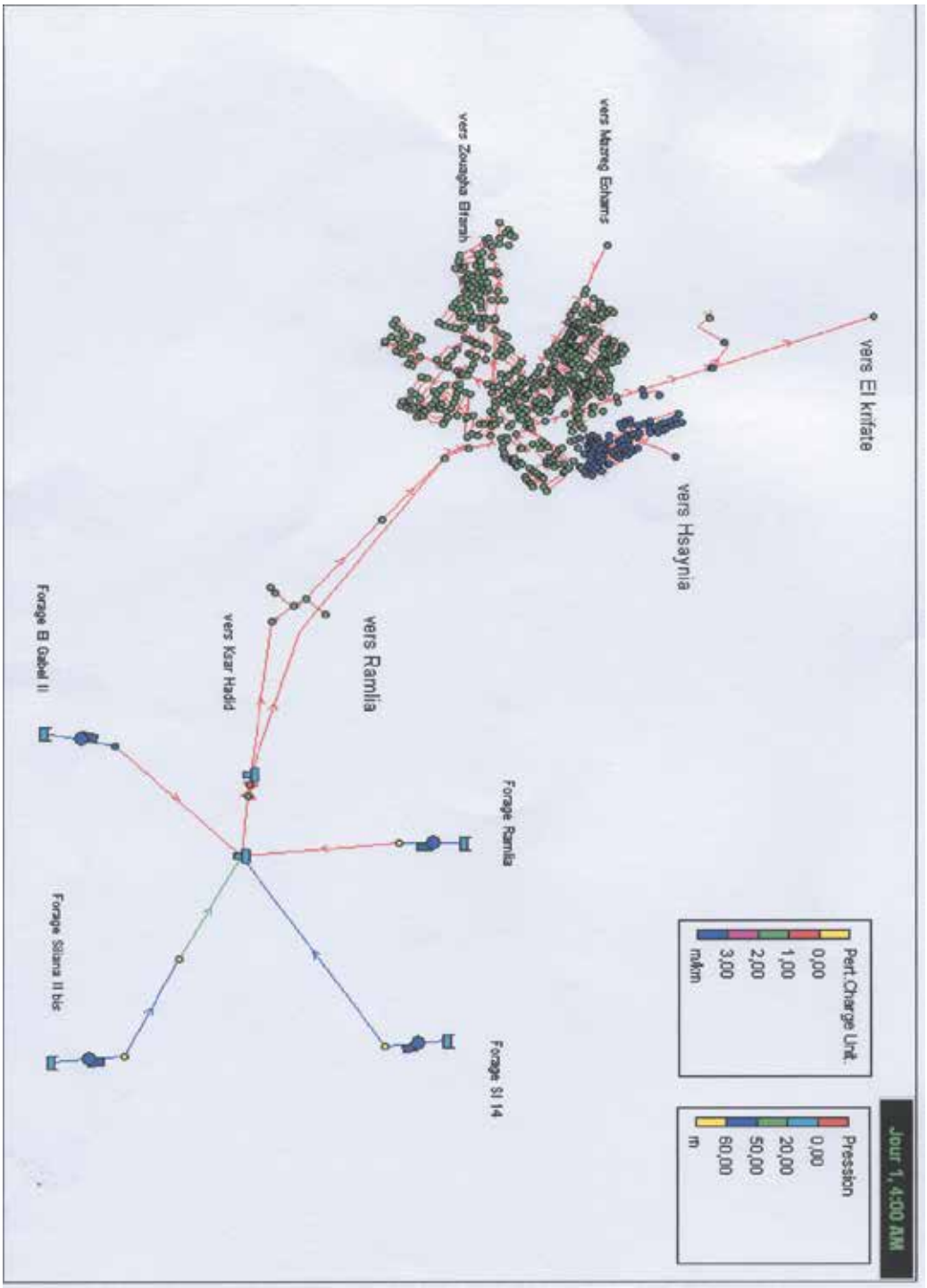

Fig. 4. Modelling of pressure and energy lost in the adduction/distribution networks without rehabilitation scenarios for the year 2030

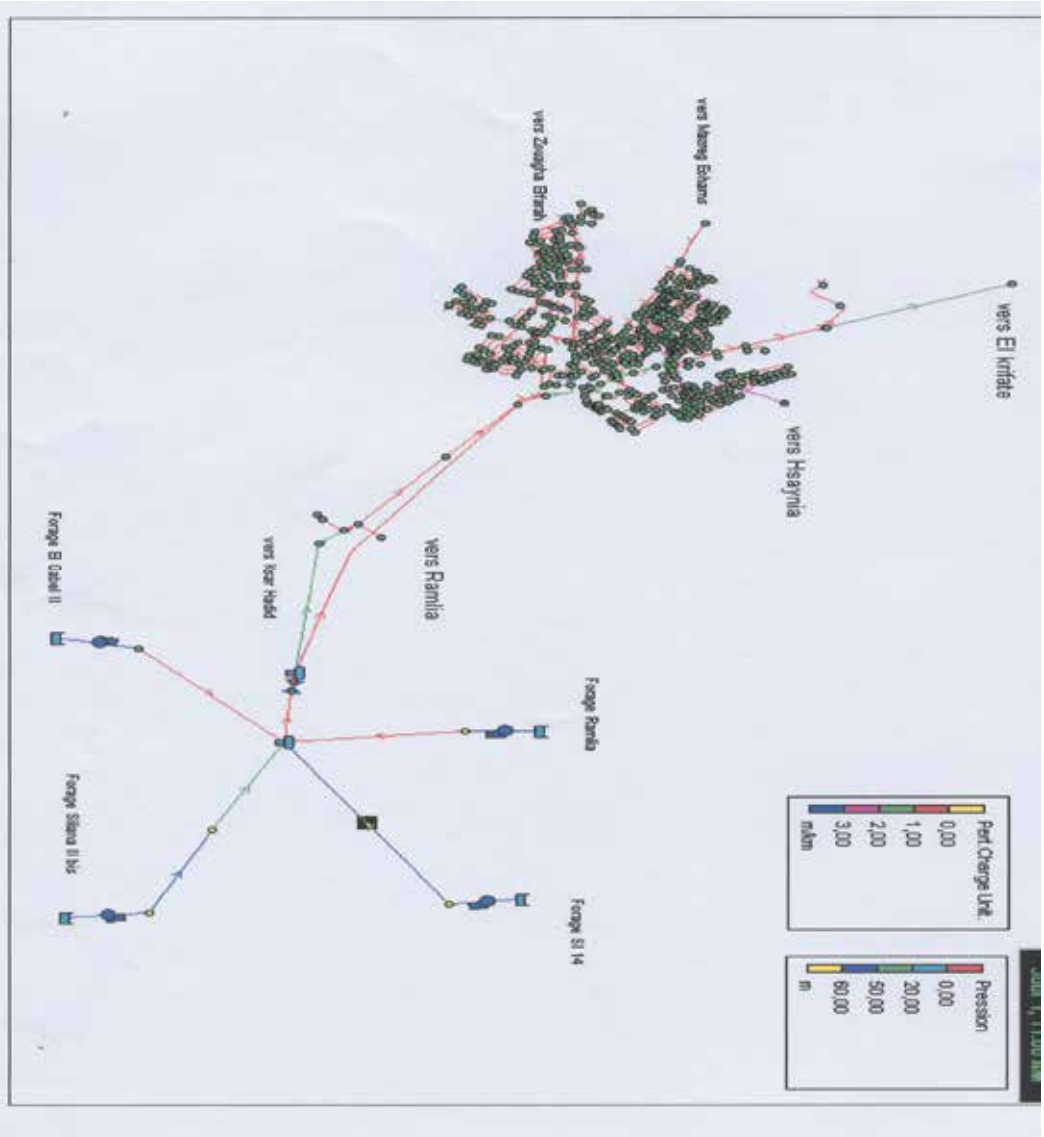

Fig. 5. Modelling of pressure and energy lost in the adduction/distribution networks after applying scenarios of rehabilitation for the year 2030

6. Conclusion

The modelling approach presented here is constituted from two complementary parts. In the first we have revolted the necessary equations to use when to evaluate the inundations effects and to manage their risks. In this sense and as beginning, we have disengaged the formulations to foresee the timing of precipitation descent, to position the averse starting and to estimate their intensities so we can localise the plains liable to floods and map the most vulnerable zones. After we can avert the decision makers about for what region we

must be prepared first and which budget we can reserve and advice them where to install our new projects. To characterise the streaming after precipitation we must be able to detect the directions of flows, their speeds and the water depth in all position of plains by considering the topography and the sorts of obstacles either in rural or urban zones. To reach that purpose we have developed a system of linear equations which can be easily resolved either analytically or numerically and permitting the estimation of those parameters. The resistance of obstacles (vegetation canopies, agriculture fields, buildings and houses, hydraulic infrastructures, water resources, forages, water adduction/distribution networks, roads/ bridges networks…) to water flow must be estimated in order to evaluate the risk of their damage as function of averse intensity for many scenarios, to size means and tools absorbing the power of water flow or deviating the water speed, to invent the adequate material of construction and to architect the efficient positioning of our projects inside villages or towns in the objective to protect human properties. To do so we have aroused the appropriate reasoning and detailed the useful formulas calculating the drag coefficients and friction factors by kind of obstacle for divers cases (totally submerged, partially submerges, flexible, solid) in either rural or urban zone.

The complete modelling of the inundation risk management can not be done successfully without responding to the question how to manage the water circuit. Because the floods have tow antagonistic effects on that circuit: on one hand they can damage the water networks (forages, pumps, treatment stations, pipes system, hydraulic accessories…), on the other hand the surplus water flowing over plains can be exploited to enhance the water resources either the surface water resources or the ground water resources. In this meaning we have evolved a basic methodology with the necessary formulas and tools permitting to test, evaluate and monitor both the actual and future situations of the water resources, the adduction/distribution network pipes and the consumers water need. It provides an interface to connect mathematical models and software to thematic maps and data basis in the hope to be capable to take momentarily the appropriate decision about the adequate solution and scenario for management, rehabilitation, renewal and projection

A first application of this model has been done for the water circuit of SILIANA region in the West-North of Tunisia. After exploiting the disposed data basis and thematic maps and by applying the mathematical models established, we have diagnosed the actual water circuit till the year 2007, we have estimated the yearly evolution of water volume for both resources and consumers and we have calculated the pressure repartition in all the knots of the adduction/distribution network until the year 2030. We have realised that the resources could not satisfy the consumers after 2030 and that we will have pressures insufficiencies in many zones of the network. We have proposed a scenario of rehabilitation, we have calculated the new hydraulic parameters of the network propounded and we have prescribed the correspondent map. We notice a net amelioration.

Finally we allow our self to say that the out puts of this approach could be easily analysed, interpreted and brought up to date and the making decision process could be ran for a moment. But a work for ameliorating this approach is needed particularly by using new and more precise models for estimating the water needed and its evolution for the agricultural, industrial and services sectors

7. Acknowledgements

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Part 3

Sustainable Building, Construction and Environment

7

Sustainable Building in Malaysia: The Development of Sustainable Building Rating System

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1. Introduction

The Malaysian building industry has over the years been developing and working towards a more sustainable and green architecture. The needs for SBRS (Sustainable Building Rating System) become more apparent with the increasing demand from building end-user for Green rated building. This is also support by objectives of many companies today where good corporate social responsibility (CSR) calls for them to support environmental friendly including their office premises.

The issue of Sustainable Building Rating System in Malaysian building industry is still new. Even though Green Building Index has been developed, but the application is only to new building. There is no study done on the application of SBRS to existing building yet. Thus, Knowledge and understanding on how the Sustainable Building Rating System (SBRS) can increase their building performance and prolong the building life span among the actors in Malaysian building industry are very low. Shafii and Othman (2005) reveal that one of the major barriers holding back the development of sustainable building in Southeast Asia is the lack of awareness of sustainability issues in related to profession. The survey conducted by Shari, Jaafar et al (2007) also reveals that the Malaysian building industry players have 'little' knowledge on sustainable building assessment, rating and labelling system. Due to this, many offices building in Malaysia lay to claim for sustainability. The building maintenance and operation cost increase drastically every year. The building condition deteriorate and this situation will lead to the lost of rental income by the owner .Tenant of an office building will go for a better building environment for their company good reputation. Even though the capital investment for sustainable building is very high, but the long term of operation and maintenance cost is very low. Before the system can be developed, there question need to be addressed such as:

i. How do the building experts evaluate building sustainability effectively using SBRS tools?
ii. What are the available SBRS tools that could be used in Malaysia?

iii. What are the current scenarios of Malaysian building industry?
iv. What are the effects of implementing Sustainable Building Rating System Tools in Malaysia?

The first section reviews available SBRS tools worldwide to select the appropriate tools to be tested. It is also analysed the Malaysian building industry issues to identified the implementation problems arise. The second section in this chapter, report the experience of conducting assessment of selected Sustainable Building Rating System on the Low Energy Office (LEO) building. It is also describes the three structures of comparison analysis on the aspect that is considered in the assessment- Theoretical Comparison Analysis, The Evaluation Comparison Analysis and Overall Comparison. Expert review on the assessment are carried out to validate the result. The third section analyses the expert review on Green Mark and SBTool. The fourth section analyses in-depth interviews with the building expert. This section describe the interviews result in descriptive form.

2. Review of various SBRS

Currently, several environmental methodologies and methods for evaluating environmental performance of buildings are being developed. In a global scale it is worth mentioning SB (Sustainable Building) Tool, formerly known as GB Tool (Green Building Tool) which is an international project coordinated from Canada, LEED (Leadership in Energy and Environmental Design) a method developed in the USA with a world wide application and CASBEE (Comprehensive Assessment System for Building Environmental Efficiency), a method developed in Japan. In Europe, some of the most frequently used include BREEAM (Building Research Establish Environmental Assessment Method) in the UK and it is worth mentioning the HQE (High Environmental Quality) developed in France during the last decade and the VERDE method developed recently in Spain (Maria Sinou, 2006).

The growth and use of buildings' environmental performance assessment methodologies, is considered to contribute greatly to the integration of methods and practices favouring sustainability in the building sector. The methods that have been developed worldwide are built upon various principles and different evaluation items, data and criteria. However, most of the tools do not take into consideration the lifetime parameters. The assessment they measures is based on original conditions and characteristic, whereas the modification of the building elements' attributes are not taken into accounts.

3. The comparison

The environmental assessment methodologies covers in this literature include SBTool, Green Mark, BREEAM, CASBEE (Comprehensive Assessment System for Building Environmental Efficiency), Green Star and LEED (Leadership in Energy and Environment Design (launched in 1998). This summarizes the approach used by each of these methods and includes a quick comparison of the environmental standards demanded to meet each rating. A common theme of each assessment method is the reliance on existing building regulations and other third party standards. As any environmental assessment methodology needs to cover such a wide range of issues there is no other way that a system could remain up to date without significant initial investment and continual extensive maintenance. Also, reliance on existing third-party standards or regulations lends credibility to the system,

especially among sceptics. As well as comparing the scores and rating levels in each of the schemes, the major differences in the processes have been investigated. The major differences between the schemes have been highlighted in table 1.

For the purposes of this review, 'sustainable building rating systems' is defined as tools that examine the performance or expected performance of a 'whole building' and translate that examination into an overall assessment that allows for comparison against other buildings. For a rating system to add value to the sustainable design and/or operation of a building, it must offer a credible, consistent basis for comparison, evaluate relevant technical aspects of sustainable design, and not be over-burdensome to implement and communicate. In order to identify the most applicable rating systems for the case study, the following review approach is used:

1. Identification of sustainable building rating systems
2. Screening analysis of rating systems to limit review to most applicable systems.
3. Identification of case study drivers for a credible rating system *(review criteria)*
4. Data collection on applicable rating systems for comparative review.
5. Review of the merits of applicable rating systems as they apply to the case study.

As each of these rating systems are being researched, it became evident that many of them do not fit the sustainable building rating system needs of case study. Therefore screening criteria are identified in order to concentrate the review on the systems that have the greatest potential of addressing case study needs. The screening criteria include:

- Relevance: Does the rating system provide a "whole building evaluation" rather than an evaluation of an individual design feature?
- Measurable: Does the rating system use measurable characteristics to demonstrate the extent of sustainable design incorporated into the building?
- Applicability: Can the rating system be used on all of the types of commercial buildings or office buildings?
- Availability: Is the rating system easily adaptable to the Malaysian market or currently available for use in the Malaysian market?

Rating Systems Screening Criteria Scores				
Rating System Name	**Relevance**	**Measurable**	**Applicability**	**Availability**
BREEAM	√	√	√	
LEEDS	√	√	√	
SBTool	√	√	√	√
GREENSTAR	√	√	√	
CASBEE	√	√	√	
GREENMARK	√	√	√	√

Table 2. Rating Systems Screening Criteria Scores

From table 2, Green Mark and SBTool are selected based on the availability criteria scores from the screening table. The nature of the tools that can be seen in table 3 is the criteria for selection of both tools.

Green Mark	SBTool
1. The structure is simple and easy.	1. The structure is comprehensive and explore various result.
2. The issues suit to local context as Singapore and Malaysia are similar in climate and social aspect.	2. The issues and benchmark can be customised to local context
3. The scores easily derives from the points allocated for each issues.	3. The scores automatically derives from the programmed tools. Save time.
4. The criteria of assessment are straight forward and easy to identify.	4. The criteria and benchmark are comprehensive and allow the assessor to explore various result. It is also allow improvement of local practice to consider on the non compliance criteria. This apply to absent of data such as embodied energy of material use in Malaysia.
5. Energy efficiency is the most important issues	5. Comprehensive and consider all aspect as framework.
6. Easy to understand the evaluation procedure as information are available through website.	6. Easy to understand the evaluation procedure as information are available through website

Table 3. The evaluation comparison of Green mark and SBTool

4. Drivers for sustainable design and use of a rating system

In order to establish review criteria for the rating systems that is consistent with Malaysian building industry's drivers for applying a rating system, government policy, Acts, program goals related to the design and operation of sustainable buildings are identified and summarized in this section.

Those drivers include:

- MS1525 being mandatory and applied to LEO building as a showcase for energy efficiency.

- Adaptation of Conquas as Qlassic by CIDB.
- Renewable energy promotion, programme and research and development.
- Quality mindset
- ISO 9001 certification

5. The Malaysian building industry issues

The possible factors of Sustainable Building Rating System success implementation will be depending on the following factors:

5.1 Government support

The Ministry of Energy, The Energy Commission, MIDA (The Malaysian Industry Development Authority), promotes renewable energy resources through research and development of biomass renewable energy, mini hydro project, solar energy, infrastructure development for renewable energy and support renewable energy industry and drive market development for renewable energy. Malaysian government built the first energy efficiency building in 2005 as a showcase of MS 1525 to the building industry on the low energy office building. The building is known as LEO building and occupied by KETTHA (Ministry of Energy, Green Technology & Water).

Ministry of housing and local government (MHLG) and National Hydraulic Research Institute of Malaysia(NAHRIM) promote rainwater harvesting for residential and industrial building through research and development on the rainwater harvesting model and design. MHLG through local authority promote and enforces the rainwater harvesting legislation to make it compulsory on new development projects. Government also monitor the quality through various ISO Certification by SIRIM research and development on the sustainable issues.

5.2 Building industry support

Malaysian Institute of Architects(MIA) until now tries to incorporate design guidelines for Energy Efficiency i.e. clauses that point to the Malaysian code of practice MS1525 to enable adoption by local authorities to ensure minimum energy performance standards in residential and commercial. CIDB enforces Quality certification for building industry players and projects to monitor the quality control of the building industry by adapting CONQUAS (from BCA Singapore) as QLassic. The recent development of Green Building Index for New Building by MIA and Institute of Engineers Malaysia (IEM) enhances the implementation factors on Malaysian building. Many architects have shifted to design sustainable building recently and make the practice demanding in the Malaysian building industry market. Promotion by the building industry player on sustainable design also increase the demand for sustainable building because they create awareness to the public and end user of the building.

5.3 Public awareness

Awareness of sustainable development by the public has created industry drive and demand for sustainable building design in Malaysia .This will result in the increase of demand for sustainable building and more building will try to be certified with SBRS to

compete in the market. Recycling, reduce and reuse are promoted everywhere by the government and non- government organisations and energy saving is the main achievement. Demand for energy saving equipment also increases recently because the equipment save the cost of energy bills.

6. Theoretical comparison analysis

The evaluative framework for environmental management approaches developed by Henrikke Baumann and Sarah J. Cowell (1999) is adapted to structure the framework of Green Mark and SBTool to represent the essence of both tools. This framework is used to give better understanding of the context structure with academically recognised terminology and methodology. The framework comprise of three aspects, generic, contextual and methodological. As we can see from the aspect table 4, under generic aspect sub for nature of approach, both of the tools are categorized as a tool for sustainable building assessment.

6.1 Type of decision maker

Under contextual aspect several types of decision maker can be identified as governments/authorities, companies and NGO's. Here, decision makers are using the approach and/or their results.

6.2 Overall purpose

The approach is used for communication purpose. It implies that the information is directed at others than oneself and the various data sources indicate that it support communication.

6.3 Object analysed

The object analysed identifies the focus of the decision. Ecosphere implies a focus on use of land and techno sphere focus on identifying the environmental effects associated with the building use. Green Mark and SBTool also focus on site selection and technology to increase building sustainability.

6.4 Perspective

Prospective approaches look forward in time and retrospective look back in time. Both approaches are used in the tools as they evaluate the previous and subsequence phases of the buildings' performance. A methodological aspect is only valid for the tool. So this aspect can be used to describe the structure of the tools.

6.5 Investigated dimension

Green Mark and SBTool assessment covers all the categories that are environmental, economic and social.

6.5.1 Character of the approach

Defined model is used under mathematical modelling.

Aspects	Categories	SbTool	GreenMark
Generic Aspects			
Nature of approach	*Type:*		
	Concept		
	Tool	√	√
Contextual aspects			
Type of decision-maker	*Decision makers:*		
	Governments/authorities	√	√
	Industrial companies/business enterprises	√	√
	Non-governmental organisation(NGOs)	√	√
	Individuals(e.g. as consumers)		
Overall purpose	*Uses:*		
	Decision support: operative or strategic		
	Communication	√	√
Object analysed	*Focus:*		
	Ecosphe re	√	√
	Techno sphere		√
Perspective	*Nature of perspective:*		
	Prospective	√	√
	Retrospective	√	√
Methodological aspects			
Investigated dimensions	*Main dimension:*		
	Environmental	√	√
	Economic	√	√
	Social	√	√
Character of the approach	*Emphasis on procedure:*		
	Problem identification		
	Problem formulation		
	Modelling		
	Interpretation		
	Implementation		
	Feedback and learning		
	Emphasis on modelling:		√
	Flexibility in model(s) used		
	Defined model(s) used	√	√
	Additional models used for interpretation		
Basis for comparison	*What is kept constant in a comparison:*		
	Measured environmental parameter or indicator		
	Facility	√	√
	Quantity of products or services		
	Total production unit		
	External standard or other level of acceptability	√	√
	Lifetime	√	

System boundaries	*Spatial modelling:*		
	One geographical area(single site)	√	√
	Many geographical areas(many sites)		√
	No defined geographical areas(no defined site)	√	
	Time modelling:		√
	Snapshot view somewhere in time (past, present, future)	√	√
	Snapshot view at intervals over a period of time		
	Whole lifetime included(use of discounting rate)		
Type of data (input and output data)	*Subject of data:*		
	Physical systems	√	√
	Social and economic systems	√	√
	Nature of data:		
	Quantitative	√	√
	Qualitative	√	√
Evaluation of results/interpretation	*Presentation of result:*		
	Single parameter	√	√
	Few parameters	√	√
	Many parameters	√	√
	Purpose of additional models for evaluation:		
	To aggregate data	√	√
	To identify critical data		

*Adopted from Henrikke Baumann and Sarah J. Cowell (1999)

Table 4. Aspect Framework of Green Mark and SBTool

6.5.2 Basis for comparison

The bases of comparison for the tools are facility and an external standard or other level of acceptability. Green Mark and SBTool approaches are comparing the site before and after construction.

6.5.3 System boundaries

Spatial modelling is used in Green Mark and SBTool as the tools only investigate one single site from the use of drawing and the content of many checklists used. Time modelling is also used as the Green Mark is not valid after three years and major renovation. This is also applied to SBTool.

6.5.4 Type of data (input and output data)

The data used for Green Mark and SBTool can be categorised as physical system, economic and social system because it concern on energy efficiency and matter in technological system for sustainability, e.g. solar panel, rainwater harvesting.

6.6 Evaluation of result/interpretation

Both tools tend to be a mixture of qualitative and quantitative data. Output data can be in single parameter, few parameters and many parameters. The result is to aggregate data or show that certain data are particularly critical to the result by tables of main aspects and charts.

7. The evaluation comparison analysis

The operational work of the evaluation can be described as a means of collecting, analyzing, calculating data to get all the criteria scored from the building assessment. The performance of the objective building can finally be express with simple charts.

7.1 Result of Green Mark

The result of Green Mark assessment method for LEO building is 81/100. This result indicates that LEO building is certified under Green Mark Gold ^{Plus}. It greatly proves that LEO building is a sustainable building in an appropriate approach. This is due to the understanding of how the tool evaluates the building. The methods are straight forward and comes with a very comprehensive descriptions and calculations. The building are assessed twice with the presence of the building manager to verify the result. Table 5 shows the overall green Mark result for LEO building.

GREEN MARK FOR LEO BUILDING

Points allocation of Green Mark Criteria

	Points allocated	Points Given
Part 1: Energy Efficiency		
1. Energy Efficiency Index	7	7
2. Continual Improvement for Energy Efficiency	7	7
3. Electrical Sub-metering	7	2
4. Energy Efficient Systems & Features	7	6
5. Roof Top Gardens & Landscaping	3	3
Sub-total	**25**	**25**
Part 2: Water Efficiency		
1. Continual Improvement for Water Efficiency	6	2
2. Water Efficient Fittings	6	2
3. Water Efficient Irrigation and Landscaping	3	3
Sub-total	**15**	**7**
Part 3: Building Management & Operation		
1. Building Maintenance	3	3
2. Environmental Management System	8	3

3. Building Maintenance and Operation Guidelines	4	3
4. Preservation & Enhancement of Landscaping	3	2
5. Public Transport Accessibility	1	1
6. Recycling	4	3
7. Occupant Health	2	1
Sub-total	**25**	**16**
Part 4: Indoor Environmental Quality and Environmental Protection		
1. Effective Ventilation	2	2
2. High Frequency Ballasts	2	2
3. Luminance Level	2	2
4. Thermal Comfort	2	2
5. Noise Level	2	2
6. Indoor Air Quality Audit	2	0
7. Refrigerants	3	3
Sub-total	**15**	**13**
Part 5: Innovation		
1. Innovation	20	20
Sub-total	**20**	**20**
Total	**100**	**81**

GREEN MARK POINTS	GREEN MARK RATING
85 AND ABOVE	PLATINUM
80 TO < 85	GOLD Plus
70 TO < 80	GOLD
55 TO < 70	Green Mark Award

Table 5. The Green Mark Result.

7.1.1 Energy efficiency analysis

From the assessment result, an average energy consumption of LEO building is 119/kWh/m2/yr. The building is equipped with a comprehensive Building Energy Management System (BEMS) that is integrated with building Control system (BCS). BEMS monitors the building energy consumption. Integration of BEMS

Under the Energy Efficiency Index, energy consumption is monitored using the BEMS and target was set to the lower point. The average index for Leo building is 119 KWh/m2/yr.

This is considered very good as Green Mark target for the lowest is 150KWh/m2/yr. For Continual Improvement for energy efficiency, 2 points are given for conducting monthly energy monitoring; 2 points are given for establishing energy efficiency target at 100kWh/m2/yr.3 points are given for establishing continual improvement plans and action. The total point is 7/7.This is because there is no regional concerned in this matter as the climate is the same and the building regulation similar to Malaysia. Table 6 shows the energy efficiency result.

Part 1: Energy Efficiency	Allocated	Given
1. Energy Efficiency Index	7	7
2. Continual Improvement for Energy Efficiency	7	7
3. Electrical Sub-metering	7	2
4. Energy Efficient Systems & Features	7	6
5. Roof Top Gardens & Landscaping	3	3
Sub-total	**25**	**25**

Table 6. Energy Efficiency

Under Criteria 3, Electrical Sub-Metering, 2 points are given for sub-meter used to monitor energy consumption of key building services. Criteria 4, Energy Efficient Systems & Features covers for energy efficient features used, energy efficient lightings, air-conditioning system, lifts, day lighting and natural ventilation. Additional points are given for extensive usage of those features. Three (3) points are given to Roof top Gardens & Landscaping as the building had a proper maintenance of the garden and landscaping.

7.1.2 Water efficiency analysis

As directed by the management, a plan to improve water conservation in the building has been provided. Sub metering is available to quantify savings and some automatic flushing system have been converted to manual flushing (auto stopped) to avoid unnecessary flushing caused by the motion sensors.

Part 2: Water Efficiency	Allocated	Given
1. Continual Improvement for Water Efficiency	6	2
2. Water Efficient Fittings	6	2
3. Water Efficient Irrigation and Landscaping	3	3
Sub-total	**15**	**7**

Table 7. Water Efficiency

Points awarded to LEO building on water efficiency are low because only part of the water efficiency target are followed and practiced. For the first parameter, Continual Improvement for water efficiency, only 2 points are given for establishing water conservation improvement plans. Only parts of the toilets are fitted with automatics water taps and automatics flushing system under the second parameters. For water Efficient Irrigation and Landscaping, full points are given for the use of rainwater for irrigation and installing

automatic irrigation system for sky garden. Rainwater harvesting system is used for landscape irrigation. Table 7 show the water efficiency result.

7.1.3 Building management and operation

LEO (Low Energy Office) building is owned by Malaysian government and comprehensively maintained by the Public Work Department (PWD)). Another party which responsible to look into the maintenance input and monitoring of the building is Pusat Tenaga Malaysia (PTM). Environmental Management System has not been established in the building. Post occupancy survey and feedback have been conducted. Daily environment monitoring, feedback complaint and corrective actions have been implemented to ensure the users comforts and safety are maintained. Building end user guidelines / pamphlets are available and distributed among the occupants. Awareness training is available. Energy monitoring and guidelines are established. Guideline for refurbishment is not available but the activities is controlled and monitored by the building manager to ensure the energy efficient features and objectives are maintained. Table 8 show the Building Management and operation result.

Part 3: Building Management & Operation	Allocated	Given
1. Building Maintenance	3	3
2. Environmental Management System	8	3
3. Building Maintenance and Operation Guidelines	4	3
4. Preservation & Enhancement of Landscaping	3	2
5. Public Transport Accessibility	1	1
6. Recycling	4	3
7. Occupant Health	2	1
Sub-total	**25**	**16**

Table 8. Building Management and Operation

7.1.4 Indoor environmental quality and environmental protection

The score for this category is quite good except for the indoor air quality audit is zero(Table 9). This is due to non audit has been performed in the building under this category. The BCS and BEMS system controls the criteria 1 and 2 and all lighting in the office area used fluorescent luminaries with high frequency electronic ballast. Luminance level and thermal comfort follows the MS1525 and consequently, it is easy to measure the level as the building is designed according to MS1525 requirement.

Noise level is at the minimum as there is no air-condition chillers. Low noise is due to low capacity and variable speed of the fans and pumps. Room partitions are sandwiched with

mineral wool for acoustic and fire control. Furthermore, the air condition distribution system is designed to have low resistance thus reduce the noise level. No refrigerant is used as the supply is from district cooling.

Part 4: Indoor Environmental Quality and Environmental Protection	Allocated	Given
1. Effective Ventilation	2	2
2. High Frequency Ballasts	2	2
3. Luminance Level	2	2
4. Thermal Comfort	2	2
5. Noise Level	2	2
6. Indoor Air Quality Audit	2	0
7. Refrigerants	3	3
Sub-total	**15**	**13**

Table 9. Indoor Environmental Quality and Environmental Protection

7.1.5 Innovation

Under innovation part (Table 10), 1 point is given for rainwater harvesting, cool paints inside the buildings, solar PV (renewal energy) for water wall system as part of education and demonstration, sky garden, skylight in the atrium, double roof at rooftop for additional shading & maximise use of space. 2 points are given to motion sensor for lightings, natural ventilated atrium, energy saving office equipment and energy efficient designed features.

Additional marks are also considered for efficient construction methods (use of IBS system - ALC blocks) and quick construction, light shelf on every façade: To harvest and bring daylight into the building and spacious interior design: Intensive area located near the façade to utilise natural daylight.

Part 5: Innovation	Allocated	Given
1. Innovation	20	20
Sub-total	**20**	**20**

Table 10. Innovation

7.2 Results of SBTool

The LEO building project is applied in SBTool under the operation phase. The Microsoft excel program of SBTool select the pre-installed criteria of the operation phase automatically. The scale of scores is divided between -1 and 5, while 0 means acceptable

practice, 3 means good practice and 5 means best practice regulated on the SBTool Ms-Excel program.

Table 11. shows individual aspects with their weights and scores. The result of total weighted score is 1.6. This result determined that LEO building sustainable performance in under an acceptable standard. Table 12 shows the graph of the performance issue area under SBTool assessment.

To see a full list of Issues, Categories and Criteria, go to the Issues worksheet.		Active Weights	Weighted scores
A	Site Selection, Project Planning and Development	6%	1.0
B	Energy and Resource Consumption	19%	2.1
C	Environmental Loadings	28%	1.6
D	Indoor Environmental Quality	23%	1.0
E	Service Quality	17%	1.5
F	Social and Economic aspects	6%	3.7
G	Cultural and Perceptual Aspects	3%	0.0
Total weighted buildings core			1.6

Table 11. Total weighted building scores

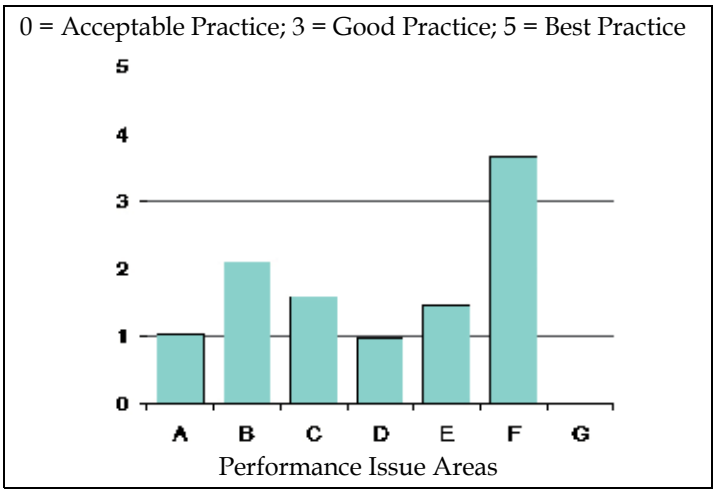


Table 12. Performance Issue Areas

It indicates that the area F, which is Social and Cultural aspect scored the highest performance issue. The Energy and Resource Consumption issue is the second highest. The result does not show that LEO building is reflect to its design purposes as low energy building. This is due to numerous criteria and weights in the tool that could not be identify during the assessment. Due to the complexity of the tool to evaluate those criteria.

Some of the criteria needs data that which not a common practice in developing country like Malaysia such as embodied energy of the materials. This features give great impact to lower down the result under several issue.

5.6%	**A**	**Site Selection, Project Planning and Development**	
41.7%	A2	Project Planning	
66.7%		A2.4	Provision of surface water management system.
0.0%		A2.5	Availability of potable water treatment system.
0.0%		A2.6	Availability of a split grey / potable water system.
33.3%		A2.7	Collection and recycling of solid wastes in the community or project.
0.0%		A2.8	Composting and re-use of sludge in the community or project.
58.3%	A3	Urban Design and Site Development	
34.3%		A3.3	Encouragement of walking.
0.0%		A3.4	Support for bicycle use.
25.7%		A3.5	Policies governing use of private vehicles.
5.7%		A3.7	Use of native plantings.
22.9%		A3.8	Provision of trees with shading potential.

Table 13. Parameters and Weights for Project Planning and Development

7.2.1 Site selection, project planning and development

The result under Site Selection, Project Planning and Development (Table 13) weighted score at 1.0 points. Weights were scored for provision of surface water management system and collection and recycling of solid waste under project planning criteria. These brings the total weights for Project Planning to 2.3 %.While criteria under Urban Design and Site Development ,only one criteria is non applicable that is support for bicycle use. Other criteria under this issue scores 3.2 % in weights. Site selection is non applicable under operation phase.

7.2.2 Energy and resource consumption

However, under Energy and Resource Consumption (Table 14), the total score is the second highest among all the performance issue which is 2.1. But this score does not reflect the LEO building as Energy efficient building because the score has to be 3 and above to feature the good practice of that issue. Renewable energy criteria gives the highest weights. It is not practical to calculate the total life cycle non-renewable energy as LCC is not a common practice in Malaysia and it is skipped due to lack of data. The skipped criteria under this issue are numerous due to lack of data and several methods of assessment are difficult to understand. The formula used to calculate the energy consumption does not tally with Malaysian practice and it is skipped due to lack of data and resources.

18.5%	**B**	**Energy and Resource Consumption**	
26.3%	B1	Total Life Cycle Non-Renewable Energy	
0.0%		B1.2	Annual non-renewable primary energy used for facility operations
10.5%	B2	Electrical peak demand for facility operations	
31.6%	B3	Renewable Energy	
0.0%		B3.1	Use of off-site energy that is generated from renewable sources.
100.0%		B3.2	Provision of on-site renewable energy systems.
31.6%	B5	Potable Water	
0.0%		B5.1	Use of potable water for site irrigation.
0.0%		B5.2	Use of potable water for occupancy needs.

Table 14. Parameters and weights for Energy and Resource Consumption

7.2.3 Environmental loading

Issue of Environmental loadings scores 1.6 and the parameters contribute to this score are green house emission, retention of rainwater for later re-use, changes of biodiversity on site and heat island effect(Refer table 15) All of this parameters contribute to 28% weights under this issue.

Even though the weight is the highest weight, the weighted scores does not reflect the scenario. The reason is, the tool has a few numbers of file that relates to each others and formatted to get the result.

The assessor also had a very difficult moments to set the required data as the excel file provide by the inventor has several formulation problems.

27.8%	**C**	**Environmental Loadings**	
11.4%	C1	Greenhouse Gas Emissions	
0.0%		C1.2	Annual GHG emissions from all energy used for facility operations.
20.5%	C2	Other Atmospheric Emissions	
0.0%		C2.1	Emissions of ozone-depleting substances during facility operations.
0.0%		C2.2	Emissions of acidifying emissions during facility operations.
0.0%		C2.3	Emissions leading to photo-oxidants during facility operations.
6.8%	C3	Solid Wastes	
100.0%		C3.2	Solid waste resulting from facility operations.
20.5%	C4	Rainwater, Stormwater and Wastewater	
40.0%		C4.1	Liquid effluents from facility operations sent off the site.
20.0%		C4.2	Retention of rainwater for later re-use.
40.0%		C4.3	Untreated stormwater retained on the site.
13.6%	C5	Impacts on Site	
81.8%		C5.3	Changes in biodiversity on the site.
18.2%		C5.5	Minimizing danger of hazardous waste on site.
27.3%	C6	Other Local and Regional Impacts	
50.0%		C6.3	Heat Island Effect - landscaping and paved areas.
50.0%		C6.4	Heat Island Effect - roofing.
0.0%		C6.5	Atmospheric light pollution.

Table 15. Parameters and weights for Environmental Loadings

7.2.4 Indoor Environmental Quality (IEQ)

As we can see, the score for Indoor Environmental Quality (IEQ), (Table 16), issue (1.0) is equivalent to the first issue- Project Planning and Development. However, it is different in weights as IEQ weights 23%.This is because the skipped criteria in IEQ,(ventilation and noise criteria) due to lack of data , gives significant impact by lower down the result .Indoor air quality gives the highest weights as the monitoring is conducted by BEMS.

23.1%	**D**	**Indoor Environmental Quality**	
36.8%	D1	Indoor Air Quality	
0.0%		D1.4	Pollutant migration between occupancies.
0.0%		D1.5	Pollutants generated by facility maintenance.
0.0%		D1.6	Pollutants generated by occupant activities
0.0%		D1.7	CO2 concentrations in indoor air.
100.0%		D1.8	IAQ monitoring during project operations.
23.5%	D2	Ventilation	
0.0%	●	D2.1	Effectiveness of ventilation in naturally ventilated occupancies.
0.0%	●	D2.2	Air quality and ventilation in mechanically ventilated occupancies.
0.0%	●	D2.3	Air movement in mechanically ventilated occupancies.
100.0%	●	D2.4	Effectiveness of ventilation in mechanically ventilated occupancies.
8.8%	D3	Air Temperature and Relative Humidity	
50.0%	●	D3.1	Air temperature and relative humidity in mechanically cooled occupancies.
50.0%	●	D3.2	Air temperature in naturally ventilated occupancies.
13.2%	D4	Daylighting and Illumination	
0.0%		D4.1	Daylighting in primary occupancy areas.
100.0%		D4.2	Glare in non-residential occupancies.
0.0%		D4.3	Illumination levels and quality of lighting in non-residential occupancy design.
17.6%	D5	Noise and Acoustics	
0.0%		D5.1	Noise attenuation through the exterior envelope.
0.0%	●	D5.2	Transmission of facility equipment noise to primary occupancies.
0.0%		D5.3	Noise attenuation between primary occupancy areas.
0.0%		D5.4	Acoustic performance within primary occupancy areas.

Table 16. Parameters and weights for Indoor Environmental Quality

7.2.5 Service quality

Under the Service quality issue (Table 17) , controllability criteria gives the highest score. This is due to efficiency of building management and security system as the building is equipped with a comprehensive Building Energy Management System (BEMS) that is

integrated with Building Control System (BCS).BEMS monitors the building energy consumption.

The total score is 1.6 and the overall weights is 18%. Maintenance of operating performance criteria also contribute to the weights and scores.

16.7%	**E**	**Service Quality**	
6.4%	E1	Safety and Security During Operations	
8.1%		E1.6	Maintenance of core building functions during power outages.
12.8%	E2	Functionality and efficiency	
0.0%		E2.5	Spatial efficiency.
0.0%		E2.6	Volumetric efficiency.
25.5%	E3	Controllability	
50.0%		E3.1	Provision and operation of an effective facility management control system.
33.3%		E3.2	Capability for partial operation of facility technical systems.
16.7%		E3.3	Degree of local control of lighting systems in non-residential occupancies.
0.0%		E3.4	Degree of personal control of technical systems by occupants.
6.4%	E4	Flexibility and Adaptability	
0.0%		E4.1	Ability to modify facility technical systems.
4.3%	E5	Commissioning of facility systems	
44.7%	E6	Maintenance of Operating Performance	
0.0%		E6.1	Maintenance of building envelope performance.
16.7%		E6.3	Development and implementation of a maintenance management plan.
16.7%		E6.4	On-going monitoring and verification of performance.
33.3%		E6.5	Retention of as-built drawings and documentation.
16.7%		E6.6	Provision and maintenance of a building log.
0.0%		E6.7	Performance incentives in leases or sales agreements.
16.7%		E6.8	Skills and knowledge of operating staff.

Table 17. Parameters and weights for Service Quality

7.2.6 Social and economic aspects

The score for Social and Economic aspects (Table 18) is 0 although the weights within all active parameters is 6%. The weightage for this criteria -Access to views from work areas is too little to derive score for this aspect.

5.6%	**F**	**Social and Economic aspects**	
20.0%	F1	Social Aspects	
0.0%		F1.6	Access to views from work areas.
80.0%	F2	Cost and Economics	
0.0%		F2.1	Minimization of life-cycle cost.
0.0%		F2.3	Minimization of operating and maintenance cost.
0.0%		F2.5	Support of Local Economy.
100.0%		F2.6	Commercial viability

Table 18. Parameters and weights for Social and Economic aspects

7.2.7 Cultural and perceptual aspects

This scenario is also identical to the Cultural and Perceptual aspects (Table 19) where the weights is 3% and scores is 0. This is due to common practice in Malaysia of not covering required parameter.

2.8%	**G**	**Cultural and Perceptual Aspects**	
100.0%	G1	Culture & Heritage	
0.0%		G1.3	Maintenance of heritage value of existing facility.

Table 19. Parameters and weights for Cultural and Perceptual Aspects

Some of the practices are available but the method of calculation contribute to lack of data required. As a result, the criteria has to be skipped off from the list.

8. Overall comparison

As to compare both tools issue and criteria, experts review have been achieved from the construction industry professionals. They are selected from their expertise in various fields of the issues and criteria of both tools.

The result of both tools has been presented to them to get their feedback on the suitability of the tool to be adopted in Malaysia. Their reviews are based on the current practices in Malaysia.

Table 20 shows the overall result of both tools. It shows the differences and the percentage of scoring on every issues.

GREEN MARK			SBTOOL			
	Scores	Percentage	To see a full list of Issues, Categories and Criteria, go to the Issues worksheet.		Active Weights	Weighted scores
Part 1: Energy Efficiency	25/25	100%	A	Site Selection, Project Planning and Development	6%	1.0
Part 2: Water Efficiency	7/15	46.6%	B	Energy and Resource Consumption	19%	2.1
Part 3: Building Management & Operation	16/25	64%	C	Environmental Loadings	28%	1.6
Part 4: Indoor Environmental Quality and Environmental Protection	13/15	86.6%	D	Indoor Environmental Quality	23%	1.0
Part 5: Innovation	20/20	100%	E	Service Quality	17%	1.5
			F	Social and Economic aspects	6%	3.7
			G	Cultural and Perceptual Aspects	3%	0.0
Total score	81/100		Total weighted building score			1.6

Table 20. Total scores for Green Mark and Total weighted building scores for SBTool

8.1 Expert review on Green Mark

The Green Mark Assessment method is getting the higher acceptance by the reviewers because it is straight forward and easy to carry out the assessment. The assessment duration is only one(1) day. The issue, criteria and parameters are very comprehensible in description and understood by all the reviewers. They can determined the sequence of the scores from the assessment sheet given. Overall scores are derived from the clear descriptions of each parameter. It is also easy to determine the components to be accessed and expertise needed as the descriptions and the marks given are clearly stated.

The assessment for Part 1-Energy efficiency achieved a full scores due to similarity in codes of practices. Energy efficiency and use of renewable energy is a central part of any environmental labelling system. In addition, in many countries, energy efficiency is part of mandatory regulations for new buildings. In those countries, the minimum standards for energy efficiency for new buildings will constitute the minimum standard in the labelling scheme, and levels above that contributes to achieve a higher scoring that 'Just Certified' will be defined.

In Malaysia, the Malaysian Standard for Energy Efficiency and use of Renewable Energy, MS 1525:2007, will become part of the Uniform Building By-Laws in 2008, as the Ministry of Housing and Local Government is expected to table a law in parliament to that effect. Under energy efficiency index, the minimum performance for office building required by Singapore practice is 240 to 220 kWh/m2/yr. This index is similar to MS 1525 standard.

From expert reviews, Air Conditioning systems and Lighting Systems shall comply with SS 530 Code of Practice for Energy Efficiency Standard for Building Services and Equipment Ventilation compliance to SS CP 13 Code of Practice for Mechanical Ventilation and Air-Conditioning Standards for Air Tightness and Leakage. Electrical sub-metering Luminance Level according to Code of Practice for Workplaces, SS 531:Part 1 : 2006. Green Mark Gold^{plus} at least 25% energy savings and Green Mark Platinum: at least 30% energy savings. The LEO building has fulfilled the above requirements.

The Environmental Thermal Transmission Value (ETTV) cannot exceed 50 W/m^2. There are maximum U-values for the roof (0.5 W/m2K for light roofs) two points for every 1 W/m2 in ETTV improvement. Extra points are given for reduction west façade walls and windows, and improvement of the roof insulation above base level. Extra points are also given for natural ventilation of car park, for improved electric lighting efficiency, improved ventilation of common areas and improved efficiency of lifts and escalators. Another extra points given by reviewer for improvement of the chillers' efficiency, the Unitary Air Conditioning efficiency and air distribution efficiency above minimum standard.

Points also given for other Energy Efficiency practices, such as using motion sensors, daylight pipes, heat recovery systems etc. Renewable Energy in the building was given up to 20 points, 5 points for each 1% of electricity consumption covered by Renewable Energy. The reviewers found that Green Mark Assessment method is suitable to be understand by building owner in Malaysia. The reason given by them is the practicality of the method (easy identification of features and points), saving time and cost efficiency .This tool also reflect the LEO building as an energy efficient building as derived by the results.

For other Part such as water efficiency, building management and operation, Indoor environmental quality and Innovation, reviewers agreed that Malaysia has to improve performance on those parts. This is due to the lack of maintenance practices and lack of requirement by statutory bodies. They suggested that the comprehensive guidelines on sustainable building must be taking into place before the assessment could be made.

8.2 Expert review on SBTool

Overall comments from the reviewers are the difficulties to understand the flow and how to aggregate data. It is also complicated because this assessment method needs a wide range of

experts and ample of time must be given to access the parameter. It takes about 3 weeks to collect data and complete the assessment and another week to compute the result. This is because of several adjustment and more information have to be synthesised to evaluate the result. So, time consuming made the tool less favourable among the experts.

The complicated structure of the tool made the assessor confuse and tend to misleading the assessment. This is because all the related Microsoft Excel files for the said tool have to be opened simultaneously. If the assessor fail to do so, the data that keyed into the file cannot be linked and the expected result will be faulty. There are too many criteria to be assess. It seems to be comprehensive but this made the assessment work complicated.

Furthermore, in SBTool, the score gained under each criteria does not reflex the final result. This is because, the score has to be multiple with the weigh tage under each criteria to get the final score. Even though the score is higher but the weightage is lowed, overall result will still be low. The significant of the achievement will be controlled by the weightage. The weightage plays an important roles determining the score of the criteria. However, the expert collective agreement conclude that it is difficult to set the weightage as the data for each criteria must be easy to obtain. Unfortunately, Malaysia lack of the important data needed to form the weightage.

According to Nil Larsson, the result of SBTool, which is +1 is good. This assessment can be a yardstick to evaluate the environmental performance of an office building in Malaysia. Further studies can be done to unveil on the non complaint issue of SBTool on LEO building. This will help to develop a comprehensive rating system that recognise worldwide.

8.3 The non-compliance criteria

The non-compliance criteria were identified from the above result. The Green Mark only have one non-compliance criteria to Malaysian building practice – Indoor Air Quality Audit. The SBTool non compliance criteria covers of seven aspect framework from Project Planning and Development, Energy and resource consumption, Environmental loadings, Indoor Environmental quality, Service Quality, Social and economic aspects, Cultural and perceptual aspects. As we can see from the result, SBTool key component have a significant number of sustainable features evaluated comparing to Green Mark and the SBTool framework are comprehensive. The SBTool system is a rating framework or toolbox, designed to allow countries to design their own locally relevant rating systems. SBTool is designed to include consideration of regional conditions and values, in local languages, but the calibration to local conditions does not destroy the value of a common structure and terminology. These key components of SBRS are the critical features to evaluate sustainable building. They are the factors that need attention from the building owner for determining the sustainability of their office building. Further studies can be done to identify the factors of non-compliance criteria of SBRS for Malaysian building from SBTool and to calibrate the tool to local conditions.

8.4 Findings of evaluation result

The overall result, explain the effectiveness of the selected SBRS tools. From the overall result it is findings that the effectiveness of the evaluation procedure can be achieve through:

i. Adapting the applicable tool to local use. This can save time and cost of developing new tools. Furthermore, the result can be used to develop more localise tools.
ii. Cost effective-Identify the cost of using a system, including cost for use or rating system materials, cost of project registration, fees associated with certification.
iii. Ease of Use for local expert: Complexity of the tools and technical knowledge needed to complete rating system process, especially for the optimization of energy use, environmentally preferable products use, and indoor environmental quality enhancement.
iv. Save time- time typically needed to complete the assessment from registration, application and result.
v. Product support: Availability and responsiveness of direct requests for assistance, availability of training, and usability of information available on the website, through case studies, documented inquiries, and frequently asked questions.
vi. The structure of the SBRS tools can be adapted to local context - the issues, criteria and benchmark must be comprehensive and suit the local context or can be customised to local contact.
vii. The criteria of assessment is understandable by local expert and common practice of the industry-e.g. energy policy.
viii. The procedure of interpreting the scores given must be easy to derive.
ix. The knowledge and skills of building expert on the building environmental practice and current technologies of sustainable building performance. e.g., materials use, use of recycle material, embodied energy of the material used, etc. Building expert also must develop skills on the use of SBRS Tools.
x. Building industry practice – develop more code of practice on building sustainability issues.
xi. Research and development by local universities on the absent data such as embodied energy of material used, biodiversity, etc.

9. In-depth interview analysis

The aim of this study is to explore the SBRS issues and implementation in Malaysia building industry. The use of in-depth interview with the building expert enable the study to get a clear picture of what is actual phenomena in the real situation. To explore the current issues, the issues are discussed under the following heading:

i. Moving into sustainability practice
ii. Understanding on SBRS issue
iii. Factors that influent the implementation
iv. Encouragement to existing building stock

9.1 Interview questions responses

Participant 1

The first participant is a consultant architect with few sustainable building project being awarded in recent years and he is one of the GBI certifier. He has been involved in sustainable building practice since year one of his undergraduate studies in Australia. So, according to him, sustainable building practice is not a new issue but recently gaining

importance due to climate change, CO2 emission and other environmental impact to the building. Due to this ,he directs his work to provide sustainable building features seriously for the past five years and involves in SBRS implementation for Malaysian building.

He said that all SBRS issue are important to reach building sustainability, resulting in him to covering all the important issues when he designed a building. He stated that SBRS will be successful in Malaysia due to strong support by the government, industry and public. The Malaysian government gives full support to the SBRS implementation by giving tax reduction to certified building and many incentives to the building developers, property owners and publics. In Malaysia, the government driven by the public but in Singapore the government push the public to implement SBRS. As he said, GBI received strong support from the industry with forty over building had submitted their registration for GBI certification. He believed that by end of 2009, there will be more building certified as for now (September 2009) one building had been certified (Pusat Tenaga Malaysia).

As to encourage the existing building stock to become sustainable, he believes that education is the key. He says that we must educate the existing building owners on the benefits and cost reduction when we reduce the BEI of (Building energy index) the building. The GBI rating system currently assess new building only but he said that the new SBRS for existing buildings will be issue in the middle of next year. He also says that the green technology never affected by the economic crisis .As for Malaysia, major developers such as Sime Darby, Sunway, support SBRS by implementing the sustainability features to their projects and registered for GBI certification.

Participant 2

The second participant is also a professional architect and GBI certifier. He says that SBRS is a system that will show us how building performed over time. In the long run, it will save energy, money ,investment and also environment. He has been involved in sustainable design since his college days.

His sustainable building design knowledge improves during training on site. He tries to make the sustainable building to comply as to design a building that kind to environment. He says that, SBRS in Malaysia start 1 1/2 years ago with the assistant of IEM (Institute of Engineer Malaysia). After a year they came up with GBI. Before that MIA, IEM and BCA Singapore worked together to modelled GBI. But, GBI differ from Green Mark because in term of geographical area, Singapore is small and more efficient whereas Malaysia is larger and having many authorities that control the building practice.

He says that Malaysian government under the Ministry of Finance supports Green technology. Under GBI, the last issue discussed is Innovation, designers can come out with any idea that they think appropriate to make the building more sustainable. Government encouragement of sustainable building issue is very important. They try to make MS1525 mandatory as a benchmark for minimum standard of energy efficiency. This will be incorporated with Uniform Building By Law.

He added that industry must drive the SBRS. Developers must develop sustainable building and certified GBI and public will help in term of buying the certified property. As in Singapore and Australia, the certified building will get higher rental rate. This is proven through the good indoor environmental quality that improve the productivity and quality

of health. This is what we can educate our existing building owners. The cost of sustainable building is higher but we can get more benefits .But the problem facing by Malaysia is inefficiency of our public transport . The building is located quite far and not a walking distance from public transport. This makes the designer having the needs to provide more parking space. Due to this situation, traffic jam is the main problem in the city. So according to him, a lot more we have to do to educate client, owners, government and public in terms of sustainability. Government must promote and encourage people to buy sustainable building and also make the people change their lifestyle towards green issue and energy saving.

He agree that SBRS can be successful in Malaysia due to the great interest from government authority . Almost every week, various government departments requested the GBI certifier to give talks on the new SBRS. This seems to contribute to more educated people on the SBRS issue.

Participant 3

The third participant is the building energy manager. He has over 10 years experience with sustainable building and SBRS issues. According to him, energy efficiency and sustainable features are interrelated. The government first designed the Leo building to implement the MS1525 and to make it as a showcase to the public on the sustainable building features. This is to promote sustainable building as a practice and to show that MS 1525 code of practice can be achieved. He said that SBRS can help to measure the performance of sustainable building. It is an appropriate yardstick as it covers almost all related issues of sustainable building. The main important features to him is energy efficiency. As the government through PTM (Pusat Tenaga Malaysia) promoted Suria 1000, the solar panel for residential housing, it was totally sold out within a short period. This phenomenon shows that the acceptance of the public on the sustainable building is very great. But he says education is still important as this situation only reflects to the well known developer that encourage sustainable development in their building projects. Understanding sustainable features is very important in order to implement the SBRS . We have to educate the building industry player on the advantages of SBRS certification to their building. Cost is a very important issues in construction. If they realise that sustainable building can reduce their maintenance cost and increase rental income, we don't have to force them to implement the sustainable features. They will do it on voluntarily. This will also encourage the owner of existing building stock to implement sustainable features on their building.

In his opinion, government support is the most important means of promoting SBRS. Malaysian government gives full support on sustainable issues by giving more and more incentives to the building that will be certified by GBI later. This will ensure the successful of SBRS implementation in Malaysia.

9.2 Moving into sustainability practice

The participants have been practising sustainable building design since undergraduate studies. According to participant 1, recent scenario on the climate change had directed them into sustainable building practice. This is due to the minimizing the environmental impact of the building and green issues that promoted worldwide. Participant 2, said that his knowledge on sustainable building improved during his training on site. The practice make

sure that the building comply to the sustainable standard that kind to the environment. Whereas, participant 3 is a building energy manager. His nature of work put him into the strong practice of sustainability.

9.3 Understanding on SBRS issue

All participants agree that understanding SBRS issue is important in order to promote SBRS to Malaysian building. Participant 1 agree that the industry is driven by the public. The public request for sustainable building to be develop and they need the tools to measure the performance of the building. So, SBRS is a yardstick to measure the building sustainability performance .All participants agree that understanding of SBRS issues can be achieved through education.

9.4 Factors that influent the implementation

According to participant 1,SBRS will be successful due to the strong support by the government, industry and the user. The Malaysian government plans to give tax reduction and more incentives for certified building. Strong support from the industry with over 40 building project registered for certifications also shows that SBRS will be successfully implemented in Malaysia. He ends with the statement that current economic crisis never affects green technology. This is due to a very good respond from the reputable developer in Malaysia like Sime Darby and Sunway to certified their building projects recently. Likewise, the remaining participants also agree with the first participant statement. Participant 3 added that encouragement by government to use alternative energy sources like providing solar panel at subsidised rate is very supportive. But according to participant 2, the current development of transportation in Malaysia is quite discouraging. The public transportation is not located within walking distance to the building. This will discourage the public from using the public transport. The use of more vehicle will increase the CO2 emission and contribute to global warming. But, according to him, the government interest in SBRS is very encouraging where various of departments asking for GBI talks almost every week. This phenomena will enhance their knowledge and acceptance of SBRS.

9.5 Encouragement to existing building stock

Participant 1 says that education is the key to encourage the existing building stock owners to implement SBRS. We must explain to them the benefits of reducing the BEI (Building Energy Index) to the maintenance cost of the building. Participant 2 and 3 also agree with the first respondent that by explaining the benefit of sustainable building and giving them example of successful building, the building owners will voluntary implement the features. Their investment is very important and to prolong the steady income, they have to be courageous to change the thought. All the participants added that with the new existing building tool that will come out in 2010, the existing building owner will be more encourage to invest in sustainability.

9.6 Findings on the effect of SBRS implementation

The finding of this section uses logic models evaluation (Figure 4.3). Joseph Wholey (1979) who is at the forefront in developing logic models as an analytical technique. The logic

model deliberately stipulates a complex chain of event over time (Yin,2003). The event are staged in repeated cause effect-cause-effect patterns, whereby a dependant variable (event) at an earlier stage become the dependant variable(causal event) for the next stage(Peterson & Bickman,1992; Rog & Huebner,1992).

Figure 1 illustrate the integration of government support, building industry support and public awareness in implementing sustainable building rating system for Malaysian building.

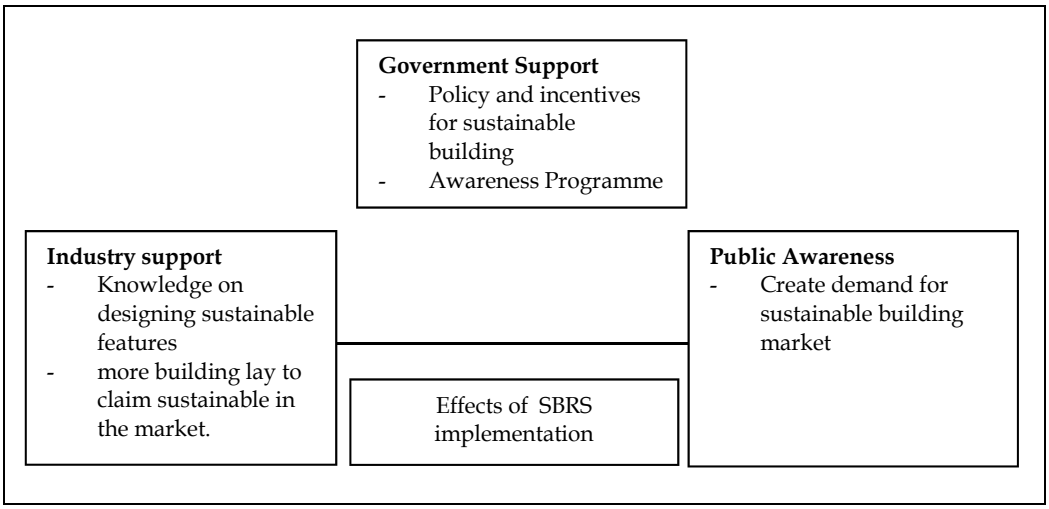
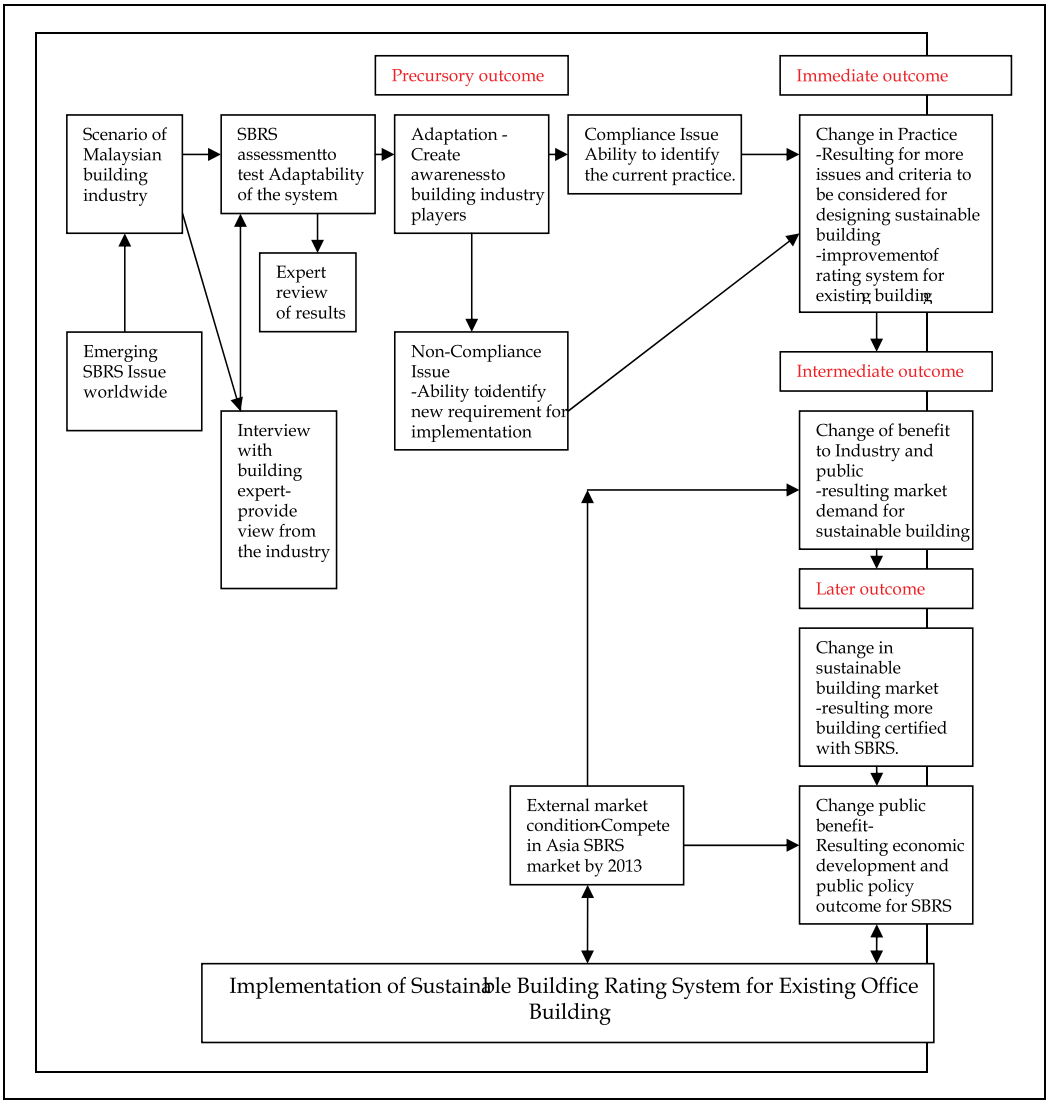


Fig. 1. The scenario of Malaysian building industry.

The overall outcome for this study is illustrated in figure 2 using logic model. The researcher begin the study with three sources of data from the scenario of Malaysian building industry, building assessment to LEO Building and interviews with the building industry player that expert in SBRS. Expert review are conducted to validate the result. The objectives of the assessment are to test the adaptability of SBRS to Malaysian building using existing office building version. This is to provide knowledge and understanding on the implementation issues arise. The compliance criteria are able to identify Malaysian building current practice that comply to the SBRS criteria. The non-compliance criteria are able to identify the required criteria which is absent in Malaysian building industry practice. This is called The precursory outcome.

The intermediate outcome from the study is the change in practice by the Malaysian building industry, resulting for more issues and criteria to be considered for designing sustainable building and development of rating system for existing building. The intermediate outcome is the change of benefit to the industry and public, resulting market demand for sustainable building. This will also effect the external market condition in Asia.

The later outcome is the change in sustainable building industry market resulting more building in Malaysia eager to claim for sustainable building. This will also change the public benefit, resulting economic development and public policy outcome for SBRS implementation. The later outcome will also effect the external market condition for Malaysia to compete in Asian SBRS market by 2013. The whole outcome is the model of



Adapted from Yin and Oldsman (1995)

Fig. 2. The effect of SBRS Tools implementation for existing office buildings.

changes in the Malaysian building industry that support the implementation of sustainable building rating system. The models shows the effects of SBRS implementation on Malaysian office buildings;

i. Adaptation of SBRS create awareness to Malaysian building industry players.
ii. The compliance issues enable us to identify the current practice that complies to international standard.
iii. The non-compliance issues enable us to identify new requirement needed in order to comply with international standard.

iv. Those issues b) and c) will result in changes in practice; more issues and criteria to be considered for designing sustainable building - improvement of rating system for existing building.
v. The change in practice will benefit the industry and public; this will create market demand for sustainable building.
vi. The effect of demand for sustainable building will result for more building certified with SBRS to cater for sustainable building market.
vii. Demand for sustainable building will result public policy outcome for SBRS as the public are aware of the benefit.
viii. The later effect will able be to competent to external market, Malaysia to compete in Asian SBRS market by 2013.

10. Conclusion

As the conclusion, the comparison on both SBRS are made using three approach- Theoretical Comparison Analysis, Evaluation comparison analysis and Overall Comparison. Under Theoretical Comparison Analysis, both SBRS are compared based on the essence of the SBRS and how the SBRS evaluates sustainability. This framework is used to give better understanding of the SBRS structure with academically recognised terminology and methodology. The evaluation comparison analysis as a means of collecting, analyzing, calculating data to get all the criteria scored. On the other hand, overall comparison is carried out to compare both tools issue and criteria, by experts review from the construction industry professionals. As the conclusion for the interviews, the researcher explores the current issues, and discussed under the following heading:

i. Moving into sustainability practice
ii. Understanding on SBRS issue
iii. Factors that influent the implementation
iv. Encouragement to existing building stock

From the result and experts review, it is define that the structure of the tools will contribute to the understanding of how the tool evaluate sustainability. The finding of this study uses logic models for identifying the effects in implementing SBRS in Malaysia. The overall result, explain the effectiveness of the selected SBRS tools. From the overall result it is discovered that the effectiveness of the evaluation procedure can be achieve through adapting the suitable SBRS tools, expert knowledge and understanding on the evaluation procedure, construction industry practice and acceptance by the stakeholder.

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8

Mapping is a Key for Sustainable Development of Coastal Waters: Examples of Seagrass Beds and Aquaculture Facilities in Japan with Use of ALOS Images

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1. Introduction

Sound coastal ecosystems provide important ecological services such as food supply, nutrient cycling, and stabilizing effects of environments (Costanza et al., 1997). They are indispensable for sustainable development of coastal areas. However, human impacts such as fisheries or reclamation destroy coastal environments and ecosystems (e.g. Huitric et al., 2002). To conserve or restore sound coastal ecosystems, it is necessary to know present situation of coastal areas including coastal ecosystems such as seagrass beds, seaweed beds, coral reefs and tidal flats, and also human activities such as fisheries related facilities and reclamation. Diving and observation from the boat are usually used for checking bottom habitats. However, these methods are laborious and time consuming (Komatsu et al., 2002a). If a boat is employed to survey a broad area with many aquaculture facilities, it requires a long time to survey it due to obstruction of rafts against navigation. The survey with the boat is unsuccessful to localize many aquaculture facilities with GPS in the cases that the boat can't easily approach to the aquaculture facilities due to ropes and rafts. Thus, it is desired to develop efficient mapping and monitoring systems of coastal areas.

Satellite remote sensing has been developed for land use studies in forestry and agriculture but not for sea surface utilization studies in fisheries science. One of the reasons of less attention on the sea surface utilization studies using satellite remote sensing is attributed to low spatial resolution of satellite images formapping such as LANDSAT (resolution: 30 m) and SPOT (resolution: 15 m) (Jensen and Cowen, 1999). Aerial photography, which has a high spatial resolution, has been used to analyze objects smaller than 4 m. However, aerial photography requires geometric correction and mosaic processing of scenes. Recently, multiband images with high spatial resolution have been provided. Commercial ones are QuickBird, IKONOS, Worldview2 etc., and non-commercial one is ALOS AVNIR-2. ALOS launched on by Japan Aerospace Exploration Agency [JAXA] in 2006 has a multispectral sensor, AVNIR-2, with 10 m spatial resolution and a panchromatic sensor, PRISM, with 2.5

m spatial resolution. These sensors, spatially more precise than those of LANDSAT 7 ETM, may permit us to map coastal areas with various ecosystems and fishing activities.

For sustainable development of fisheries, it is necessary to conserve coastal habitats such as seagrass and seaweed beds that play an important role in marine coastal ecosystems. Seagrass beds support flora and fauna, including epiphytic organisms, as well as coastal fisheries (Coles et al., 1993; Fortes, 1996), and contribute to the marine environment by stabilizing bottom sediments and maintaining coastal water quality and clarity (Jeudy de Grissac and Boudouresque, 1985; Komatsu et al., 2004; Komatsu and Yamano, 2000; Ward et al., 1984). Additional effects of seagrass beds include those of seaweed forests such as buffering of water flow (Komatsu and Murakami, 1994), pH distribution (Komatsu and Kawai, 1986), and dissolved oxygen distribution (Komatsu, 1989; Komatsu et al., 1990). Many commercially important species spawn in seagrass beds (e.g. sea urchins, balaos, cuttlefish); larvae and juveniles use the beds as nursery grounds (Arasaki and Arasaki, 1978). Thus, seagrass beds support biodiversity and are an important habitat for marine animals.

Increased seafloor reclamation and industrial and agricultural pollution as a result of economic development have decreased the size of large areas of seagrass beds in coastal zones (e.g., Hoshino, 1972; Komatsu, 1997). Since seagrass beds are sensitive to pollution and water quality deterioration, they serve as "bio-indicators". Lower depth limit of seagrass distribution in Chesapeake Bay was used as a bio-indicator when runoff impacted water quality, causing changes in light penetration and consequently affecting seagrass abundance and distribution patterns (Dennison et al., 1993). Monitoring has also been carried out at 24-33 survey sites along the coast of Provence and the French Riviera since 1984, using the lower limit of *Posidonia oceanica* L. as a bio-indicator, (Boudouresque et al., 2000). Thus, mapping of seagrass beds is a very practical method to assess the condition of coastal environments.

Recently, it has been stressed that preservation, restoration, and creation of seagrass beds are necessary to recover coastal environments, biodiversity, and bioresources for sound littoral ecosystems and for the sustainable development of fisheries. To preserve or conserve seagrass beds, it is very important to map and monitor them (Lee Long et al., 1996). This study examined possibility of ALOS AVNIR-2 images as recent non-commercial ones for mapping seagrass beds as a typical coastal habitat. We targeted seagrass beds in Akkeshi Lake, Hokkaido Island, in boreal waters in Japan.

In coastal waters, aquaculture has been developed in the world since 1980s (Katsuky et al., 2000). On the other hand, aquaculture has sometimes destroyed natural ecosystems. For example, it is well known that shrimp aquaculture has caused deforestation of mangrove forests. Therefore it is needed to establish databases and information networks to collect, share and disseminate data related to aquaculture activities to manage aquaculture facilities for sustainable development of coastal fisheries. Sound aquatic ecosystem has to be also conserved and maintained for sustainable development of fisheries and society. Thus it is necessary to monitor present states of fisheries and aquatic ecosystem.

In Japan, aquaculture has been already developed since 1970s. A lot of aquaculture facilities are deployed in sheltered waters. Fishermen's cooperatives manage practically fishing rights in coastal waters on behalf of a local government. Usually, a map of fishing right territory used for management depicts not positions of each fishing gear and facility but only zones of fisheries in coastal waters. When aquaculture facilities are numerous, it is difficult to map all by sea truthing. When more than one fishermen's cooperative exist in the bay, it is hard

to map aquaculture facilities with the same method or at a same level of precision by hearing from the coopeartives.

We tried to map aquaculture facilities in Sanriku coast, Japan, where shell fish and seaweed aquacultures are developed intensively, by the satellite remote sensing using ALOS AVNIR 2 with PRISM satellite images with high spatial resolution.

This chapter apply satellite images taken by ALOS to map seagrass beds in Akkeshi Lake in Hokkaido Island and many aquaculture facilities in Yamada Bay along the Sanriku Coast for developing methods to monitor present situations of coastal waters.

2. Study sites and methods

This section describes here study sites and methods for mapping seagrass beds and aquaculture facilities.

2.1 Seagrass beds in Akkeshi Lake

Akkeshi Lake is located in Hokkaido Island northern part of Japan facing the Pacific Ocean (Fig. 1). This area belongs to boreal coastal waters. Although Akkeshi Lake is a bay, it is called "lake" as a geographical name. Hereafter we use its geographical name, Akkeshi Lake. The maximum bottom depth was 9 m. The seawater comes into the lake by tidal currents through the narrow bay mouth (400m). Since Nature Conservation Bureau, Environment Agency of Japan (1994) reported that broad seagrass, *Zostera marina* L., was distributed in this lake, it is suitable for examining possibility of AVNIR-2 images to map seagrass beds in shallow waters. Inside the lake, aquacultures of oysters and manila clams have been developed on the tidal flats since 1930s. Seagrass beds are an important source of particulate organic matter as foods for oysters and clams. Therefore conservation of seagrass beds is needed for sustainable aquacultures.

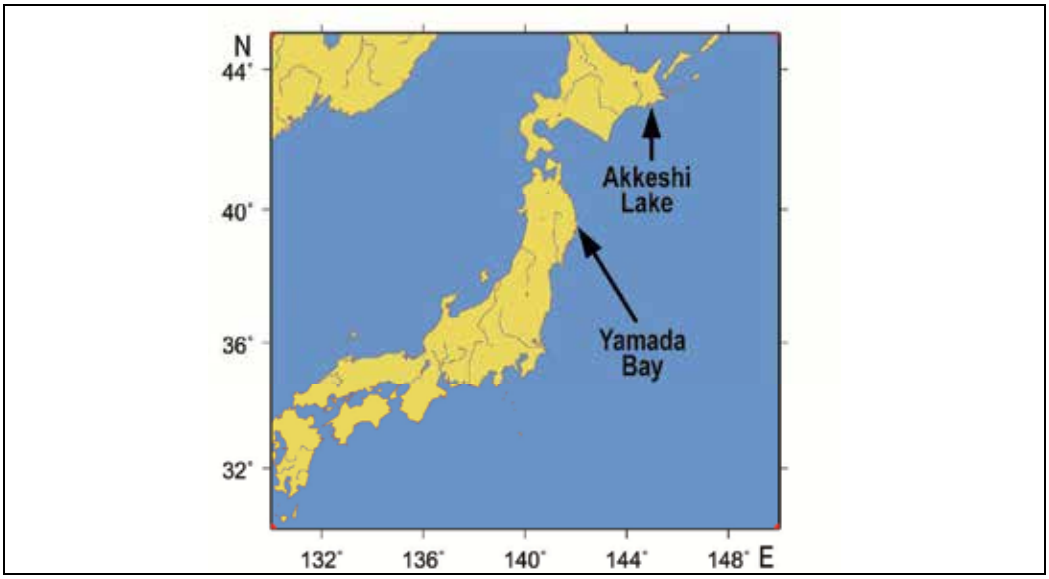

Fig. 1. Map showing Akkeshi Lake and Yamada Bay in Japan

2.1.1 Sea-truthing survey

In applying a remote sensing method for mapping seagrass beds, field surveys are essential for sea truth (Lee Long et al., 1996). Sea truth of bottom substrates was conducted from 30 June to 3 July 2009. A researcher observed bottom feature from the boat localizing survey points with a portable Differential-GPS (D-GPS) and divers with SCUBA took seagrass samples within a quadrate of 0.5 x 0.5 m^2 at 6 stations consisting of three from dense and the others from sparse seagrass beds. Samples of seagrass were preserved in plastic bags with 10 % formalin seawater.

2.1.2 Seagrass biomass

Plant materials were rinsed in fresh water and cleaned of sand and shells in the laboratory. Shoot density (i.e. density of only the above-ground foliar portions of a plant) and shoot length (i.e. length from the bottom end of a shoot to the top of the longest blade) were measured. Samples were also sorted into above- and below-ground parts. Epiphytic plants and animals were removed from leaves by dipping the plants into 5% acetic acid water. Wet weights were taken prior to drying the seagrass in a hot-air oven (DX300, Yamato Scientific Co. Ltd) at 60°C for 48 hrs. Dry weights of the samples were then obtained and used to calculate above- and below-ground biomasses. Biomass was expressed as dry weight (g) per unit area (i.e. g DW/m^2), which is the most widely used expression for biomass.

2.1.3 Satellite image and analysis of seagrass distribution

Image data of ALOS AVNIR2 sensor taken on 29 September 2006 were analyzed with image processing software, TNTmips (Microimage Inc., USA). Since the red and especially the near-infrared part of the spectrum attenuate rapidly in water (Mumby and Edwards, 2000), the near-infrared band is usually used for detecting land area (White and El Asmar, 1999). The land area outside the Akkeshi Lake was masked using the infrared band of ALOS AVNIR2 because the terrestrial radiance variations were too wide compared with those occurring in marine areas, preventing us from classifying the sea area accurately. Pixels inside the lake were classified by a supervised classification with regard to the different bottom-type areas. Five different classes were highlighted: dens seagrass and sparse seagrass beds consisting of *Z. marina*, muddy bottom, river turbid water and tidal flats (Fig. 2). Sea-truth data and satellite images were overlaid using the abovementioned software to obtain training data and then to classify every pixel with reference to the five classes designed into dense seagrass beds, sparse seagrass bed, muddy bottom, river turbid water and tidal flat with supervised classification (maximum likelihood method) after masking land area.

2.2 Aquaculture facilities in Yamada Bay

Yamada Bay is located in Sanriku Coast facing the Pacific Ocean. The bay is one of the rias-type ones in Sanriku Coast in temperate coastal waters (Fig. 1). There are a lot of aquaculture facilities for oysters and scallops in the bay. Thus the bay is suitable for the study site.

2.2.1 Fishing right territory and aquaculture licenses

Fishing right territory in Yamada Bay was divided by four fishermen's cooperatives, Yamada, Orikasa, Ohsawa and Oura. Aquaculture facilities were classified into two types:

wood-raft type and buoy-and-rope type. Fishermen used two types of facilities for scallop and oyster aquacultures. Aquaculture license of the former type by Iwate Prefecture stipulated for the size of the raft; it was rectangular and its length and width were 12 m and 4 m, respectively. On the other hand, aquaculture license of the latter type stipulated not for size and color of buoys but for rope length. Clusters of oysters or scallops were attached to vertical rope, which was suspended from the raft or buoy-and-rope facilities. The length of horizontal rope ranged between 50 and 100 m. Number, size and color of buoys depended on a facility. We compared positions of representative rafts and buoy-and-rope facilities localized by image analysis with those by D-GPS in situ. Differences in positions localized with both methods were within several meters equivalent to those of errors of D-GPS.

2.2.2 Satellite image data and analysis of aquaculture facilities

Some satellite images provide a high spatial resolution while other focus on providing several spectral bands. The fusion process brings the information from different sensors with different characteristics together to get the best of both worlds. Most of the fusion methods in the remote sensing deal with the pansharpening technique. This fusion combines the image from the panchromatic sensor of one satellite (high spatial resolution data) with the multispectral data (lower resolution in several spectral bands) to generate images with a high resolution and several spectral bands. Panchromatic sharpening increases the spatial resolution and provides a better visualization of a multiband image using the high-resolution, single-band image where the two rasters fully overlap. JAXA provides low-resolution, multiband images, AVNIR2, with a spatial resolution of 10 m and higher-resolution panchromatic images, PRISM, of the same scenes with a spatial resolution of 2.5 m. Image data of ALOS AVNIR2 and ALOS PRISM taken on 10 September 2006, respectively, were used for producing pansharpened RGB image with the image processing software (TNTmips, Microimage Inc.). There are several methods to produce pansharpened images such as HIS transformation, wavelet transformation etc. We used the Brovey transformation. The Brovey transformation uses a method that multiplies each resampled, multispectral pixel by the ratio of the corresponding panchromatic pixel intensity to the sum of all the multispectral intensities (Anon., 2011). It assumes that the spectral range spanned by the panchromatic image is essentially the same as that covered by the multispectral channels. Enhanced pansharpened image was used to detect aquaculture facilities.

3. Results and discussion

This section introduces results and discussion about mapping of seagrass beds in Akkeshi Lake and aquaculture facilities in Yamada Bay, respectively.

3.1 Seagrass beds in Akkeshi Lake

3.1.1 Sea survey

Sea survey revealed that broad seagrass beds were distributed whole lake and dense seagrass beds were distributed around the center of the lake (Fig. 2). River turbid water was distributed northwest and east of the lake where the rivers discharge fresh water. Tidal flats were distributed mainly in east area of the lake and near the lake mouth.

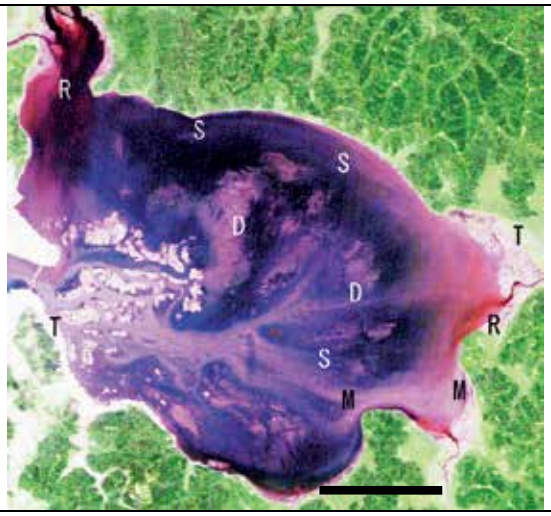

Fig. 2. Enhanced image of ALOS AVNIR2 on Akkeshi Lake. Characters of D, S, R, M and T are dense seagrass, sparse seagrass, river turbid water, muddy bottom and tidal flat, respectively. Small dots near characters are areas belonging to these classes identified by sea truth. Black bar shows a distance of 2 km.

	Above-ground biomass		Below-ground biomass	
	g WW/m^2	g DW/m^2	g WW/m^2	g DW/m^2
Dense seagrass	2743.9±528.3	227.1±19.2	481.3±54.3	48.0±11.1
Sparse seagrass	1251.5±408.0	143.9±38.4	340.7±167.6	46.4±20.8

Table 1. Above- and below ground biomass of dense and sparse seagrass beds consisting of *Zostera marina* obtained by three quadrat sampling at each category in Akkeshi Lake on 3 July 2009. WW and DW are abbreviations of wet weight and dry weight, respectively.

3.1.2 Seagrass biomass

Above-ground biomass of dense seagrass was 227.1±19.2 g DW/m^2 (n=3) while that of sparse seagrass was 143.9±38.4 g DW/m^2 (n=3). Below-ground biomass of dense seagrass was 48.0±11.1 g DW/m^2 (n=3), while that of sparse seagrass was 46.4±20.8 g DW/m^2 (n=3).

The maximum and minimum biomass of *Z. marina* growing at depths of about 5 m in Otsuchi Bay were 370 g DW/m^2 in August and 30 g DW/m^2 in January (Iizumi 1996). At depths between 4 m and 5 m in Iida Bay the maximum and minimum biomass of *Z. marina* was 170 g DW/m^2 in July and 20-30 g DW/m^2 in November (Taniguchi and Yamada 1979). Therefore, biomass of *Z. marina* in Akkeshi Lake is between those in Otsuchi Bay and Iida Bay.

3.1.3 Image analysis of Seagrass beds

Enhanced image of AVNIR2 was shown in Fig. 2. Bands of NIR, R and G were allocated to red, green and blue colors (Fig. 2). Field survey showed that the seagrass beds were distributed in the areas of dark blue (sparse seagrass) and grey colors (dense seagrass). River

turbid water, tidal flat, muddy bottom were reddish, brighter grey and purple, respectively. Using the distribution information (Fig. 2), supervised classification was conducted.

The result demonstrated that classification well corresponded to ground truth data (Figs. 2 and 3). User accuracy of dense seagrass was 97.8% while that of sparse seagrass was 78.5% lower than dense seagrass due to misclassification of dense seagrass as sparse seagrass (Table 2). User accuracy of tidal flat was 97.5%. User accuracies of muddy bottom and river turbid water were 82.0 % and 85.3%, respectively. Overall accuracy was 86.0%. If dense seagrass class was combined with sparse seagrass class as seagrass, user accuracy of seagrass became 93.5%. Overall accuracy was ameliorated to 90.0%.

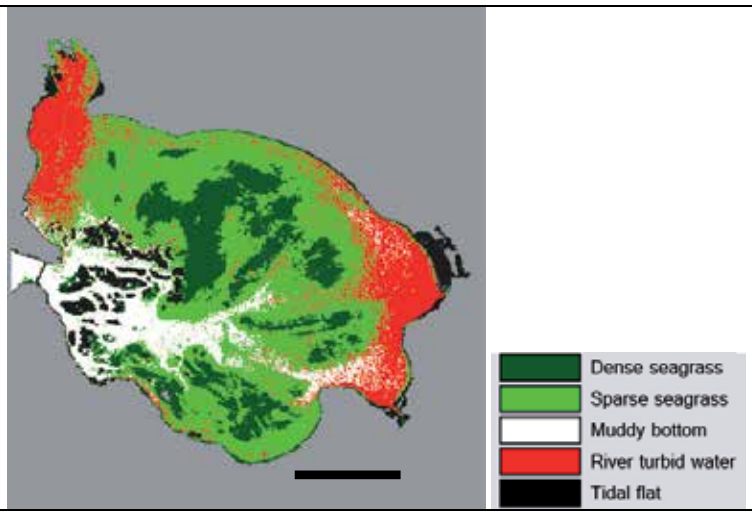

Fig. 3. Supervised classification of five classes of dense seagrass, sparse seagrass, muddy bottom, river turbid water and tidal flat. Black bar shows a distance of 2 km.

Accuracies of classification for mapping and monitoring habitats are required to be 80% and more and 90% and more, respectively (Mumby and Green, 2000). Therefore, our results of two seagrass classes were nearly above or eaqual to the necessary accuracy for habitat mapping. If we combine two seagrass classes to one, seagrass, we can use the distribution data of seagrass beds mapped by the ALOS AVNIR2 image data for monitoring temporal change in spatial distribution.

ALOS AVNIR2 could detect seagrass beds in Akkeshi Lake. Shallow bottom depth and clear water except river turbid water lead successful classification in the lake. The high accuracy levels were attributed to the broad homogeneous distributions of habitats in Akkeshi Lake, which bring good matching locations on image and field data sets. Accurate mapping of seagrass cover in this lake, using simple approaches, corresponds to high-spatial resolution (< 10 m) and multi-spectral image data. Further work is required to examine ability of ALOS AVNIR 2 to detect seagrass beds with more patchy distributions.

Acoustic surveys are also strong in detecting seagrass beds due to acoustic reflection of seagrass stronger than those of sand or mud (Komatsu et al., 2003). Echosounder can detect

		Sea truth						
	Class	Dense seagrass	Seagrass	Muddy bottom	River water	Tidal flat	Total	User Accuracy (%)
Classification	Dense seagrass	44	1	0	0	0	45	97.8
	Sparse seagrass	11	73	6	3	0	93	78.5
	Muddy bottom	0	9	41	0	0	50	82
	River water	1	5	3	58	1	68	85.3
	Tidal flat	0	0	0	1	35	36	97.2
	Total	56	88	50	62	36	292	
	Producer accuracy (%)	78.6	83	82	93.6	97.2		86.0

Table 2. Error matrix of supervised classification of five habitat classes in Akkeshi Lake. River turbid water is abbreviated to river water.

vertical distribution of seagrass beds along a track (e.g. Komatsu and Tatsukawa, 1998). Sidescan sonar can detect horizontal distribution of seagrass with a wide band width such as 30-50 m along a track (e.g. Sagawa et al., 2008; 2010). Narrow multi-beam sonar can measure three-dimensional spatial distribution of seagrass (Komatsu et al., 2003). However, usually, the boat equipped with these materials navigates at 3 to 4 knots (about 5 to 7 km/hr) with narrow swath width. Thus, it is impossible to cover broad area with acoustic surveys of seagrass beds in horizontal scales of more than 100 km^2. It is also difficult to survey seagrass beds with dense canopy preventing the boat equipped with acoustic devices from navigating. Satellite image analysis is suitable for mapping in these scales.

Class	Area (km^2)	Percent (%)
Dense seagrass	6.12	17.82
Sparse seagrass	15.19	44.25
Muddy bottom	4.71	13.72
River turbid water	5.88	17.14
Tidal flat	2.42	7.06
Total	34.32	100

Table 3. Areas and percentage of each class mapped by supervised classification in Akkeshi Lake

3.1.4 Biomass estimation of seagrass

The areas occupied by dense and sparse seagrass beds calculated from the sum of pixels were 6.12 km^2 and 15.19 km^2, respectively (Table 3). Mean biomasses of above-ground and below-ground parts of *Z. marina* were 227.1±19.2 (±SD) g DW/m^2 and 48.0±11.1 g DW/m^2 in dense seagrass beds and 143.9±38.4 g DW/m^2 and 46.4±20.8 g DW/m^2 in sparse seagrass

beds, respectively. The total biomasses of above- and below-ground parts were estimated to be 1390±118 t DW and 294±68 t DW in dense seagrass beds, and 2186±583 t DW and 705±316 t DW in sparse seagrass beds, respectively. Total biomasses of above- and below ground parts in Akkeshi Lake were 3576±701 t DW and 999±384 t DW, respectively. Finally, total biomass of seagrass was 4575±1085 t DW. This standing stock of seagrass beds contributes to foster oysters, clams and other organisms in the lake. Some of the biomass is transported from the lake to offshore by currents and become debris on the ocean which may be consumed as prey for benthic animals. Thus it is very important to monitor the seagrass beds in coastal waters not only for coastal fisheries but also probably for offshore fisheries.

3.2 Aquaculture facilities in Yamada Bay

Aquaculture facilities consisted of two types: wood-raft type and buoy-and-rope type (Fig. 4). This section describes mapping results of two different types of aquaculture facilities.

Fig. 4. Pictures of wood-raft (left picture) and buoy-and-rope (right picture) types of aquacultures in Yamada Bay.

3.2.1 Distribution of wood-raft type facilities

Pansharpened AVNIR2 true color image hardly distinguished wood-raft type aquaculture facilities from the sea (Fig. 5). On the other hand, enhanced image showed rafts distributions around north and west sides of the bay clearer (Fig. 6). Cloud like pattern from north-northwest to south-southeast was distributed on the seasurface in the east side of the bay. Since radiance of this pattern was similar to those of rafts, it was impossible to process the image of the whole bay to extract rafts from the seasurface at once. Then we divided the image of the bay into several sections with similar radiance of rafts. The sections were enhanced to examine rafts distributions. One example was shown in Fig. 7. Radiance of wood rafts was greater than those of the seasurface because the rafts were completely exposed on the sea surface. Then they were extracted from the image. All the wood rafts in the bay were shown in Fig. 8.

Iwate Prefecture licensed 179, 313, 825 and 1625 wood-type rafts to Oura, Orikasa, Yamada and Ohsawa Fishermen's Cooperatives, respectively (FY2006, Iwate prefecture). From Fig. 8, 189, 311, 811, and 1525 rafts belonged to waters of above-mentioned cooperatives,

respectively. Only rafts number of Ohsawa Fishermen's cooperative between licensed and counted numbers was different by 100 wood-type rafts. However, percent of counted number to the licensed number was 96.4%. The result obtained by image analysis of ALOS image is enough accurate for practical use.

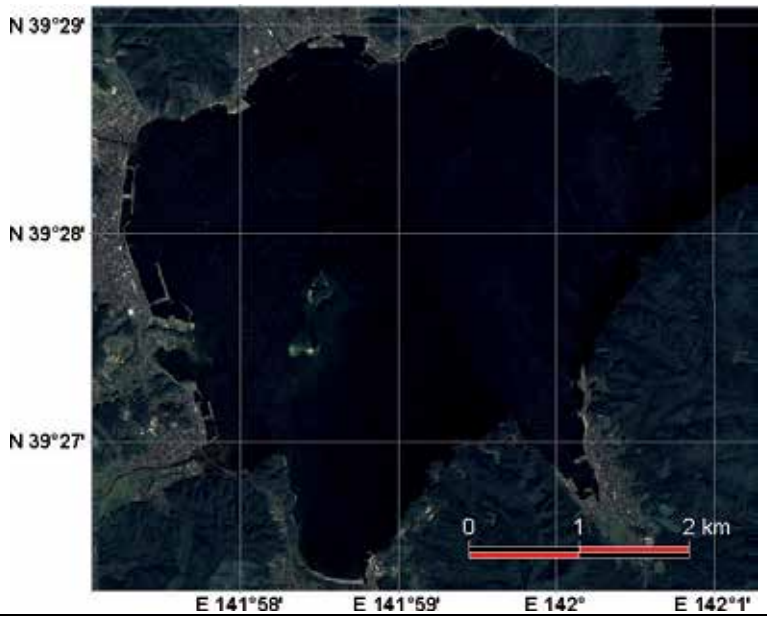

Fig. 5. Pansharpened true color AVNIR2 image of Yamada Bay

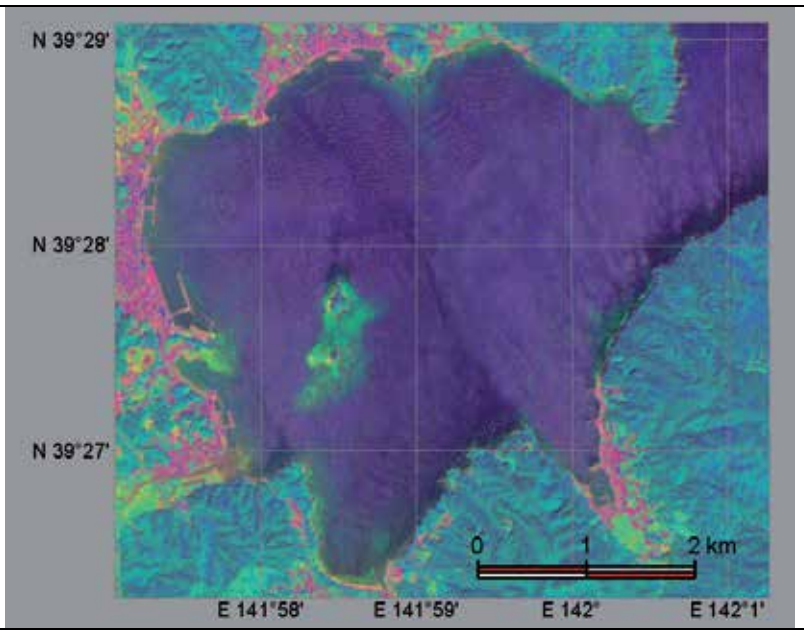

Fig. 6. Enhanced pansharpened true color AVNIR2 image of Yamada Bay

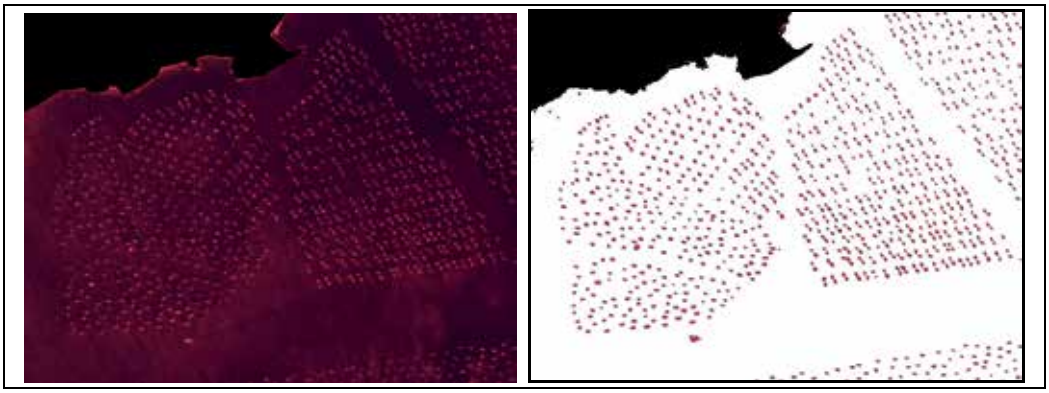

Fig. 7. Pansharpened image of the northwest area of Yamada Bay of which red color was enhanced (left picture) and extracted rafts (right picture).

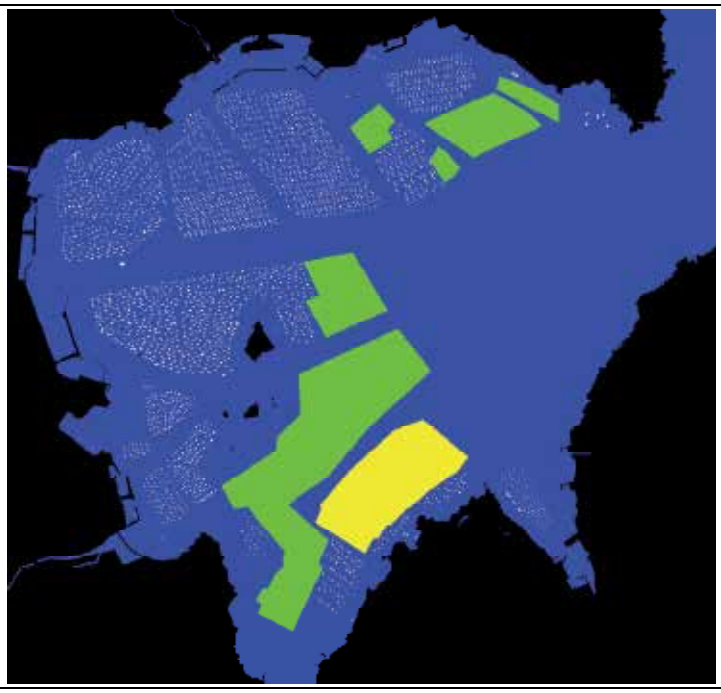

Fig. 8. Distribution of wood-raft type aquaculture facilities (white points) and buoy-and-rope ones. Green and yellow areas were occupied by measurable and non-measurable facilities of buoy-and rope types, respectively.

The license of Iwate Prefecture determined the size of raft was 48 m^2 (12m x 4m). Since the resolution of one pixel of ALOS pansharpened image is 2.5x2.5 m^2, one raft consists of about 2 x 6 pixels. In reality, wood rafts on the image consisted of more than 12 pixels. It is known that image analysis of satellite image overestimates a plane area of object with strong reflectance due to light diffusion. It is also true for rafts in Yamada Bay because they had relatively strong reflectance.

Komatsu et al. (2002b) analyzed IKONOS pansharpened image with a spatial resolution of 1 m to detect wood raft type. The present result shows that ALOS pansharpened image provides information similar to that of IKONOS in a scale of wood-raft type aquaculture facility with 12 m x 4 m. Thus pansharpned AVNIR2 image is very practical to detect wood raft type.

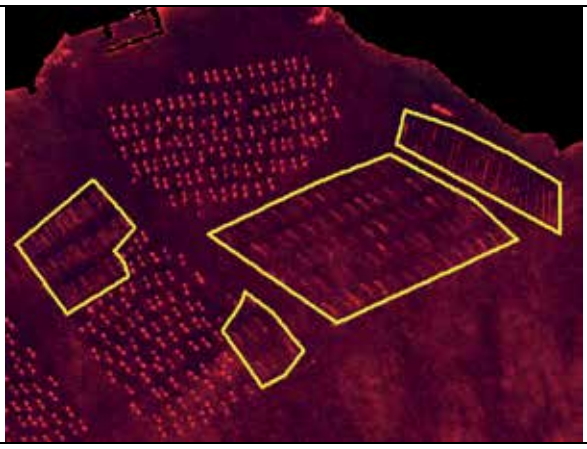

Fig. 9. Pansharpened image of the north area of Yamada Bay of which red color was enhanced.

3.2.2 Distribution of buoy-and-rope type aquaculture facilities

Buoy-and-rope type aquaculture facilities in Fig. 9 were clearer than those in Fig. 6 due to enhancement of image characteristics through adjustment of color tone levels. They were distributed east and south of the island in the center of Yamada Bay (green area in Fig. 8). The other type of buoy-and-rope aquaculture facilities were distributed in southeast area of the bay (yellow area in Fig. 8). Field observation showed that this kind of facilities was composed of black buoys and their diameters between 0.4 and 1 m. Since the buoys were smaller than 1 m below the resolution of ALOS PRISM sensor, image analysis couldn't distinguish them. In some cases, suspended clusters of scallops or oysters were so heavy that buoys were submerged under the sea. Thus, it is very difficult to measure the lengths of the facilities of this type, which appeared as bands parallel to northwest-southeast in a southwest part of the bay (Fig. 6), due to pixels with low radiance (yellow area in Fig. 8). Surface area occupied by the aquaculture facilities of buoy-and-rope type were summarized in Fig. 8.

Figure 6 shows darker green area surrounded with light green around the islands in the center of the bay. This area corresponds to seagrass beds consisting of *Zostera caespitosa* Miki classified into threatened seagrass species by the red data book of Japan (Wildlife Division, Environment Agency of Japan, 2000). Therefore, Figure 8 gives important information to conserve this species and to realize sustainable aquaculture fisheries.

The results above-shown well agree with those of image analysis of IKONOS pansharpened multispectral image with 1 m spatial resolution (Komatsu et al., 2002b). Therefore this method mapping aquaculture facilities in Yamada Bay using ALOS image data is very practical and useful for management of coastal aquaculture activity like as IKONOS image data.

4. Conclusion

Mapping with ALOS AVNIR2 is a simple, laborsaving, and efficient method to assess the seagrass bed distribution in boreal waters. It can be used to estimate the area occupied by seagrass, and, in conjunction with quadrat sampling, the biomass of seagrass beds can also be estimated.

It is verified that the image analysis can obtain information on distribution of small-scale aquaculture facilities including aquaculture facility types in the rias-type bay in Sanriku Coast from the pansharpened image created with ALOS AVNIR2 and PRISM. The image analysis of ALOS AVNIR2 and pansharpened image data serves as a tool for management of coastal fisheries for the long-term conservation of coastal environment and sustainable use of fisheries resources. This method is applicable to monitor small-scale fishing gears and aquaculture facilities not only in rias-type bays but also in any coastal waters.

We developed two practical methods to map seagrass beds and aquaculture facilities that are indispensable an aquatic ecosystem and an element of coastal fisheries in coastal waters. Our future work is to examine applicability of the methods to other regions where seagrass beds or aquaculture activities are developed.

5. Acknowledgment

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9

Sustainable Development of the Built Environment: The Role of the Residential/Housing Sector

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1. Introduction

Sustainable cities have existed much longer than the sustainability discourse. From a historical perspective it can be argued that private investment into the built environment was always paramount for creating the great cities where ingenuity flourished in both civic and business arenas. This was the case in late medieval Florence and (perhaps incorrectly) is assumed to be the case in contemporary Manhattan – the 'Florence of our times'. Innovations in the banking-sector tend to generate property investments and eventually the accumulated prosperity further fosters high-level social and cultural life. In other words, sustainable investment practices much steer urban development. When assessing various possibilities for sustainable investment practices, one vital task we cannot escape is to assess the contribution to energy savings that could be made by cities, their buildings and their citizens. To leave it here would however only serve a narrowly defined sustainability agenda that neglects other dimensions than the 'green' ones. In fact, it can be argued that social and economic sustainability issues show more resonance with property investors than that of the older type of environmental-energy sustainability (see Sayce et al., 2007).

According to Goodland (1995) the economic sustainability concept has been applied in practice since the Middle Ages, when merchant traders had to know how much stocks would need to be maintained for securing a continued trading. Today this problem is reformulated as to how much profit is deemed necessary to reinvest in environmental, social and cultural amenities. Interestingly, while Goodland considers the distinction between economic and environmental sustainability subtler than that between the social and environmental sustainability dimensions he nonetheless incorporates a social agenda as he predicts that, rather than relying on growth alone, sharing and population stability will be necessary for attaining a greater equality between rich and poor. Poverty reduction, *de facto*, is dependent on redistribution and sharing, population stability and community sodality, Goodland notes. In fact, when discussing the social aspect it should be noted that the international sustainability development agreements include poverty eradication as a vital element (Bramley and Power, 2009).

On the other hand, social sustainability is conditional upon environmental sustainability, Goodland (1995) asserts. In the property sector, and if a process oriented view is taken

(rather than a mechanistic view so typical for the equilibrium traditions), the issue becomes that of making the market for buildings, land use and location quality (including elements of the surroundings). In a more general sense, shaping the market translates onto two analytical key concepts: one is about institutions and the other about the behaviour of market actors. Additionally, the role of production technology comprises a third such concept, albeit for the location less so than for the buildings.

Within this realm the implications for *housing*, arguably an (if not the most) important sector of the property industry, are many and of great significance: cities don't exist without people, and people need shelter. In this contribution we look at a variety of private as well as public features of *housing market sustainability*, and in particular from spatial perspectives ranging from the neighbourhood to the city region. Above all, sustainable housing developments also need to be sustainable places to live, and that this requires, above all, dynamic private investments regulated by smart policymaking and flexible public institutions. This formulation recognises that, whatever the particular trajectory of urban development, on top of private investments also public support is required to sustain a credible sustainable development agenda. The key words here are *cooperation* and *adaptability*. To cite Vatn (2005, p.434) "We were able to create the large corporation. Why shouldn't we be able to create the grand cooperation? The choice is ours."

Going back to the investment perspectives, following Bryson and Lombardi (2009) the two contrasting ideal types of residential development projects in cities may be summarised depending on whether the goal is maximising short-term profits or reinvesting the extra profits onto sustainability of the project:

- If only *profit* is considered in the development of housing, the project is unsustainable in the long run.
- If *sustainability* related motives dominate: normal profits are reaped and the remaining margins are fed back to the use value of the project; this is one of the cornerstones of a sustainable market approach.

For the purposes of this study a conceptual model is developed based on evolutionary economics; here property investments are considered the primary factors for establishing urban sustainability before regulation and planning processes. This line of theorizing underscores the role of diversity in so far as the outcome is allowed to evolve through selection processes. In this chapter two examples, largely based on expert interviews and observation: de Pijp, a neighbourhood in Amsterdam; and the Budapest metropolitan region, indeed demonstrate that the issues at stake are typically, neither problem free nor straightforward (for more profound information about the case studies, see Kauko, 2009; Kauko 2010; and Kauko, forthcoming).

2. Outlining a theoretical framework for the sustainability of urban residential projects

As an academic research objective, sustainable buildings and areas are currently approached from three different literatures:

1. The impact of the building on their users – health issues of the workers and residents in particular.

2. Global impacts: emissions, energy efficiency and renewable energy (see e.g. the literature on *passive houses*.)
3. Urban and environmental sustainability of cities/city-regions.

The focus of the present paper is on the third tradition: more precisely, about spatial planning or development of areas – both Brownfields and Greenfields. The point here is about incremental changes rather than 'one grand planning vision'. However, it might come as a surprise that, instead of multi-criteria decision methods (MCDM), a 'partial criteria' or 'single criterion' approach, where the economic dimension always comes first, is applied here. Despite the current global shift in emphasis from economic criteria towards ecological ones, this study prefers an alternative logic. The main justification for this selection is that the rolling back of the state has resulted in more local responsibilities in relation to retaining sustainability – this development begun in the early eighties in Western Europe and early nineties in Eastern Europe. Therefore, it is reasonable to assume that, at a local level, the economy comes before other aspects of sustainable development after all. To continue this argument, nowhere is this more so than for real estate projects as these are tied to location even if being global investments. The issue here thus is how the economic sustainability can generate environmental and social sustainability in a given locality (either the urban area as a whole or only a particular neighbourhood of it) by reinvesting the profits made with view on long term developments – following the postulates of Bryson and Lombardi above.

For any sustainable development to occur the ultimate challenge is to prepare for a long time-horizon – say, at least to the next generation, but preferably much longer. If we accept an evolutionary perspective to sustainability – like RICS recently does, see e.g. Macintosh (2010) and Ratcliffe et al. (2010) – the key to success is innovativeness. This requires heterogeneity in product ranges, which in turn is fostered by flexible and market sensible administrative structures and is influenced by the changing tastes of individuals – consumers and citizens. Therefore we can purport that real time *management* is far more important and effective than *plans* and traditional government bureaucracies. As a consequence, a system based on 'trial & error' is preferable, of course, rather than 'one giant leap forwards' no matter how well meaning welfare agenda there is in place. Such failure of adaptability can today be seen in places such as the extremely homogeneous, polished and Corbusier-inspired Belarusian capital Minsk: even in a seemingly perfectly environmentally and socially apt context the lack of product diversity will eventually turn into to a problem. At the same time, however, a market-based agenda alone cannot lead us onto the right sustainable development track. It can be argued that we also need the following two elements:

1. Good governance and incentives (such as tax and subsidies), either in the form of public-private-partnership (PPP) or development agreements.
2. Education of all actors involved (including scenarios and forecasting).

It is to observe that economic sustainability is not only about the (*n*th year) cost savings, but how one reinvests these savings so as to maximise the provision of public amenities, at least one generation ahead. The players involved include bureaucrats, professions, corporations and smaller market actors as well as citizens/residents. Here we identify several factors, namely the impact of the size of the home on carbon-dioxide emissions, whether the focus on the improvement of the sustainability of existing areas ought to be inner cities or suburbs, and the role of new high tech developments situated peripherally in the city

region. Within each point, we need to assess the role of the government as well as rethink our own behaviour.

McIntosh (2010) points out that we all have the means to shape our future, for example by lobbying a slow government, and furthermore, if we want a sustainable future the private sector has to take the lead. Jones (2010), in turn, purports the issue about setting the limits is about setting error margins of operative space; according to him the issue is also ethical and not only scientific – we need an increasingly trans-disciplinary approach here where the social aspect is integrated into the framework – a more robust transition management, otherwise we face an IPCC type of backlash, Jones warns. Finally, according to Fisher (2010), we need a policy framework based on future and past – in principle, every city and town can be a resilient, prosperous, life-affirming place. Instead of one-size-fits-all policies one needs to know the context dependent starting point, in particular, what kind of housing preferences people express, she concludes.

Economic and environmental sustainability concepts both focus on the longevity of the physical inputs into production. However, in doing so Goodland (1995) refers to "the stewardship approach of safeguarding life-support systems" rather than focusing on intergenerational equity. In other words, consumption needs to be curbed with future production in mind rather than just with future decrease in incomes in mind. Interestingly, he speculates that cutting the consumption of the developed countries by ten per cent is a more feasible expectation that to wait for the developing countries to raise their per capita income levels to the OECD average. Consumption above sufficiency, in other words, living off inherited and finite capital, inevitably leads to unsustainability, Goodland claims. According to him the human economy has become unsustainable due to overconsumption and inapt regulation of pollution and population growth by governments.

While the conventional wisdom is that rules and regulations cannot keep up with the markets (e.g. Ball, 2006), the current financial crisis showed us that the government matters after all for the property market and determination of property values and prices. Thus we realised that we need regulation of the markets, but the question is: who sets the limits, that is to say, how do we determine the sustainability benchmarks that any coercion is based upon? Thus, do we anchor our institutions and policies on completely *ad hoc* decisions, evidence or ideology? The Nordic countries are a good case in point: due to the absence of population pressure (i.e. of the continental European or British magnitudes), there has not been a serious need to design innovative strategies for community governance and, as a consequence, even one-size-fits-all policies have proven successful on national as well as local levels.

Goodland (1995) notes that the use of the term sustainable development is surrounded by confusion to such an extent that all discussion surrounding it becomes ambiguous immediately. At the classical extremes, we have *Malthusian* definitions based on finite resources and *Ricardian* definitions of infinite resources, and in between we have the weak sustainability concept launched by *the World Bank* in the mid eighties. Within the housing research field, Støa (2009) argues along similar lines that, while sorting out the obscurity and internal conflicts surrounding the concept of sustainability remains a challenge in itself, it is worth to be pragmatic and plan in relation to what we think sustainability is. Støa therefore suggests to apply ones own preferred definitions and to constantly revise ones goals in

relation to new knowledge of the state of affairs. At the end of the day, for analytical purposes a set of definitions for various kinds of sustainability are required, even if existing definitions often are ambiguous.

Assuming that housing development, and thereby also the housing market, comprise an important element for defining a sustainable place, three issues are pertinent here:

1. A grossly substandard level of housing is unacceptable for health and safety reasons. *The quality* (largely a subjective indicator though) therefore ought to develop in the same direction and with the same pace as the price level. This is about the site and building specific attributes as well as the characteristics of the surrounding environment, neighbourhood and the city as a whole.
2. It is not sufficient with high quality unless people can afford to buy (or rent) the products. In other words, *affordability* (often approximated as net income) of the dwelling also ought to develop in the same direction and with the same pace as the price level. It may be found that some of the wealthiest areas are also among the economically least sustainable ones.
3. The diversity of the product ought to be respected. Even if the quality and affordability criteria are fulfilled, it is not sufficient for value stability (and hence economic sustainability) unless there is a *wide enough range* (i.e. product variety generated for most apt selections to be made) of different quality and affordability levels on the market. This is because the drivers of sustainability: production technology, community governance as well as consumption fashions, all tend to change fast and then it is vital not to have neglected any specific housing package even if it may seem marginal at some stage. (Or put differently, if a potential market trend setter or other innovation in terms of quality or affordability is not recognised this will have harmful impacts for the evolution of the property portfolio in terms of its value stability.)

The three housing market sustainability issues above do not readily fit in to the definitions of the three sustainability dimensions, but are rather combinations of them. Figure 1 synthesises the various facets of the problem area. It should be read as follows:

- Assuming a new type of business culture, economic sustainability (i.e. the investment of extra profits for the long term) can help directly in generating social sustainability (e.g. affordability) and creating 'green' environments. The emphasis here is on the second (rather intuitively) and third (via the evolutionary argument) of the issues above.
- Assuming a new type of culture in civic areas too, social sustainability criteria can also be fulfilled more indirectly, if quality-of-life (QOL) is invested in after economic and physical sustainability is achieved. In principle, this could pertain to all three issues above via their respective logics.
- Value stability implies constant price development in relation to other indicators such as income and quality levels (i.e. all three issues above). This is a much narrower concept than economic sustainability – notably, if the quality or affordability balanced price trend declines it may nonetheless indicate sustainable development with respect to some other aspect that can be considered economic in a broad sense.
- There are some more particular types of sustainability criteria, for example the asset valuation aspect that potentially incorporates elements of all three issues above. Asset valuation here implies that we can include various sustainability indicators onto the valuation using the income approach instead of relying on merely financial indicators.

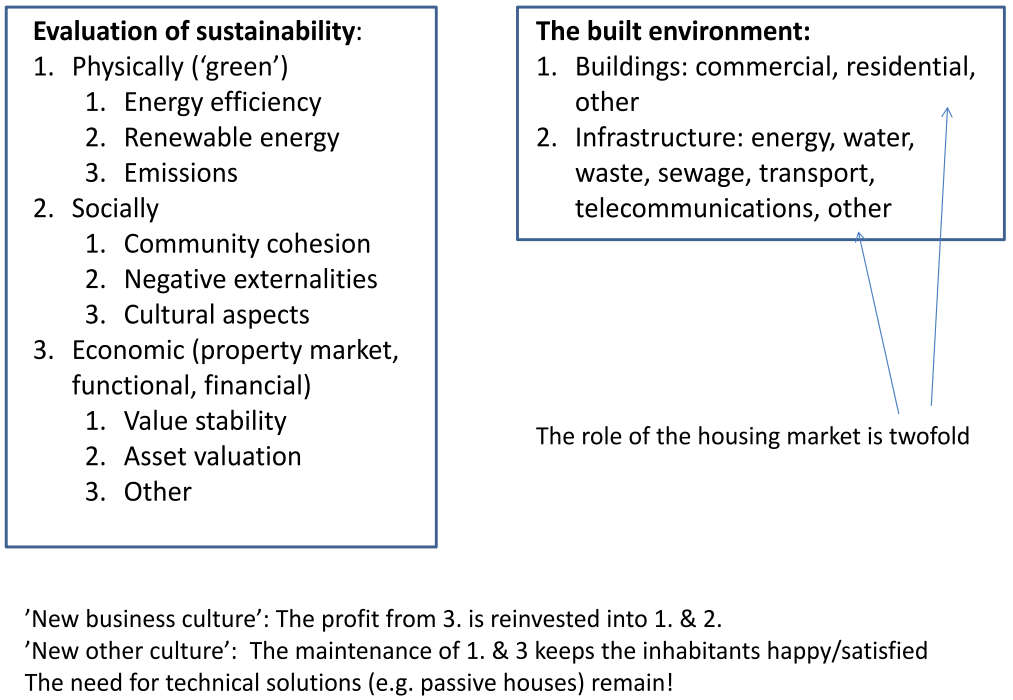

Fig. 1. Evaluation of sustainability in the built environment context.

Using the definition of Kauko (2008) a classification of housing market sustainability to various ordinal classes of sustainability would be a prerequisite to subsequent value modelling in order to determine whether the long-term outcome is of a healthy or distorted kind. In fact, value stability is only one part of economic sustainability as a stable market development is a subordinate concept to an overall dynamic market context required for a 'more total' economic sustainability. In other words, if we observe that the quality adjusted price (P/Q ratio) is declining, it then cannot indicate value stability, but may instead imply economic sustainability due to some other criteria, notably viable developments (Jones et al., 2009). On the other hand, such circumstances might also or alternatively be socially sustainable due to safety and cohesion, as perceived by the inhabitants of the place. For example, in Oud-west (the Amsterdam district one of the cases in the present study, de Pijp neighbourhood, is part of, see fig. 2) 1991 and 2001 were particularly unstable years in terms of the recorded P/Q ratio, but the area was in fact at the same time (and still is) one of the most socially sustainable in the whole city (see Kauko, 2009). Or *vice versa*, the recorded price trend suggests value stability, but the development is still deemed unsustainable either economically or socially (as is the case in another Amsterdam district, see fig. 3). Thus, house price trends can be considered unstable but economically or/and socially sustainable; they can also be stable but not sustainable in either of these generic dimensions.

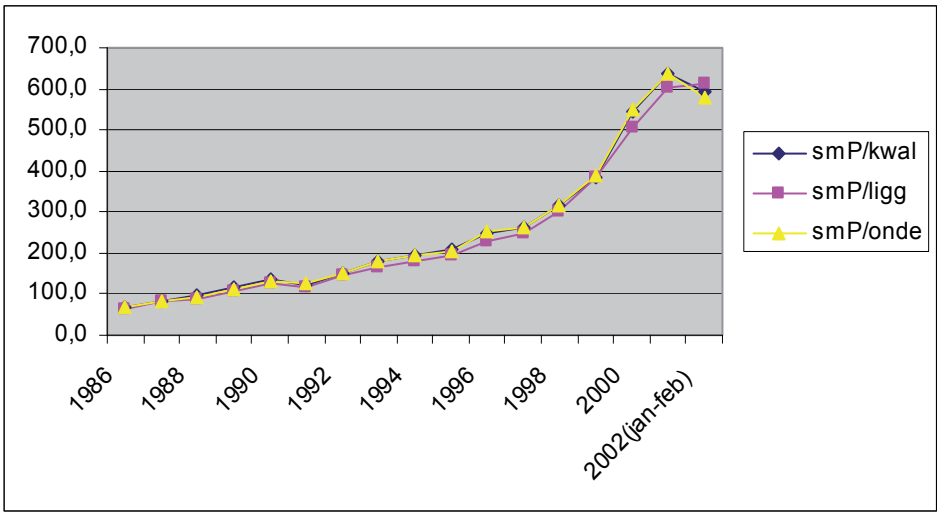

Fig. 2. Oud-west Three P/Q indicators: Square-meter price (SmP) in relation to quality level of apartment (kwal); quality level of location (ligg); and maintenance level (onde); levels 1 to 10 assed subjectively by a valuer.

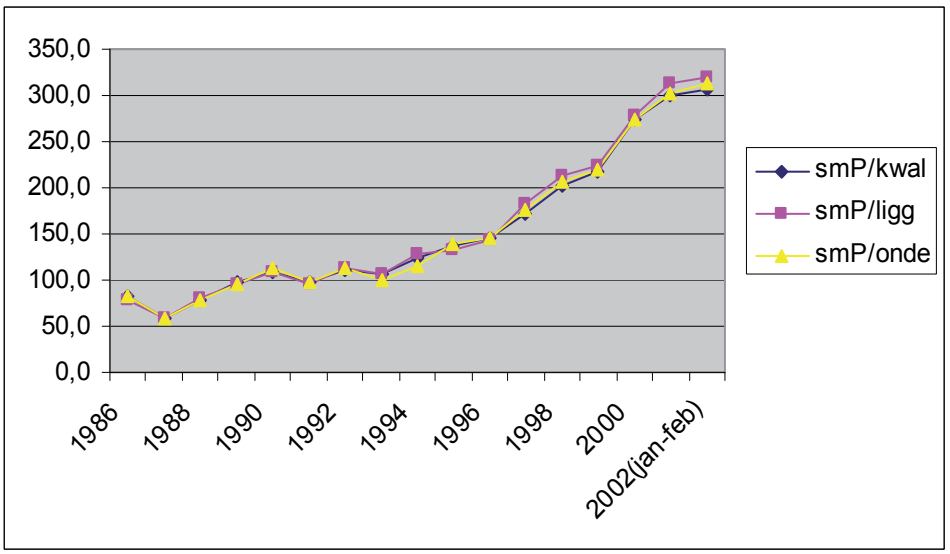

Fig. 3. Geuzeveld-Slotermeer (as in fig 2.).

Following Ratcliffe et al. (2010, p. 4) the key to success is real time management using ICT instead of planning based on ideology and 'one-size-fits-all' regulations/policies. Within a green agenda solutions such as passive houses then become strategies worth trying. Townshend (2006) has a much similar argument: housing quality and design, including the quality of the buildings and their surrounding environment should be given equal weight in relation to housing quantities in urban planning policy.

At the outset Manhattan was mentioned as a supposedly sustainable built environment. The reality, however, is not so rosy.[1] The amount of new building in Manhattan is less than 1% annually, which does not leave room for creating any kinds of sustainable innovation within a town planning machinery. As a consequence, those who wish to "build more than usually sustainable" need to look at other– even developing – countries, which in itself, is not a rare order of progress, as latecomers in many sectors often develop quicker than the pioneers. If not Manhattan, then what would be an example of a truly sustainable city, given the current circumstances of worsening global problems such as climate change, financial crisis and urban poverty? Probably Berlin then is a better candidate for this nomination, insofar as land use availability is concerned: due to the historical contingencies of that city, ample amounts of building land is provided by sites of what formerly constituted *Die Mauer*, Tempelhof airport, and inefficiently developed suburban housing estates of East Berlin. On top of that, the German capital is polycentric, affordable, does not suffer from harmful levels of ethnic segregation and so on. In other accounts, Vienna is suggested to be such an urban sustainability leader, and that this is not so much in response to policies or directives, but rather through the 'intrinsic logic' meditated through local actors (Pessina and Scavuzzo, 2010).

The brief discussion on various cities above much sustains the assertion that the economy in itself is insufficient in explaining longer-term urban housing market processes (Ferrari and Lee, 2007). Nonetheless, the economic dimension is prioritised following ideas outlined by Bryson and Lombardi (2009): the message here is to reinvest the profits made and also regulate the property market in order to eventually obtain the resources required for improving the other sectors of 'the sustainability cake'. The context matters, in other words, a locally tailored fit of the model of ecological, environmental, social, cultural, financial and economical sustainability is necessary. The approach chosen for the present paper is an economic one in the broadest possible sense as it also incorporates government interventions: here a controlled local market is necessary in order to avoid the mistakes of the past. The key to understanding here is to examine why certain areas are successful with respect to given criteria and others are less so. This results in "best practice" and eventually in new theory. When the reasons are clarified the issue becomes one about how to apply that theory for another place, but so that the particular context is taken into account. However, prioritizing one dimension, like here the economic one, is necessary to reach practically relevant results.

To sum up the argument so far, it can be assumed that a sustainable development of the built environment, including economic and socio-cultural sustainability, necessitates incentives for consumers as well as community governance. Tragicomically strict regulation of everything a la Minsk, just comic lock-inns of Manhattan, the favourable but somehow alternative path-dependence of Berlin, and the curious bottom-up trajectories of Vienna all illustrate the multitude of urban settings in this context. Many of the preconditions for sustainability originate in privately initiated residential property development and housing market processes. While environmental-ecological sustainability comprises the most common criteria and social-cultural criteria for sustainability exists too, the emphasis of this study is on economic sustainability, as defined as follows: affordable housing, quality control and product diversity.

[1] As the former town planning chief of the city of Manhattan informed me during a session at the ISEE conference, 23 August 2010, Oldenburg, Germany.

To the extent such ideals correspond with the reality is exemplified below by two cases: one on the neighbourhood level and the other on a metropolitan level. When designing the method one should note that, only by comparative research one can isolate the institutional and behavioural elements that make the marketplace sustainable to a varying degree. The methodology comprises analysis of the sustainability of urban property developments using house price data together with other local information collected from documents and expert interviews.

3. De Pijp in Amsterdam[2]

The neighbourhood de Pijp in the inner city of Amsterdam (see fig. 4) is seen as one of the classical examples of Dutch urban restructuring processes, as the pro-market change in policy has led to an upgrading of de Pijp. Both individual action (organic change) and government policy and subsidy have initiated the renewal. It has mainly been about dwelling improvement, whereas demolishing and new building development have taken place sporadically. Housing corporations, investors, who own a small number of dwellings, and individuals, including the renters and the homeowners themselves are the main actors, rather than large-scale private owners.

Fig. 4. Map of de Pijp

The described redevelopment is indicative of a shift from a traditional 'active' government towards a more 'passive' type of government. Nevertheless, public regulations are still in place in the Netherlands. It is worth noting that buyers have got tax incentives to buy apartments and housing associations have got incentives to sell their stock (Aalbers, 2008, p. 157). What perhaps is more relevant is that, in Amsterdam, the social housing is still hugely significant (only 21% owner-occupation on the city level; 16% in de Pijp).

[2] See Kauko (2010) for a profound discussion on the revitalization of de Pijp.

On the other hand, even though rehabilitation is supposed to have taken place here, neither the dwelling quality nor the quality of the micro-location has increased, when examining the findings of a quasi-controlled experiment (see Kauko, 2009). In fact, here is a contradiction between this conclusion and the media discourse. Which is a more valid claim, that a particular dataset has not captured the change in quality that, according to popularised information, has occurred since the 80s, or that the reputation of an upgraded de Pijp is not at all factual, but merely based on hearsay and media spun discourse?

How much of the perceivably successful regeneration outcome really is sustainable in terms of economic, social or environmental criteria? Can we also conclude that the housing market upgrading has been successful? Here one cannot make definite conclusions due to the fragmented and speculative nature of the evidence. In particular, it was observed that the economic and quality development of the neighbourhood is uneven across house types and microlocations (i.e. only certain buildings or blocks, namely those built in the style of the interwar years, experienced a price lift during the period of examination from 1986 to 2002.) Even if the area under study was small, the quality and affordability varied greatly, which in itself indicates a wide diversity of available housing market products. On the positive side, both demand and supply led mechanisms of institutional change towards a more sustainable outcome driven by incentives were observable in de Pijp.

To sum up the evaluation of de Pijp, economic sustainability exists in relation to the product diversity criterion, but otherwise the evaluation is contradictory given that the price (and ostensibly rent) level far too often is unaffordable; another issue is that arguably the area can be perceived as rather messy. Both problems have to do with decreased government involvement in the renewal processes.

4. The Budapest region[3]

Hungary is a rather one-sided economy, where Budapest attracts talents from the rest of the country. At the same time, the density in terms of households is declining in Budapest. This is manifestation of a variety of reasons: the new dwellings are bigger, household size is shrinking and people are increasingly moving from the city to the urban periphery of the agglomeration (see Fig. 5, over). What many are wondering is how a relatively well-functional society (in the early days after the transition) has deteriorated into one with all kinds of problems. While a range of factors have played their parts, arguably the main reason lies in the extreme neo-liberalism implemented under the socialist-liberal rule 2002-2010. As a part of this mismanagement, the current housing market situation in Hungary can be characterised by a falling demand caused by the financial crisis of year 2008 together with an oversupply originating from an earlier speculative building activity.

Undoubtedly, in many Western countries a relatively centralised approach has been the key to creating successful housing environments. This has to do with path dependency of political and policy routes taken at the time when building the welfare state was deemed the ultimate goal after WW2 (in some countries already since the early 19th century). In a Central Eastern European (CEE) context such an approach has obviously been unpopular since the

[3] This section makes a brief summary of Kauko (forthcoming).

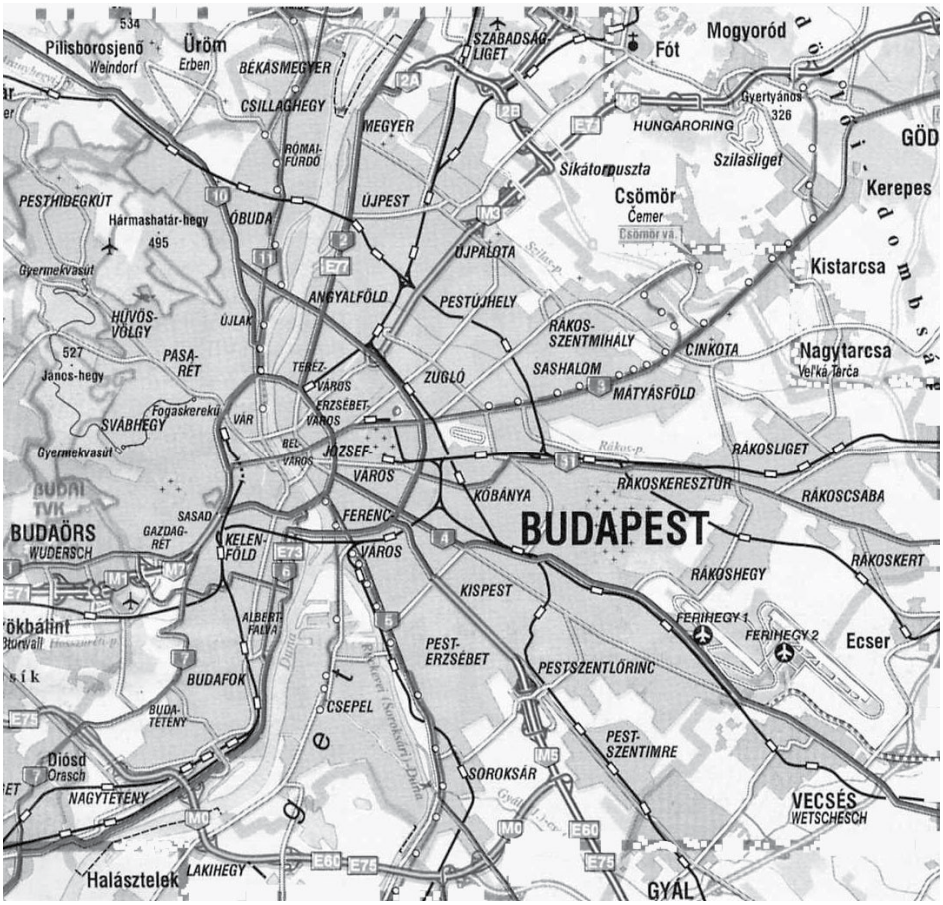

Fig. 5. The Budapest region.

transition. At present, in Budapest planning and policy is still rather decentralized and fragmented. Such a state of affairs cannot be considered sustainable (even with goodwill).

The reality of this near total (un)sustainability can be exemplified with the Hungarian type of gated communities (residential park, *lakópark*, *lakókert*). First of all, as elsewhere, the environmental-ecologic sustainability criterion may also remain unfulfilled if the costs are minimised (except perhaps in the most modern niche market cases). Then, the residential park is arguably not socially sustainable either as it segregates the wealthy from the poor, which was condemned in the second section. This, of course, works against the *lakópark* agenda. Finally, looking at the economic sustainability, a number of obvious shortcomings can be found with residential parks:

1. The quality of the location is often poor – at least in the more recent products which are marketed for the middle-class housing consumers.
2. In some cases the same can be said about the building quality – where costs have been pressed down in order to attract younger families and first-time buyers.
3. The market situation is marred by diminishing demand and already existing oversupply, which means that trying to sell these products is difficult and many such

dwellings risk remaining vacant for a long time. It is speculated that, in twenty years time, the *lakópark* will be perceived as unfavourably as the *lakótelep* (panel built housing estate) is perceived today.

Going back to our theoretical issues, in the Budapest region the quality varies sharply across locations, and correlates negatively with the age of the building. Thus older buildings, often in the inner city or in the housing estates, are mainly of low quality, whereas the newly built projects are mainly of a better quality. Affordability is however low overall. The differentiation across new built products is low, however, as the global investments seem to apply much standardised building concepts, notably the *lakópark*. To a large extent, the increasing differences in quality as well as the narrow range of new products are due to an increased share of private sector driven property developments. Whereas during the late nineties also the public sector could participate in PPP types of urban regeneration, nearly all urban development projects today are privately financed, often also by global capital.

Because of all this one is entitled to criticise the actions of the government and lack of planning policy in these circumstances. Nevertheless, by the same token one is entitled to be optimistic, now that the new government has officially included sustainable development rhetorics in its documents that affect housing developments. Housing construction is furthermore seen as a potential boost for the depressed Hungarian economy.

To sum up this case, due to the lack of any coherent backup by a planning system, currently the housing and housing market development in the Budapest region is unsustainable in all dimensions. While there are promising plans underway after the new government took place in May 2010, it is not sure as to whether public support will be targeted correctly, i.e. to most optimal locations, house types and consumer segments.

5. Conclusion

Beneath the global discourses, EU frameworks and national guidelines, two different spatial levels are crucial for observing the contemporary issues related to housing market sustainability: the local and the regional. To be able to capture the essence of sustainable market development, in both cases we must begin to realise the potential *long-term* economic benefit arising from convergence of the motives of the people on one hand and the corporate decision makers on the other. This includes also social and ethical values. Here some of the most important issues concern density and land use. Are for example, the Nordic countries sustainable? Perhaps, but this is 'no thanks' to good governance, as these circumstances experience relatively problem free situations due to a lack of population pressure. And to reiterate the key point of this argumentation: to promote diversity is better than a one best way, as variety leads to selection.

The two cases reached largely different evaluations of economic sustainability of residential developments and sustainable housing market. Whereas de Pijp at least could pride itself on the diversity issue, the current state of affairs in the Budapest region reached a rather miserable verdict. We cannot, however, compare the two cases analytically as one is a region and the other is neighbourhood. Therefore any normal conclusions from comparable studies cannot be made here. Instead these cases have shown how the housing market structures and processes affect the sustainability of the built environment on two very different spatial scales.

The conclusions of the theoretically informed case studies are that sustainable urban housing development is ideally, just, convivial, functional and aesthetic, possibly with a stable property value development but, in any case, a dynamic market process that encourages innovations in investment and management activity. However, many of these qualities are tradeoffs by definition. In particular, this is the case between value stability metrics (e.g. P/Q) and other economic and social sustainability subcategories. This study has argued that, in principle, such ideal residential environments can only be maintained through long term private investment processes that coexist together with apt public sector interventions. The case studies each showed how the neglect of the latter point plausibly can affect a sustainability evaluation negatively on a given spatial level ranging from the neighbourhood to the city region.

From these findings we can derive further arguments about how to attract potential in-movers using a well-geared socially or economically sustainable competitiveness strategy based on housing market regulation. In this context it is to observe that, while migration as such is, on balance, considered favourable for the host society from both general economic and social points of view, the problem is the fit between the transition periods of migrants and the regulations (Varga, 2010). Hence the way behavioural and institutional factors play out determines the sustainability position of a given territorial unit in terms of its real estate and housing situation – first along the economic dimension and subsequently along other dimensions. As van Weesep (2000) already over a decade ago put it: housing policy still matters in the New Economy.

6. Acknowledgment

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10

Using Index to Measure and Monitor Progress on Sustainable Development

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1. Introduction

Since sustainable development of a country or a region has received more and more attention recently, many countries and regions have implemented policies to ensure or protect sustainable development. For this reason, it is necessary to develop approaches to measure and monitor both the effectiveness of these policies and the progress made on sustainable development in different regions. To achieve this goal, some countries or regions have developed their own sustainable development index (SDI). On the one hand, for the country or the region itself, SDIs can provide objective information and act as a tool for assessing performances, evaluating progresses, predicting future trends and identifying priority areas in formulating policy and decision-making. On the other hand, governors and scholars also need SDIs to make comparisons of sustainable development among countries or regions, considering multidimensional variables, such as economic, environmental and social variables.

Nowadays, there are different ways of measuring sustainable development which basically depend on the specified objectives of the study. One approach is to construct a SDI based on official statistics to provide an objective measure. However, this approach cannot reflect directly the opinions and feelings of the people living in the study region. Another approach is by conducting a survey. This alternative can measure the views from different sub-group population and produce indicators that can compare the sentiments amongst the sub-group population.

The main challenge of measuring sustainable development is to identify policy areas, while the underlying problem is to identify and prioritize local community's concerns and issues regarding sustainable development. In this chapter, a method of how a multi-stakeholders engagement process was applied to achieve the target is illustrated. A systematic methodology of using index to measure and monitor progress on sustainable development is also constructed after identifying priority areas. The city of Hong Kong is used as a case study to show these approaches in detail. This chapter unfolds as follows. Section 2 reviewes the relevant literatures to introduce significant issues and examples of constructing SDI at both national and regional levels. Some development millestones of SDI for Hong Kong is also included in this section. Section 3 introduces these factors often used in measuring sustainable development. The method of identifying priority areas is described briefly, and then how Hong Kong determines priority areas through this method is

discussed to show operation details. Section 4 talks about the survey scheme adopted to collect the data and the structural equation modeling techinque employed to estimate the Hong Kong sustainable development index (HKSDI). Section 5 summarizes the key findings from the survey. Section 6 discusses reasons of importance and performance data for some priority areas through analyzing those key findings. Conclusions and limitations of the framework are shown in Section 7.

2. Literature review

2.1 Examples of developing SDI at national level

Wackernagel and Rees developed a calculation model for the environmental footprint, which was used as a world-recognized indicator to monitor the impact of global environment to our actions and assess the sustainability of different nations (Wackernagel & Rees, 1997).

In 1996, the United Nations (UN) Organization listed 134 indicators relevant to sustainable development to help these countries monitor their development conditions and implement efficient policies to ensure the sustainable development at national level (Division for Sustainable Development, 2001).

The UN set out the United Nations Development Programme (UNDP) in 2000; the United Nations millennium declarations and millennium development goals were also formulated in that year, which aimed at making sure that human development would reach everyone and everywhere. A human development report for UNDP was published in 2005, which was about the scale of the challenge facing the world at the start of the 10-year countdown to 2015 (Charlotte, 2005). The UNDP focused on three pillars of cooperation, each in urgent need of renovation. They were developing assistance, international trade and security. They also constructed the human development index for 177 countries as a composite indicator to provide a measure for comparing country achievements across all levels of human development.

In 2005, the United Kingdom (UK) government reviewed their sustainable development strategies which were set out in 1997, and updated these strategies according to a series of indicators in economic, environmental and social outcomes, since some of these indicators had moved very much in the right direction and they didn't adjust to development trends any more. Through these updating strategies and measurements, the UK government aimed at constantly promoting the sustainable development in UK (United Kingdom Goverment, 2005).

Barrios and Komoto proposed a SDI for the Philippines (Barrios & Komoto, 2006), in which sparse principle component analysis was used to facilitate interpretation of results. In their study, the SDI was used to indicate the areas in which improvements were required so as to achieve a better and sustainable quality of life.

Short investigated the methodologies and policies used in Rwanda, a country with a special history background, to promote and ensure sustainable industrial development and examine the government's role in providing an appropriate sustainable development framework (Short, 2008). As Rwanda's unique position presented difficulties in representing the relationship between governance and industry, Short introduced a six-dimension of

sustainability adapted from the royal academy of engineering as an analysis model to analyze those special responses from interviews.

The U.S. Environmental Protection Agency (EPA) reported the most reliable indicators currently available to answer key questions about trends in human health and the condition of the nation's environment (EPA Project Team, 2008). The EPA also demonstrated the importance of scientifically sound information to help people understand the state of the environment, identify areas of concern, and monitor progresses.

2.2 Examples of developing SDI at regional level

Although SDIs at the national level are important as lots of powerful decisions are made at this level, SDIs at the regional level are also needed, since for many countries, especially for those large ones or small ones with various diversities, indicators at the national level may mask the sustainable development performance at the regional level. Hence, SDIs at the regional level with indicators adaptable to the local condition are developed.

The organization Sustainable Seattle presented a report to citizens of Seattle on long-term trends in the community (Sustainable Seattle, 1993). The indicators of the sustainable community covered four aspects: environment, population & resources, economy and culture & society. The organization presented these indicators to alert the people of Seattle to learn the problems they faced and got them involved in finding solutions to those problems.

Hoffman developed the roots index as a measure of local sustainable development in New York City for the years 1990-1995 (Hoffman, 2000). The index focused on the foundations of sustainable economic activities and factors that had long-term impacts, such as education, health, housing, infrastructure, environment, access to the legal economy and equality of opportunity, each belonging to one of three UN sustainability categories: social, economic, and environmental. The roots index results also revealed several areas of future problems for the New York City.

Herrera-Ulloa et al. proposed a methodology to evaluate sustainable development within defined regions (Herrera-Ulloa et al., 2003). They developed a regional-scale SDI for Baja California Sur (BCS) of Mexico through the principal component extraction and factor analysis, taking into consideration the social, environmental, economic and institutional dimensions with 27 indicators. The SDI not only reflected an integrated measure of overall sustainability for the BCS region, but also was helpful for developing policies and strategies to obtain better sustainable development conditions.

Ledoux et al. presented an overview of a set of sustainable development indicators recently adopted by the European Commission to monitor, assess and revise the sustainable development strategy adopted in Gothenburg in 2001 (Ledoux et al., 2005). It introduced a hierarchical theme framework based of the policy priorities of the sustainable development strategy to contribute to efficient choosing of indicators, and placed energy and climate change issues in a broader perspective.

2.3 Millstones of developing SDI in Hong Kong

The city of Hong Kong, which is a special administrative region of China after 1997, has an increased awareness of the need for continuous growth and sustainable development.

For China, the sustainable development was set up in 1992 after the holding of Rio Conference on environment and development. Referring to China's Agenda 21 in 1994 (Department of Planning Committee of China, 1994), the Department of Planning Committee of China published a series of plannings, targets and policies of sustainable development, considering China's population, environment and development in the 21st century. The agenda divided policies into three dimensions, they were sustainable social development, sustainable economic development and rational utilisation of resources & environmental protections. Since then, the sustainable development has been a main topic at both national and regional levels in China. In 1999, the Chief Executive of Hong Kong stated in his Policy Address an endeavor to building Hong Kong into a world-class city. Making Hong Kong a clean, comfortable and pleasant home requires a fundamental change of mindset. Every citizen, business, Government Department and Bureau needs to start working in partnership to achieve sustainable development. In simple terms, sustainable development for Hong Kong means finding ways to increase prosperity and improve the quality of life while reducing overall pollution and waste; meeting our own needs and aspirations without doing damage to the prospects of future generations; and reducing the environmental burden we put on our neighbors and helping to preserve common resources. Since 2000, a social development index has been developed by the Hong Kong Council of Social Services. Corresponding reports are published bi-annually since then.

Chiu preliminarily assessed the overall environmental sustainability of the existing housing system of Hong Kong and the usefulness of Bhatti's building life-cycle model in developing a policy for sustainable housing development (Chiu, 2000).

Chiu applied the sustainable development perspective to investigate whether policy changes and government responses to the collapse in the property market have made the distribution and consumption of the resources in Hong Kong more equitable (Chiu, 2002).

Robert and Hills discussed the sustainable development of Hong Kong and Scotland by considering the impact of changing circumstances (Robert & Hills, 2002).

Hills discussed the recent evolution of environmental policy in Hong Kong, the emergence of a regional environmental management agenda and the potential of ecological modernization (Hills, 2002). They were used as a basis for the development of a broader strategy to manage the environmental problems of the Pearl River Delta Region.

Lai et al. discussed a Coasian interpretation of a model of sustainable development for Hong Kong that incorporated economic, societal and environmental factors (Lai et al., 2006).

Chua et al. summarized the current state of social development in Hong Kong, based on the Social Service Index 2008, and identified the major social, political and economic challenges that were confronted by Hong Kong (Chua et al., 2010). They also discussed a range of policy options proposed for promoting a more balanced approach to social and economic development.

While progress has been made in raising public awareness of sustainable development, the fundamental change of mindset has yet to occur. The government formed the Sustainable Development Council in April 2003 to lead the development strategies in Hong Kong. The Council has developed strategies for addressing the specific issues of waste management,

urban planning and renewable energy, with new strategies for population policy and air quality through public consulation.

These are positive setps, but what is needed is a holistic strategy to address the diverse yet interconnected issues that will further enhance the sustainability of Hong Kong, not a set of strategies on individual topics. To get a clearer picture of areas to be improved, however, Hong Kong needs an effective way to measure its quality of life. For this reason, the HKSDI has been designed and launched in 2003 based on the 10 priority areas that represent a wide range of community concerns in relation to the local economy, social progress and the environment(Tso et al. 2011). The construction of HKSDI can reflect a wide range of economic, social and environmental issues that are relevant to Hong Kong and track the public's view on Hong Kong's progress toward a more sustainable future.

3. Factors included in measuring models

3.1 Introduction of factors

Analyzing those examples of developing measurement on sustainable development reviewed in the foregoing section, we find that development problems faced by different countries or regions could be diverse. For these countries and regions, it is often difficult to figure out the areas of major concern, when it comes to putting sustainable development into practice. So in order to get a clear picture of areas to be improved and a holistic road map to improve the quality of life in the region, we need sustainable development indicators to influence behaviors, assist in the design and implementation of improvement programs and enable progress to be monitored.

Referring to the UN's report in 2007 (Department of Economic and Social Affairs, 2007), at the international level, the United Nations Commission on Sustainable Development (CSD) published the first edition of CSD indicators set in 1996, including 134 indicators. During 1999 to 2000, some countries tried to test this indicator set, and they found that this CSD indicator set was too large to be easily managed. So the CSD revised the set, drastically reducing it into 58 indicators, embedded in a policy oriented framework of themes and sub-themes. With evolving of the world, some countries had developed their own indicator set based on the CSD indicators. In 2005, the United Nations Division for Sustainable Development (DSD) decided to review the second edition CSD indicaton set, and they announced the third, revised set of indicators of sustainable development prepared for CSD in 2006. The newly revised CSD indicators contained a core set of 50 indicators, which were part of a larger set of 96 indicators of sustainable development. Instead of using division of indicatiors through "four pillars" (social, economic, environmental and institutional), the newly indicator set was placed into a framework of theme and sub-themes. These indicators belong to 14 themes, which can continuely be divided into 44 sub-themes. The theme details are poverty, governance, health, education, demographics, natural hazards, atmosphere, land, oceans, seas and coasts, freshwater, biodiversity, economic development, global economic partnership and consumption and production patterns.

Fig.1 shows the concept of sustainable development disscussed in the 2nd Kyoto International Seminar on Sustainable Growth in the Asia-Pacific region. The sustainable development is the integration of economic, social and environmental dimensions. Although multidimensional variables are always involved in developing sustainable

development indexes, and those newly CSD indicators had inter-thematic linkages, we still can classify these common themes into three catalogs namely economic, environmental and social factors according to this integration. Fig.1 also gives us a direct simple classfication of those themes mentioned in CSD indicators set. Natural hazards, atmosphere, land, oceans, seas and coasts, freshwater and biodiversity are often measured as environmental factors. At the same time, economc development, global economic partnership and consumption and production patterns are grouped as economic factors. Poverty, governance, health, education and demographics are considered as social factors.

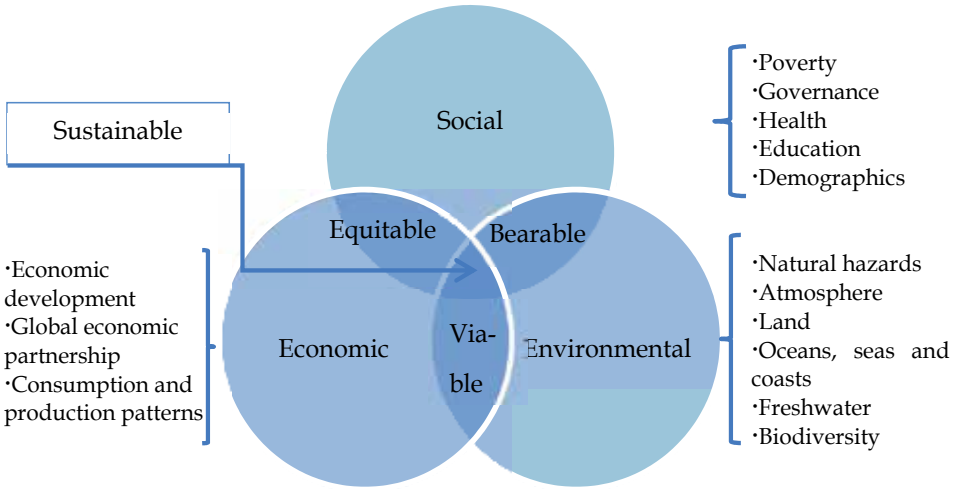


Fig. 1. Sustainable Development

In the construction of SDI, it's not necessary to include all variables in each catalog. Some SDI measuring models cover all three kinds of factors (e.g. Ledoux et al., 2005), most models integrate at least two kinds (e.g. EPA Project Team, 2008) and a few models specialize in only one aspect (e.g. Wackernagel & Rees, 1997). Referring to the work of Ledoux et al. in 2005, of the indicators designed for communication with the general public, 34% integrate three kinds of factors, and 86% address at least two aspects. Hence, for different regions, the construction of SDI should depend on the local practical situation and the real problems they are facing to choose related factors.

In summary, in order to identify policy areas exactly, governors need to locate priority areas accurately, choose adaptable themes, and use indicators into measuring models. However, the CSD indicator framework was designed for monitoring sustainable development at the national level, and most measurements of indicators were official statistics, which cannot reflect directly the opinions and feelings of people living in the study region. So it would mask sustainable development performance at the regional level if the CSD indicators were transplanted directly into the construction of SDI at the regional level.

Hence, when it comes to monitoring the effectiveness of a region, we need comprehensive approaches to determine priority areas according to local sustainable development conditions, considering three dimensions of environmental, economic and social factors.

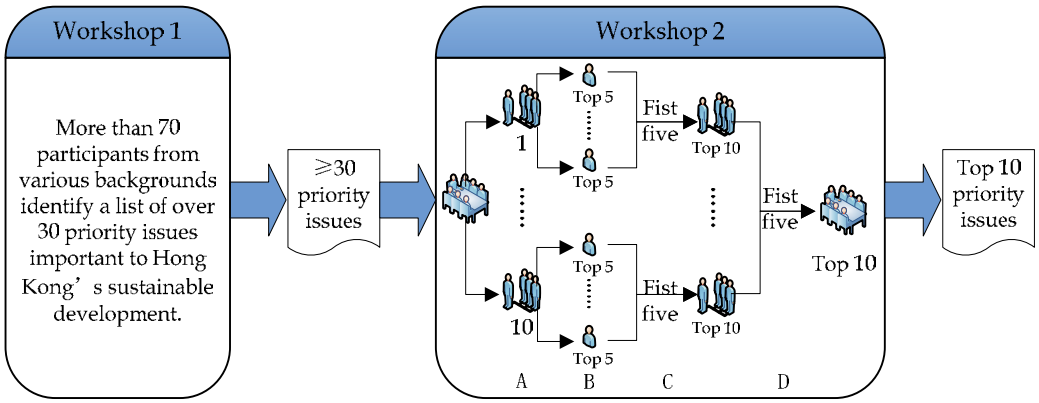
3.2 Method of determining priority areas

Considering the limitation of official statistics, a new method of determining priority areas of sustainable development was developed. This section introduces the framework of determining priority areas and explains how Hong Kong used this methodology to achieve its priority areas for the sustainable development.

The HKSDI is based on the 10 priority areas that represent a wide range of community concerns in relation to the local economy, social progress and the environment. These 10 areas were identified through multi-stakeholder engagement workshops conducted to identify priority areas for Hong Kong's sustainable development. Thus, this index can reflect a wide range of economic, social and environmental issues that are relevant to Hong Kong and track the public's view on Hong Kong's progress toward a more sustainable future.

Fig. 2 shows the method of determining the top 10 priority areas to be focused on for Hong Kong. The methodology consists of two workshops. The first one is to identify a list of priority issues which were important to Hong Kong's sustainable development, conducted by those participants who were interested in this topic. While the second one is to achieve the target top 10 priority areas used for HKSDI through an interactive consensus building process conducted by multi-stakeholders. Operation details of this method are as follows.

The first workshop conducted in 2001 involved over 70 participants interested in the topic, including government officials, business operators, environmental consultants and members from various chambers of commerce. During the workshop, particular questions like "what are your priorities for a sustainable society in Hong Kong" and "how would you define them and what targets should Hong Kong achieve" etc. were used to focus discussions on three topic areas of social, economic and environmental sustainability. As a result, participants reached consensus, through interactive and facilitated discussions, on a list of over 30 priority issues, which were important to Hong Kong's sustainable development.



Note:
A: Divide participants into 10 groups, each with ≤10 members from different stakeholder groups
B: Each member in a group identifies top 5 priorities
C: Each group reaches an agreement with a list of the top 10 priorities
D: All participants reach a consensus on a list of the top 10 priorities

Fig. 2. Method of determining the top 10 priority areas

The second workshop, which was part of the Government's International Symposium on Sustainable Development, reviewed the identified priority issues and reached consensus on the top 10 priority areas for sustainable development in Hong Kong through debates. The second workshop involved a diverse group of stakeholders who represent a variety of sectors including business, government, environmental and social organizations, academics and professionals. The goal of the workshop was to identify top 10 priority areas that participants believed should be the focus of action to further sustainable development in Hong Kong. An interactive consensus building process was used to reach the conclusion of the 10 priority areas. During the process, the workshop participants were divided into 10 small discussion groups, each comprising up to 10 members from different stakeholder groups and being led by an independent facilitator. Each small group then reviewed and discussed according to the following outlines:

1. Individuals in each group first reviewed the priorities from the previous workshop, considering the local and international context of Hong Kong's sustainability; they then selected their top five priorities.
2. Each member then shared their top 5 priorities with the group while the facilitator counted the votes of each priority.
3. Each group discussed the selected priorities in order to understand each other's views and to see whether there was an agreement on the group's selection of top 10 priorities.
4. After discussing their rationales for why a priority should be on the list or not, each group member was then asked individually to identify the top 10 priorities that he/she believed should be on the list.
5. These results were shared within each group and, however, if an effective consensus was not attained on the list of top 10 priorities, the "fist five" tool [1] was employed to show members' support for including or excluding particular priorities.
6. After reaching a consensus on the list of top 10 priority areas in each small group, all participants re-convened to share their results and to discuss ways forward to reach a consensus as a larger group on the final list of top 10 priorities. As a result, criteria were suggested to filter the priorities, and a list of top 10 priorities emerged. The "fist five" technique was used again to gauge the level of support for the final list among the participants.

At the end of the second workshop, the following 10 areas were determined to be the priority areas for sustainable development in Hong Kong, including: caring and ethical employers, civil liberties and human rights, community spirit and well-being, educational system, environmental protection, health and hygiene, healthy economy, integration with the mainland, population policy, and urban planning.

As a remark, the above method of determining priority areas of sustainable development may be criticized as subjective. However, given the resource limitations and other constraints, to conduct a large scale opinion poll to determine the priority areas is infeasible.

[1] "Fist five" is a consensus-building tool that enables group members to indicate the extent to which they support a decision, e.g. five fingers indicates unwavering support and a fist indicates absolute disagreement with the way forward. Depending on the number of fingers shown, from none to five, the group can effectively gauge the level of support for an outcome and then discuss it until the group agrees on or accepts the outcome or decision.

The current way to determine the priority areas is an attempt to strike for a balance, with an aim to systematically collect information from multi-stakeholders, which is assumed to be representative for the population's view.

4. Measurement process

4.1 Data collection

The HKSDI was developed as an indicator to reflect changes in public opinion regarding sustainable development in Hong Kong. Annually between July and September over 2,000 randomly sampled Hong Kong residents, aged 18 or above, were surveyed by telephone. Respondents were engaged in detailed conversations, usually lasting for 20 to 30 minutes, about issues that were critical to the sustainability of Hong Kong.

For each priority area, respondents were asked to indicate their ratings, using a 10-point scale, regarding the following attributes:

1. How important the priority area is for achieving and sustaining quality of life in Hong Kong?
2. Which aspect(s) of the priority area are important for improving quality of life in Hong Kong?
3. How satisfied he/she is in regard to Hong Kong's performance in the priority area?

4.2 Calculating the index

The HKSDI is defined by a weighted average of satisfaction scores of the 10 pre-specified priority areas. It has a range between 0 and 100. The relative levels of importance of the 10 priority areas were used as weights. The importance levels of the 10 priority areas were first normalized into a percentage distribution, so as to produce a summed total of one.

In particular, the computational formula of HKSDI is given by

$$\text{HKSDI} = \frac{\sum_{i=1}^{10} \overline{W_{i1}}\,\overline{P_{i1}}}{\sum_{i=1}^{10} \overline{W_{i0}}\,\overline{P_{i0}}} * 100 \tag{1}$$

$$\overline{W_i} = \frac{1}{n}\sum_{j=1}^{n} W_{ij} \tag{2}$$

$$\overline{P_i} = \frac{1}{n}\sum_{j=1}^{n} P_{ij} \tag{3}$$

where

n is the sample size;

W_{ij} is the level of importance for priority area i provided by respondent j;

P_{ij} is the satisfaction level for priority area i provided by respondent j;

$\overline{W_{i1}}$ and $\overline{P_{i1}}$ are the average importance level and satisfaction level respectively for priority area i of the current year;

$\overline{W_{i0}}$ and $\overline{P_{i0}}$ are the average importance level and satisfaction level respectively for priority area i of the base year 2003.

The specific objectives of the index are:

1. To assess the importance of sustainable development priority areas within the Hong Kong community;
2. To determine what sustainable development priority areas mean to the community;
3. To track community perceptions on the importance of sustainable development priority areas and the progress in managing these areas; and
4. To raise awareness of the important role of the priority areas in furthering sustainable development.

5. Key findings

5.1 HKSDI values and respondents' expectations

Each year an aggregated score is calculated based on the results of the survey that provides an annual measure of progress in furthering sustainable development in Hong Kong. The following table (Table 1) shows the HKSDI values from 2003 to 2007.

Year	Sample Size	HKSDI value
2003	2,501	100.0
2004	2,515	102.8
2005	2,051	102.5
2006	2,054	102.2
2007	2,021	103.7

Table 1. HKSDI values from 2003 to 2007

HKSDI values act as a quantitative measurement tool for the sustainable development. The HKSDI in 2003, which is the baseline measure, was 100. Statistically, the index values in 2004, 2005 and 2006 do not significantly deviate from each other. They were 102.8, 102.5 and 102.2 according to the time sequence. While in 2007, the overall index score was 103.7, slightly higher than 102.2 in 2006. There is an annual increase in the index from the baseline of year 2003 to the year 2007, this modest increase trend indicates that Hong Kong people perceived some progress has been made in addressing the priority areas measured by the index since 2003. So the sustainable development index can be used to measure levels and monitor progress on sustainable development.

At the same time, respondents were asked in an open-ended question to identify the aspects in each of the 10 priority areas that needed further improvement, which can be used as a qualitative monitor tool to help the stakeholders to identify specific aspects that are essential for improving performance in the priority areas, and thus contribute to improve the overall sustainable development.

The results obtained over the years reveal that for the economy, aspects such as creating employment, improving employee benefits, and trade opportunities are most important, whereas reducing air pollution, improving cleanliness of the city and establishing more open and green space are important on the environmental side. On the people side, Hong Kong people demand good teaching quality be found in schools, better immigration policy for mainland people, higher civic consciousness and care for others, as well as freedom of speech. These demands have not been changed over the past few years.

5.2 Importance of each priority

Respondents were also asked to rate the level of importance for each of the 10 priority areas which were determined through two workshps mentioned before. Along the 5-year study period, all the 10 priority areas received consistently high ratings of importance of 7 or higher out of 10. Their average scores are given in Table 2, which are graphed in Fig. 3.

Mean value in each year / Priority areas	2003	2004	2005	2006	2007
Education System	8.3	8.4	8.3	8.5	8.3
Health and Hygiene	8.3	8.3	8.2	8.4	8.2
Environmental Protection	7.9	8.2	8.2	8.4	8.3
Healthy Economy	8.3	8.1	8.1	8.2	8.0
Caring and Ethical Employers	7.9	7.9	7.9	8.0	7.9
Urban Planning	7.6	7.7	7.6	7.9	7.7
Community Spirit	7.5	7.5	7.5	7.8	7.7
Population Policy	7.5	7.6	7.6	7.8	7.6
Integration with the Mainland	7.1	7.4	7.4	7.6	7.5
Civil Liberties and Human Rights	7.5	7.5	7.3	7.5	7.2

Table 2. Average importance score of each priority area in Hong Kong from 2003 to 2007

Fig.3 shows that, from 2003 to 2007, Education System, Environmental Protection, and Health and Hygiene ranked top most important issues (except for the average score of Environmental Protection in 2003) contributing to the sustainable development in Hong

Kong. In contrast, Civil Liberties and Human Rights, Integration with the Mainland and Population Policy always ranked the least important issues (except for the average scores of Population Policy in 2004 and 2005) contributing to the sustainable development in Hong Kong.

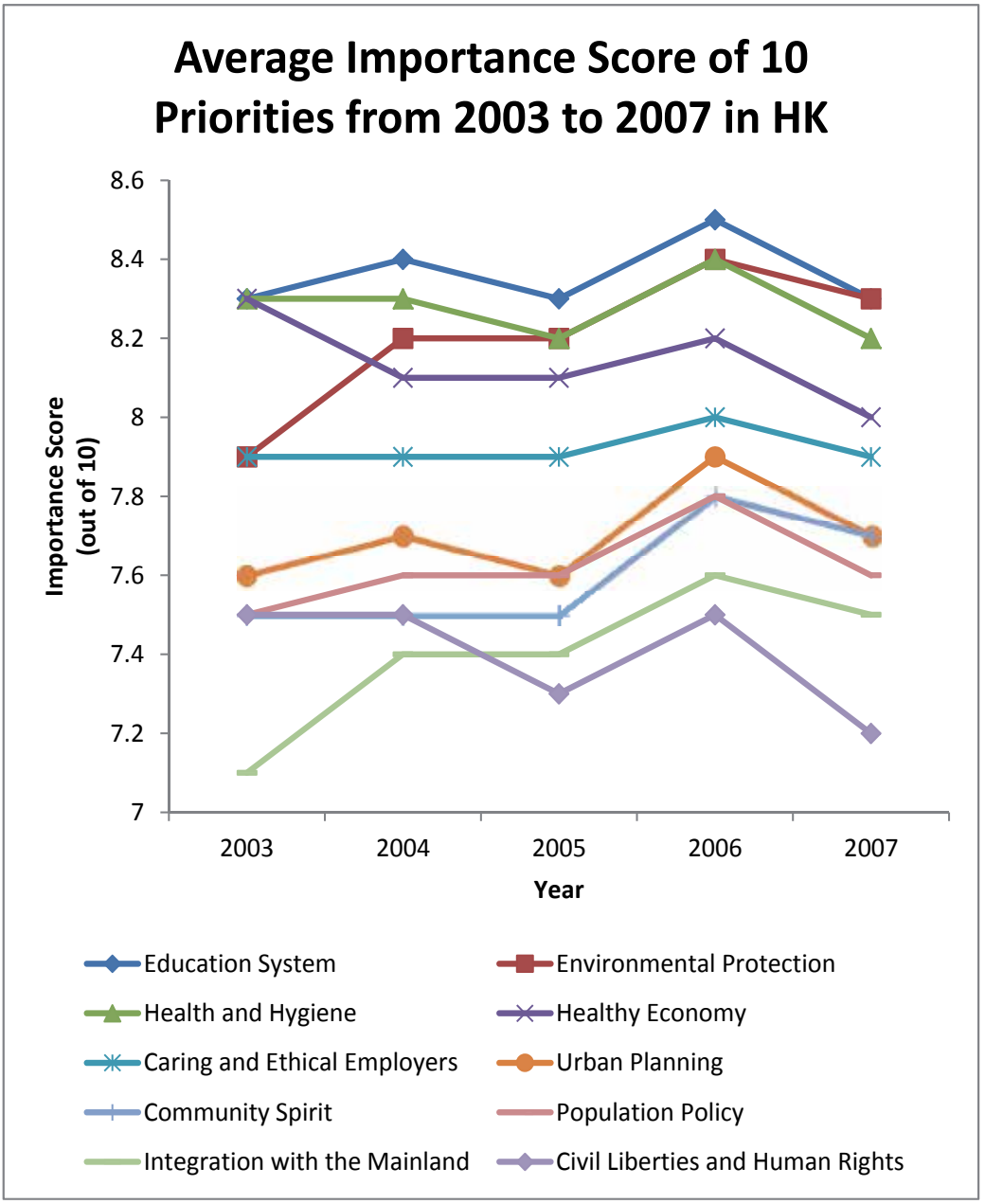


Fig. 3. Average importance score of each priority area in Hong Kong from 2003 to 2007

To further understand the trends, the "most important" and "least important" areas along the 5-year period are listed in Table 3. It is found that Education System has always been perceived the most important aspect. On the other hand, Integration with the Mainland was initially rated as the least important area, and then it shifted to Civil Liberties and Human Rights. During the growing economy period from 2005 to 2007, it is interesting to note that respondents rated Civil Liberties and Human Rights the least important aspect for sustainable development.

Furthermore, in order to monitor the possible changes in the importance ratings of the 10 priority areas along the 5-year study period, a one-way analysis of variance (ANOVA) was conducted. Here the factor refers to the year from 2003 to 2007, and the response variable is the importance rating of each priority area. Concluding that there was strong evidence that the expected values in the five groups be the same, so no significant difference (at 5% level) in the 5-year period for each of the priority areas has been found.

	2003	**2004**	**2005**	**2006**	**2007**
Most important	Education System(8.30)	Education System(8.37)	Education System(8.34)	Education System(8.48)	Education System(8.34)
Least important	Integration with the Mainland(7.12)	Integration with the Mainland(7.35)	Civil Liberties and Human Rights(7.29)	Civil Liberties and Human Rights(7.49)	Civil Liberties and Human Rights(7.23)

Table 3. Importance trend from 2003 to 2007

5.3 Performance of each priority

Respondents were also asked to rate how satisfied they were with Hong Kong's performance in each of the 10 priority areas that were important to their quality of life. Their average scores are given in Table 4, and graphed in Fig. 4.

Fig.4 shows that, from 2003 to 2007, Health and Hygiene and Civil Liberties and Human Rights always ranked top two issues in the average performance score graph. While the Healthy Economy was the unique issue which has markedly improved its performance since 2003, and satisfaction levels have remained relatively consistent for other priority areas. None of them received an average score of more than 7 out of 10 and the majority average scores were around 5.5 out of 10. In contrast with those issues which always ranked at the top, Population Policy ranked the worst satisfying issues, except for the special priority of Healthy Economy, as the average scores of Healthy Economy in 2003 and 2004 were lower.

To further understand the trends, the "best performance" and "worst performance" areas along the 5-year period are listed in Table 5. It is found that Health and Hygiene has continuously been rated as the best performing area. On the other hand, Healthy Economy was rated as the worst performing area from 2003 to 2004, and then Population Policy in the follwing 3 years while the performence of Healthy Economy was continuously improving during this time.

Mean value in each year / Priority areas	2003	2004	2005	2006	2007
Health and Hygiene	6.2	6.4	6.2	6.3	6.3
Civil Liberties and Human Rights	6.0	6.2	6.2	6.3	5.9
Healthy Economy	4.7	5.2	5.7	5.7	5.9
Integration with the Mainland	5.6	5.7	5.8	5.9	5.8
Urban Planning	6.0	6.0	5.9	5.8	5.8
Education System	5.5	5.6	5.6	5.6	5.8
Caring and Ethical Employers	5.4	5.5	5.6	5.6	5.7
Community Spirit	5.6	5.6	5.7	5.6	5.6
Environmental Protection	5.8	5.6	5.5	5.5	5.5
Population Policy	5.2	5.3	5.5	5.4	5.4

Table 4. Average performance score of each priority area in Hong Kong from 2003 to 2007

	2003	**2004**	**2005**	**2006**	**2007**
Best performance	Health and Hygiene 6.21)	Health and Hygiene (6.37)	Health and Hygiene (6.24)	Health and Hygiene (6.28)	Health and Hygiene (6.30)
Worst performance	Healthy Economy (4.73)	Healthy Economy (5.23)	Population Policy (5.47)	Population Policy (5.39)	Population Policy (5.35)

Table 5. Performance trend from 2003 to 2007

Similar to checking the changes in important ratings, the performance ratings of each priority area along the 5-year study period were used as response variable in a one-way ANOVA model with the year from 2003 to 2007 being the single factor. An *F*-test on overall significance revealed statistically significant difference (at 5% level) exists in three areas: Healthy Economy, Caring and Ethical Employer and Environmental Protection.

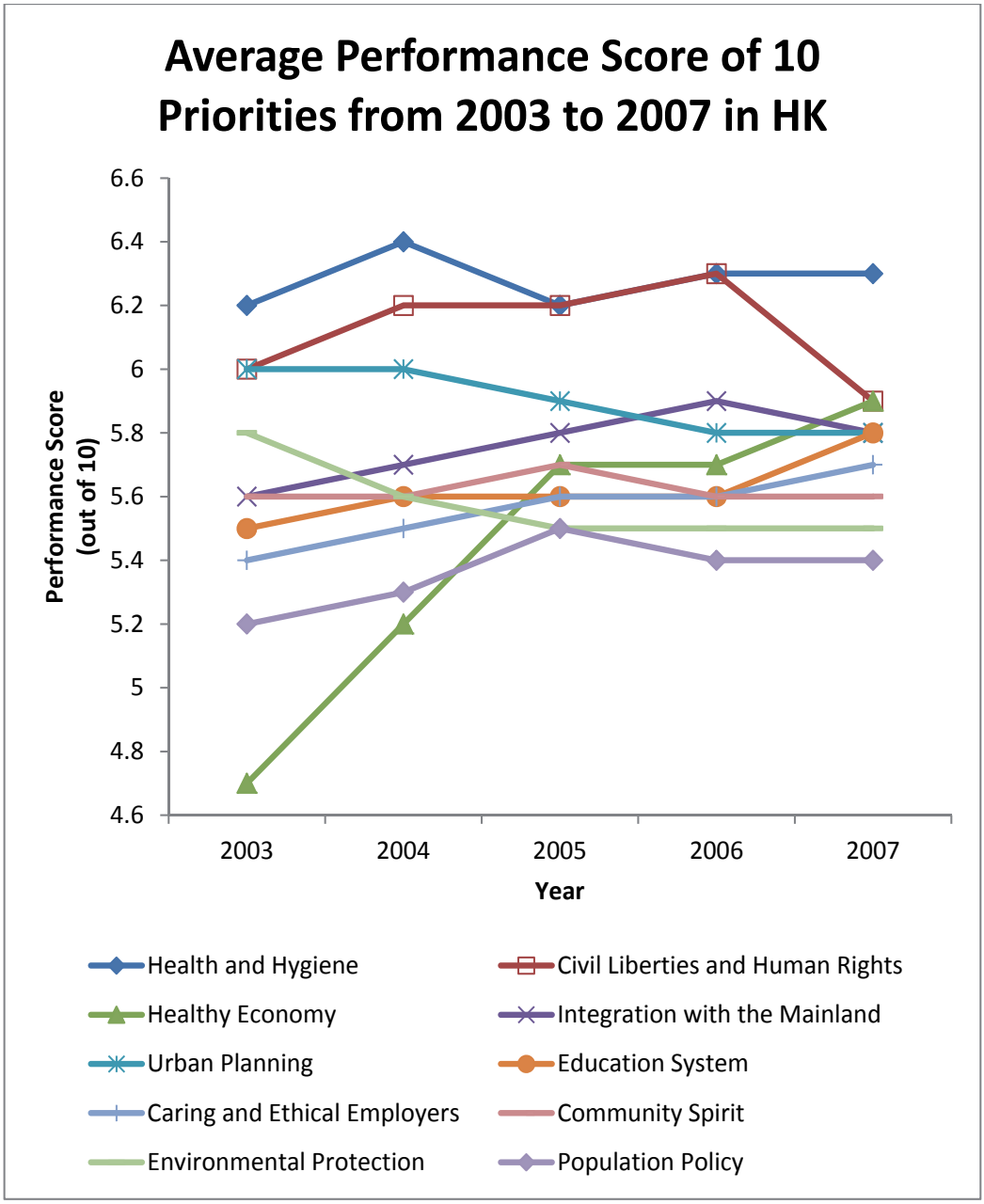


Fig. 4. Average performance score of each priority area in Hong Kong from 2003 to 2007

The mean scores and the corresponding groupings according to the post-hoc Tukey procedure for these three areas are given in Table 6. The post-hoc procedure performs pairwise multiple comparisons at 5% level of significance. It aims to determine which yearly mean score differs from the others. Homogeneous groups of yearly mean scores that are not significantly different from the others, and the corresponding yearly patterns, are identified.

Table 6a, b suggest an increasing trend in performance ratings in the priority areas of Healthy Economy and Caring and Ethical Employer. Regression analysis has been used to formally test the existence of such linear trend. As a result, significant trend coefficients (at 5% level) are found in both priority areas of Healthy Economy (linear trend: 0.272) and Caring and Ethical Employers (linear trend: 0.059).

Year	Group 1	Group 2	Group 3
Priority area: Healthy Economy			
2003	4.74		
2004		5.26	
2005			5.74
2006			5.74
2007			5.83
Priority area: Caring and Ethical Employer			
2003	5.41		
2004		5.56	
2005		5.60	
2006		5.67	
2007		5.69	
Priority area: Environmental Protection			
2003	5.73		
2004		5.44	
2005		5.53	
2006		5.53	
2007		5.55	

Table 6. Homogenous groups of yearly mean scores according to the post-hoc Tukey procedure

5.4 Importance versus Performance

For the 10 priority areas, their corresponding average importance and performance scores along the 5-year period are depicted in Fig. 5. The figure provides a set of descriptive information to schematically present the relative ratings of importance versus performance on the 10 priority areas for sustainable development.

Furthermore, we define

$$\text{Gap} = \text{Importance} - \text{Performance} \tag{4}$$

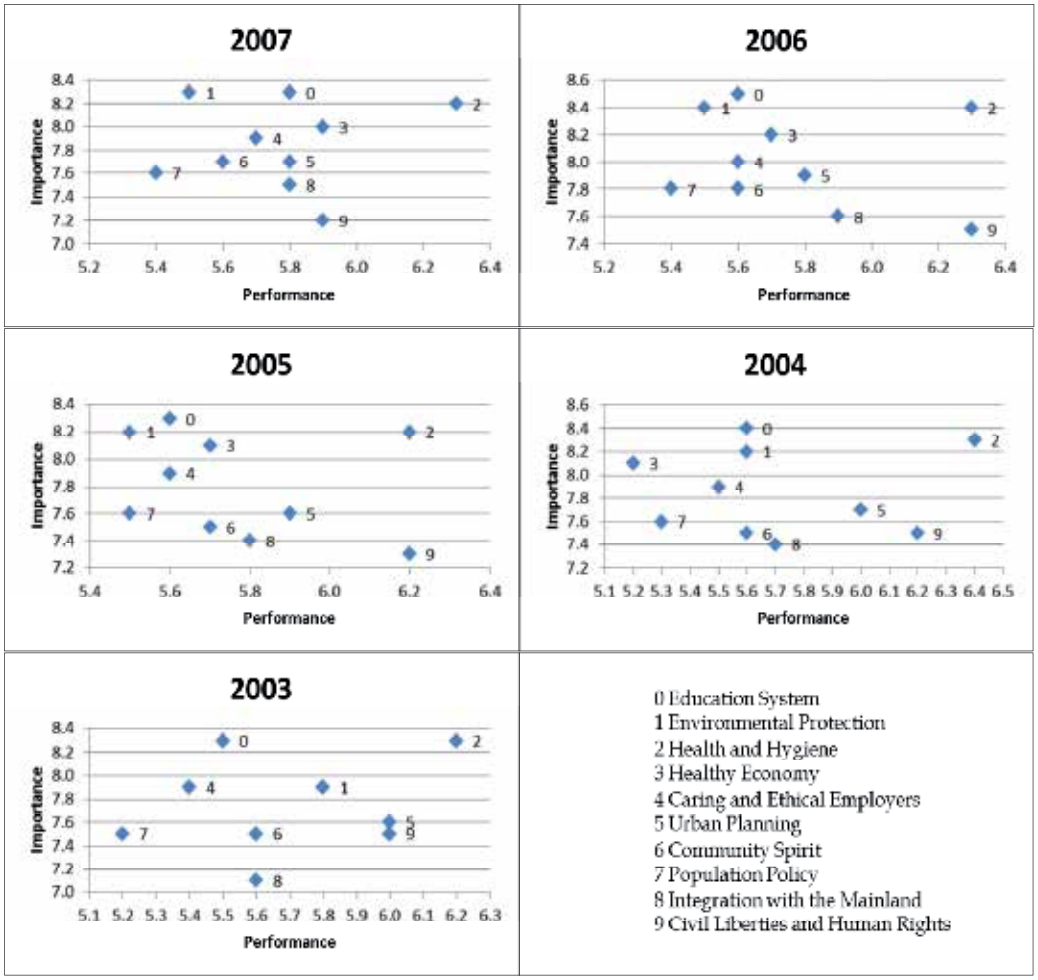


Fig. 5. Importance versus Performance from 2003 to 2007

The approximate performance gap in each of the 10 priority areas can be computed through this definition. Table 7 shows the "largest and smallest gap" results along the 5-year period. Healthy Economy was found to have the largest gap from 2003 to 2004. The largest gap

appeared in Education System for the year 2005. Then, from year 2006 to 2007, Environmental Protection shows the largest performance gap. On the other hand, Integration with the Mainland was recognized as having the smallest gap for the year 2003. Then, from year 2004 to 2007, the smallest gap was mainly found in Civil Liberties and Human Rights.

	2003	**2004**	**2005**	**2006**	**2007**
Largest gap	Healthy Economy (3.53)	Healthy Economy (2.92)	Education System (2.73)	Environmental Protection (2.99)	Environmental Protection (2.75)
Smallest gap	Integration with the Mainland (1.48)	Civil Liberties and Human Rights (1.35)	Civil Liberties and Human Rights (1.10)	Civil Liberties and Human Rights (1.21)	Civil Liberties and Human Rights (1.30)

Table 7. Gap trend from 2003 to 2007

6. Analysis

This section pays attention on the reasons that led to those trends of the 10 priority areas, especially for the ones which have a high average improtance score and those have special ranking or trend characters. On the one hand, the analysis explains how these data and trends were caused; on the other hand, governors can make adaptable policies for future development based on this analysis. First of all, the results revealed that Hong Kong people consider Education System, Health and Hygiene, and Environmental Protection as the three most important issues catching their concerns. The analysis of these three areas unfolds as follows.

Education System is the priority area always listed in the first place for the importance aspect from 2003 to 2007. In fact, education is a critical issue in changing people's norms, values, interests as well as behaviors. Educational strategy is significant in shaping the culture of the society, which deeply changes the norms of the people and influences individuals' behavior. Nowadays, education is also a hot topic, as more and more people pay attention on education, not only for young generation's education, but also for the adults' continuing education. Wong investigated the contribution of continuing education and leadership empowerment to sustainable development (Wong, 2003). For its performance part, we can see that Education System is listed in the middle of Table 4, meaning that Hong Kong people were satisfied with the performance of Education System in the past years. But the year 2005 is a particular case, since the gap of importance and performance in this year is one of the largest. This may reflect the society's overall disappointment with the education reform policies that gave rise to confusions and created uncertainties as well as lots of changes at that time. According to respondents' answers in the open-ended questions of the survey, for Education System, people of Hong Kong

demand the society to improve the quality of teaching and the government to restructure Hong Kong's Education System.

Health and Hygiene is another priority area with high importance scores. It gets the same score with Education System in 2003, and is listed in the second place during 2004 to 2006. In 2007, it's in the third place. At the same time, Health and Hygiene also acts as the priority area which always gets the highest performance score from 2003 to 2007. This means that Hong Kong people remained satisfied with the performance of Health and Hygiene along the 5-year study period and reasons should relate to the community's general awareness in Health and Hygiene and the government's effort in alleviating public health standards, particularly after the severe acute respiratory syndrome (SARS) ourbreak in 2003. Asian countries and Canada suffered the SARS in 2003, the outbreak of this pestilence has aroused public concern over Health and Hygiene. After the SARS crisis, more people become aware of the importance of the environment to their health. Subsequently, a practical assessment scheme for assessing the Health and Hygiene performance of apartment buildings in Hong Kong has been developed by some scholars (Ho et al. ,2004). Hong Kong government has spent a lot of efforts and resources in this area and more policies have been put forward to prevent the occurrence of disease in various ways. The survey results suggest that these actions are effective.

Environmental Protection is also an important issue, as it always lists in the first three of those 10 areas during the 5-year study period. But its performance rating always ranks at the low side as shown in Table 4. This indicates that people were not satisfied with the environment in Hong Kong, although it got a high importance score. Following Hong Kong's return to China in 1997, Hong Kong has been struggling to retain its status as a world-class city and the financial capital of East Asia. In the fight to maintain a competitive edge, air quality has taken on increased importance. But the results of ANOVA in Table 6c show that there is a significant difference concerning the performance between 2003 and the years after. In fact, Hong Kong's long-persisted air pollution problem has been internationally recognized. As early as 1966, the government set up a committee to study air pollution generated by the industrial activities and motor vehicles. Despite historical concerns, air quality deteriorated markedly in the 1990s. As reported by the Hong Kong Environment Protection Department in 2002, the increase in the number of poor-visibility days raised public awareness of the problem. At the same time, from 2006 to 2007, it shows the largest performance gap, this is because that the air pollution problem is getting more obvious and people are demanding to see a clear sky again. In particular, Hills discussed the evolution of environmental policy in Hong Kong and a regional environmental management agenda (Hills, 2002). According to the survey results, along the 5-year study period, air quality is consistently identified as the major aspect which needs to be further improved, although currently people are satisfied with the performance in this area. More efforts made in this aspect will definitely help people achieve quality of life.

Besides the above three important priority areas, Healthy Economy and Population Policy are two other areas with interesting results worth to be mentioned. Due to the fact that Hong Kong's economy has reached its bottom in 2003 and 2004 since the Asian financial crisis occurred in 1997, and started to pick up slowly from the second half of 2004, the area of Healthy Economy was rated the worst performed area in year 2003 and 2004, but rapidly improved in its performance since 2005. When the economy started to rebound, many Hong

Kong people switched their attention to the immigration problem from mainland China, especially because the local news often reported the inflow of pregnant women from the mainland to give birth in Hong Kong, whereas the birth rate of local residents keeps on decreasing. This may increase the number of people to opine that the government should perform better in setting up her population policy. This is why that Population Policy acted as the worst performance area from year 2005 to 2007. At the same time, we find that the area of Healthy Economy has been continuously improved, according to the ANOVA results on the possible change in performance ratings. The successful experience of achieving improvement in this priority area can be summarized and used as a reference in other areas. Let's see an example, from Table 6a, we can see an increasing trend in performance rating in Healthy Economy, this may reflect the rebound of Hong Kong's economy in post-SARS outbreak since 2003, employees also started to have their incomes being increased again. At the same time, Healthy Economy suffered the largest gap from 2003 to 2004. This is because that after experiencing the Asian financial crisis in 1997, its impact continuously affected Hong Kong's economy. The SARS incidence in 2003 further expedited the economy from bottoming out. At that time, a strong voice longing for a Healthy Economy should be anticipated.

The area of Population Policy has a relatively lower importance rating and the lowest performance rating. In particular, it received the worst performance score from 2005 to 2007 with managing immigration from the mainland China being the major aspect demanded for further improvement. Law and Lee investigated the relationship between citizenship, economy and social exclusion of mainland Chinese immigrants in Hong Kong (Law & Lee, 2006). Three interrelated dimensions of the social exclusion of Chinese migrants in Hong Kong: globalization, political attempts of territorial states, and nature and strength of local place-based social identity, were discussed. Hong Kong is often viewed as a society of Chinese immigrants. Hong Kong's immigration control regime has changed in accordance with the development of the economy. Different regime was applied in different historical periods, such as Touch-Base Policy in 1980, One-Way Permit, Two-Way Permit, General Labor Importation Scheme, Admission of Talents Scheme, etc. On the one hand, these policies were helpful to the economic development in Hong Kong by providing labor resources during a certain period of time. But on the other hand, it also created a lot of other problems at the same time. The newcomers were sometimes seen as aggravating the territory's social problems by increasing competition for jobs, houses, and welfare benefits. After the Asian financial crisis in 1997, Hong Kong's economic recession deepened. Hong Kong people's negative perception towards new arrivals further intensified. Looking ahead, to reinforce Hong Kong's high-tech and high value-added industrial development strategy, an appropriate population policy is needed. Given the keen competition among global cities, the government needs to continuously seek mainland Chinese talents that might help transform the economy into a knowledge-based metropolis in order to enhance the competitive status of Hong Kong. As such, it is essential to have a flexible immigration policy to attract mainland Chinese talents to root in Hong Kong.

7. Conclusion

There is no doubt that nowadays many societies are concerning their abilities to satisfy the needs of present generation without jeopardizing the possibility of doing so for future

generation, thus the issue of sustainable development becomes an important issue for many countries and regions. It is therefore necessary to produce meaningful measures capable to effectively monitor the current progress on sustainable development for the region concerned. This chapter introduces a methodology to construct a regional sustainable development index which can identify important priority areas being considered by people through a multi-stakeholders engagement process, and measure people's satisfaction levels toward each area. The city of Hong Kong is used as an example to present details of the methodology, including identification of prioritizing areas, the SDI model, and the data measurement process. There exists, however, two major limitaions in the project of measuring the HKSDI. The first point being the response rate of telephone survey involved in the study is not very high. Ideally a good telephone survey requires a high response rate, but the resources we can afford on the interviewing cost and the length of the questionnaire were limited, so the response rate in our study is not ideal. The second one is that the score given for one priority area may mean for various aspects. Although each respondent has provided a rating on his/her importance and satisfaction levels towards each priority area, they may in fact refer to different specific aspects in that area. Nevertheless, this problem is unavoidable in practice because individuals have their own concerns in each priority area. Although there are some limitations, we have achieved our measuring and monitoring goals. Hence, this methodology can be adoped by different regional areas to measure and monitor their sustainable development progress.

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11

Sustainability in Urban Ecosystems and Detecting Urban Vegetation from Different Images Using an Object-Based Approach

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1. Introduction

Lexical meaning of ecology is "the study of the interrelations of organisms and their surroundings" (Odum and Barrett 2008). Every individual in the society must be aware of and know his surroundings, plants in his surroundings, other living beings and all the factors that affect the life in the nature in order to continue his life. Because of various opportunities provided by the success in technology for our lives, many of us are not aware of the fact that we depend on nature for air, water, and food, though indirectly. It is among the biggest misconceptions of developed societies of the present time that individuals perceive opportunities offered by technology as direct needs in addition to the basic needs provided by nature for us in daily life. Tangible value of services provided by nature for us both as a human being and as a society is very low. In this sense, we tend not to understand and comprehend the value of these services unless there is a problem (Odum and Odum 2000).

Association and living environments created by the societies have caused individuals of the societies to fail to adequately make use of advantages brought by nature in the course of time. Therefore, problems and solution offers concerning meeting the needs peculiar to nature in the urban areas are effectively discussed in scientific circles. The system formed by relationships between living beings and non-living things in nature is called ecological system or ecosystem (Çepel 1992). This system formed by living beings and non-living things tries to maintain its balance also in the environment where human beings live. Ecosystems which emerge through rearrangement of natural ecosystems based on human factor and which urban-industrial communities live on is defined as techno-ecosystems (Naveh 1982). It is possible to say that techno-ecosystems negatively change the balance in natural ecosystems. That is why, in order to continue their existence, urban communities have to establish an order based on mutual benefit with natural ecosystems within current ecosystem.

Looking at a piece of land (landscape) within a particular area as a whole, it is seen to have a heterogeneous structure peculiar to time and place. In such a structure, different developments, changes and dynamics appear depending on time and place. Landscape

ecology is the discipline which studies the characteristics of a landscape with a heterogeneous structure and reveals management policies of the land for benefit and life of the society (Risser et al. 1984). Principles and concepts in landscape ecology make theoretical and experimental contribution to many applied disciplines such as urban and regional planning and resource management. Calow 1999 defined landscape as "a term which unifies the human and the nature". However, on the contrary, there also exist some landscapes designed by people as the ecosystems formed by human interference. Techno-ecosystems defined as cities and industrial districts result in ecological effects which are relatively small but highly strong. The majority of these effects are negative as well. The development of such districts is possible by interconnecting the urban ecosystem once more and the habitats surrounding it. The sustainability of the protection of the urban ecosystems is a problem whose solution is complex. The most prominent one of the main goals is the protection or to make the reconstruction of the natural potential of urban open green area systems possible. In order to do this, the necessary precautions within the scope of the sustainability have to be taken. The basis of the plan to be made is the detection of green area existence and the convenience of the vegetative form to the natural potential. The existence of urban open green areas is important in terms of urban climate, urban aesthetic, human psychology as well as ecological and economical aspects. One of the important research subjects for today's modern cities is to record the existence of the trees and green areas in the urban texture, to determine the amount of area it covers in the surface of the area and to set forth its temporal variations. In this context, the techniques of remote sensing technologies play an important role for the above-mentioned analysis to be carried out. As a result of these analysis, planning new parking areas in the urban texture and also being able to carry out new adjustments will be ensured (Bulut et al. 2010; Melchert 2005).

2. Urban ecosystem and the concept of green area

The rapid population growth, mechanization, asphalt and concrete housing in today's cities disturb the biological balance in the urban environment. As a result of this, the possibility for the urban people to lead an unconstraint and a secure life disappears. The environment created by human progresses in the opposite direction. The urban people are faced with the negative living conditions owing to the environment that has been destroyed. People form the type of a new (artificial) ecosystem by manipulating the natural ecosystem existing in the environment in which they live. Whereas the activities of people in the urban areas determine the land use, the outcomes of the industry improved by using the technology also determine the effect to the environment. In this context, the balance of the urban ecosystem depends on the interrelations of the factors composing this balance to offset in a renewable ratio (Yeren 1991). However the urbanization process has adversely affected the ecological systems. A healthy urban life and a sustainable urban ecosystem have to be integrated into the natural habitat because the city itself has to be a part of the ecosystem. Urban people live in small places, are enclosed in terms of indoor and outdoor, distant from natural beauties. As a result, a conscious physical and social planning is needed more in the urban environment.

The most important factor of the habitat is definitely its vegetal elements. The concept of green area is defined as the surface areas of the available open areas covered or combined with vegetal elements (wood and non-wood plants) (Bilgili 2009; Gül and Küçük 2001). The

urban open and green areas are gathered into two groups one of which is open green areas within the urban texture and the other is open green areas around the urban texture. Green areas composing a crucial part of the city in terms of area have to be in a certain structure within the urban texture. Since their usage is for social purposes, they are planned as expansive areas in a natural character within the city (Uzun 1990).

The contributions of green areas to the urban ecosystem can be enumerated as cooling of the air, increasing the relative humidity of the air, supplying clean air, infiltrating the air, absorbing the noise, producing oxygen, decreasing the greenhouse effect, and saving energy. Green areas serve like a respiratory organ especially in the urbanized areas as well as enabling a healthy development for people physically and psychologically through doing recreative and sports activities. In addition, by enabling people to recreate, green areas contribute to establishing social relations, maintaining these relations and developing the social solidarity (Aksoylu et al. 2005). In short, urban green areas are of great importance so as to bring about the three essential requirements: daylight, clean air and free motion opportunities. Moreover, green areas are needed in terms of many functions such as social, physical, and psychological. Figure 1 shows the classification of the functions of urban green area.

Ecological Functions	Economical Functions	Social Functions	Planning Functions
Real Natural function	Economic Value	Recreation function	Structural function
	Production function	Usage function	
Genetic Diversity function	- Service function	Aesthetic function	Interaction and Competition function
Life Support function	Hedonic function	Cultural function	
		Historical function	
		Character Structure function	
		Therapeutic function	
		Social Interaction function	
		Substitution function	

Multidimensional Functions
Scientific Value
Educational function
Political Value
- Financial function
Public function

Fig. 1. The Classification of the Functions of Urban Green Area (Levent and Nijkamp 2005)

3. Remote sensing and extraction of urban vegetation

Open green areas in the urban ecosystem are the leading elements of the main life support systems in the urban life. The qualities of size, shape, texture, color of the plants in terms of light and shadow effects are recognized in the urban environment (Aslanboğa 1997). Plants used in landscape are classified according to their heights as brier, shrub and wood. As much as their forms are concerned, unique structure forms of each plant are one of their distinctive features. Leaf features are especially important for the recognization of the texture qualities of plants. Likewise, leaves and flowers are again the dominant organs of the plants in the color effect. Changes in the color of the leaves as a result of seasonal variations or problems arising from various causes offer important information extraction. Light and shadow effects are important for the textures of an object to be sensed, highlighted, and negatively masked as well. All these elements are keys to help the vegetation in urban area to be detected and the information related to it to be extracted. In

remote sensing technologies, detecting the difference between vegetation and urban texture is achieved through making use of the elements aforementioned.

3.1 Information content and resolution

Remote sensing is the science of retrieving information about an object by means of the measurements performed in a certain distance from the object, that is, without actually contacting it (Maktav and Sunar 1991). The most crucial reason for the fact that the extensive use of remote sensing has begun in our day is because Ground Sampling Distance (GSD) of these images have been reduced. This fact enables an increase in the geometric resolution of the image and thus the extraction of the objects in a meaningful manner (Marangoz et al. 2006). In addition to GSD value, the radiometric and spectral resolutions of the images also affect the information content. Together with this resolution concept affecting the information content, other parameters which affect the information content are atmospheric conditions, sun elevation angle, incidence angle, the condition of the objects and the contrast among them while image acquisition (Marangoz 2009).

In today's world, depending on geometrical resolution, medium and high resolution satellite images have become a fast, accurate and economical source of data for producing vector maps. Besides, high radiometric resolution satellite images are effective on feature extraction of ground objects. This resolution facilitates image interpretation and by making use of such algorithms as automated feature extraction and matching, it promotes to obtain more efficient results. Whereas low resolution images were to be obtained in numerous bands with the previous satellite systems, generally high-resolution images are obtained contains visible and near infrared bands with the new satellites (Akdeniz and Erdoğan, 2005).

3.2 Image preprocessing

In order to facilitate the interpretation and the analysis processes of the image, image preprocessing procedures are carried out. Image enhancement algorithms are used with an aim to increase the display variation of the objects, whose visual interpretability is different, among each other (Lillesand et al. 2004). Ratio images are often used in order to enhance the images by the processes performed on several bands of multispectral images. By changing the properties of the original images with the arithmetic operations (addition, subtraction, multiplication, and division) carried out among bands, new images with a better visual interpretability can be obtained. Ratio images can be described as the transferring process as a new form of an image by adding, subtracting, multiplying, and dividing the pixel grey values belonging to two of the bands of an image data. These images are specifically useful in detecting spectral variations that have been masked due to low grey value changes in a single spectral band of image. For example, for an area having healthy green vegetation, the ratio of the band containing near-infrared to the band containing red color is normally very high. Thus, using ratio images obtained by the ratio of a near infrared-red band is very useful in the detection of green vegetation areas. Ratio images are especially used for information extraction about the vegetation from the various uses related to urban texture. The efficiency of any specific spectral rate depends on the actual application area and the spectral reflectance characteristics of the related objects.

Besides having some advantages based on resolution, satellite images also have color information, which is an element increasing the detectability of the object. Another image fusion technique, which is used depending on the superiority of the information content that can be obtained from multispectral image to the panchromatic, is Pan-sharp algorithm. In this algorithm which makes use of the color-geometry information in image bands, high-resolution panchromatic band is fusioned with color bands whose resolution is lower. The outcome is a high resolution multispectral image (Karakış 2005). Many pan-sharp algorithms are available nowadays. Some of those algorithms are Intensity Hue Saturation (IHS) Sharpening, Principal Components Analysis (PCA) Sharpening, Gramm Schmidt (GS) Sharpening, Wavelet Sharpening (WS), and UNB Sharpening.

The reflection of green areas in visible spectrum is low in contrast to their reflection being fairly higher in near infrared band. This high reflection for the near infrared band results high grey value of the pixels on the image. As a result, color noise values of the image increase. General disadvantage of all algorithms except UNB algorithm is that the green band cannot be obtained perfectly due to the causes mentioned above. However, the color transformation in UNB Sharpening Algorithm is perfect. In this algorithm which developed out of UNB by Dr. Yun Zhang, colors yield very close results as of the original multispectral bands (Padwick 2005). UNB Algorithm is a statistically-based algorithm. Least square method is used for determining the best alignment among the grey values of the image bands having fusioned, decreasing color distortion and calculating how much contribution will be made to the outcome by each different band. It includes some statistical approach to calculate the grey value relations among bands to eradicate the data set dependence problem and to automate the fusion operation process (Zhang and Wang, 2004; Cheng et al., 2003).

3.3 Image classification

The final phase of the analyses is the classification of the enhanced images. Generally, classification means including certain number of objects into a specific class with respect to class descriptions. For this reason, a class description is the description of typical properties and states that the intended class has. Then, objects are included to a class depending on whether they meet these properties or states. As a result, each object is included in a certain class or it is not included in any class. In the remote sensing applications, classical classifiers (for example with regards to the maximum likelihood, minimum distance or parallelepiped) assign membership to the objects as 1 or 0. Such classifiers are usually also called hard classifiers since they express the objects' membership to a class only in a binary manner. In contrast, soft classifiers (mainly fuzzy systems and/or Bayes classifiers) use a degree of membership/a probability to express an object's assignment to a class. The membership value usually lies between 1.0 and 0.0, where 1.0 expresses full membership/probability (a complete assignment) to a class and 0.0 expresses absolutely nonmembership/improbability. Thereby the degree of membership/probability depends on the degree to which the objects fulfill the class-describing properties/conditions (Baatz et al., 2004). Even though the probability value might change in the software using soft classification method, these values can be rounded up to the upper and lower limits by using crisp (rectangular) membership function.

In addition to pixel-based method, which is one of the classical classification approaches, object-based methods have also begun to be used in image processing and thus remote

sensing technologies of our day. Rich information content obtained by high resolution images could not be reflected precisely in the pixel-based classification approaches. The reason is that the basis for these classification approaches is the grey values of single pixel and consequently only spectral information has been used for the classification. Due to the structure of the pixel-based classical methods, this situation necessitates the use of the object-based classification methods. Algorithms used in this type of approach also use structural or textural supplementary information besides spectral information in forming classes so as to make the segments more appropriate. Classification phase in the object-based approach begins with grouping of adjacent pixels forming meaningful areas. Such kind of segmentation and topology formation should be arranged according to the resolution and the scale of the objects intended to be extracted. Whereas this segmentation can be applied in different resolutions, it also enables to detect the layer of object categories. With the object-based approach, the results from many image analysis applications are expected to be real classification and a real shape of the real-world objects (Hofmann, 2011 a, b, c).

Dividing the image into different subdivision is called segmentation (Baatz and Schäpe, 2000). Image segmentation procedures have been the main focus of research for years in the area of image analysis and various approaches have been followed for solution. Only some of these can be applied under operational settings and have given persuading results quantitatively. A great deal of degrees of freedom has to be reduced to one or several degrees of freedom which are able to meet the given requirements. Moreover, another difficulty is that the areas dealt with are, in many cases, heterogeneous. The case of heterogeneity results in uncertainties and the information needed and required to be understood cannot be extracted directly. What is longed for in image segmentation is that in many cases it is possible to extract the desired and intended objects automatically for a specific task. With a general overview, segmentation methods are divided into two main categories: information extraction methods (top to bottom) in one hand, and data extraction methods (bottom to top) in the other. Both approaches can be performed through applying the operations below (Baatz et. al. 2004):

- Creating the hierarchical structure of the image objects by using multi resolution segmentation operation. Whereas top layer image segments displays small-scale objects, the bottom layer segments display large-scale objects.
- The classification of the obtained objects according to their physical properties. This also means that class names and class hierarchies serve as an example when two features are taken into account: real world whose mapping has been carried out and the physical measurable size of the image object. Using other methods accelerate the classification process as well as sharpening it more.
- The definition of the semantic relations of the building objects when neighborhood or being sub or super object comes into question. This generally ensures the development of the physical classification resolution in class hierarchy.
- The fusion of the classified objects as meaningful groups that can be used for classification-based segmentation. The adjacent segments that are obtained can be used later after they were transferred to GIS environment. In addition, the semantic groups can also be used for other neighboring analyses.

Whereas carrying out the first two operations is obligatory, the application of the other two operations is recommended depending on the software user and the image content. The

segmentation itself is not an aim. The aim of image analysis can be land cover/land use classification or the retrieval of the related objects. Furthermore, in many cases the related objects might be highly heterogeneous. A segmentation operation carried out based on general homogeneity criteria in many cases will not directly retrieves the related result fields or objects. Moreover, individual methods giving a support for segmentation and classification, increasing its opportunities and enabling operation optimization have to be chosen. Various methods with the data input-output, vectorization, information interfaces, the analysis and statistics of accuracy complete the whole. The best segmentation result is the one which provides optimum information for next steps. The first segmentation constitutes the most important step of the application. The original image information is required to be retrieved in any resolution desired and as in object blocks which will be appropriate for the classification operations. A segmentation phase has to produce segments with high homogeneity for the optimum division and presentation of image areas. While every image analysis problem is dealing with data based on a specific data in a spatial scale, average dimensions of the image objects have to be suitable to the related scale. The properties of image objects such as grey value, texture, structure, and relations with the adjacent areas depend on the scale. Only the structures in similar scales have a comparable quality and they have comparable features. As a consequence;

- Result image objects have to be similar value.
- Segmentation phase has to be universal and it can be applicable to a large number of various images and problems.
- Segmentation results have to be able to reproduce.
- Segmentation process has to be as fast as possible.
- Human eye is a powerful and an experienced source for segmentation evaluation.

Segmentation replaces visual digitization by applying segmentation process to the automation of image analysis. None of the segmentation results are completely meaningful unless they satisfy the human eye sufficiently. Multi segmentation is a space fusion technique, to top bottom, starting with one-pixel objects (Benz et al. 2003) (Figure 2). In a large number of sub-levels, small image objects are fusioned with the bigger ones (Burnett and Blaschke 2003).

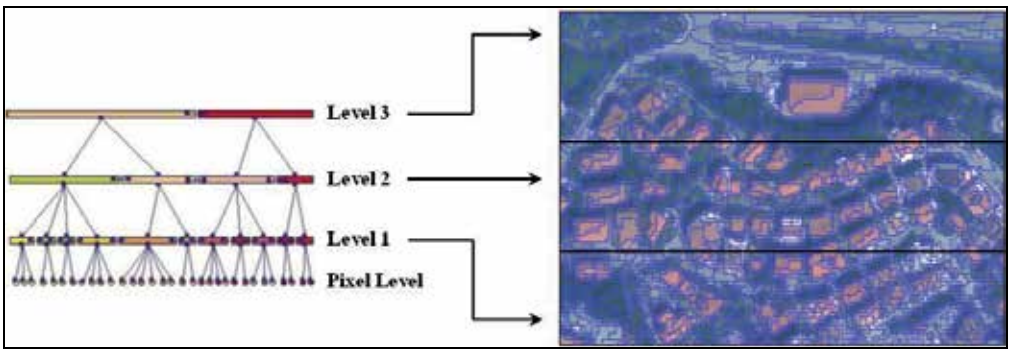


Fig. 2. Hierarchical Net of Image Objects Derived from Segmentation (Karakış et al. 2006).

In the segmentation phase, the parameters below have to be determined as close to the real world as possible.

- Scale Parameter: This parameter affects the average object size indirectly. In reality this parameter determines the maximum value which enables the heterogeneity of the objects. The bigger the scale parameter is, the bigger the objects are.
- Color/Shape: With these parameters, object production effect of the homogeneity of color and shape conflict can be adjusted. The higher the shape criteria, the less the object production effect of the spectral homogeneity.
- Smoothness/Compactness: When shape criteria is bigger than 0, the user can decide whether the objects should be more compact or more smooth (Hofmann, 2001a, b, and c).

The classification process of the images follows segmentation process. Based on the classification results, the statistical information produced for its users displays the accuracy values in addition to the confusion matrix.

The most important feature of the object-based classification is the mutual relation between the scale and the image objects in image interpretation. The scale is one of the important steps in understanding the image. Whereas the resolution usually expresses the area that a pixel occupies, the scale describes the size of extraction or the level that a phenomenon can be described. Thus, working on different scales rather than on different resolutions with an object facilitates the analysis. For example, in urban ecosystems when the high resolution image of the urban settlement, singular houses, buildings, roads, and other urban objects are recognized in detail. If the zoom distance is increased, then singular buildings are not viewed, but highly various settlements or neighborhood can be detected. They can also be detected by their different textures, different sizes and shapes. The neighborhood texture includes its sub objects and structures in a larger scale (e.g. Houses, roads, and green areas) and these are described in terms of grey value, shape and also topological relations. There is a kind of hierarchy in different phenomena and the structure real-world objects. This hierarchy is determined explicitly by the scale. For example when houses, buildings and roads are determined, by combining them together, settlements and neighborhoods are extraction as well. By combining many settlements together, town or city structure is achieved. Ecosystems show similar features: for example with regards to green areas, combination of several trees composes a group of trees, combining more trees composes the stand or combining many groups composes the forest.

What is important on the basis of the mutual relations among the image objects is contextual information. Two kinds of contextual information exist: the global context defining the state of the image (basically time, sensor, and spatial information) and the local context defining the mutual relations or the mutual meanings of the image areas. Processing the context information always exists in the human perception either conscious or unconscious. In order to extract meaningful context information, image areas in the correct scale have to be associated. This scale is determined by the integration of the resolution of the image data through the classification process. For example, in a high resolution image, the parks always compose of large and successive green areas. This different scale distinguishes between the park and the garden. Additionally, the parks are different from the meadows because of their locations in urban areas. Singular neighboring houses are not an enough condition to define parks. Nevertheless, being adjacent to singular buildings is a suitable criterion for the gardens to distinguish them from meadows. This simple example already shows how many

context information is available based on the scale of structures related to each other. In order for the image objects to detect their spatial context, associating them together is necessitated. For this reason, a topological network is created (Baatz et al. 2004).

The object-based image analysis is extracting a great deal of additional information from the image objects. What lies behind this is the information elicited from shape, texture, neighboring and other object layers. Using this information, classification can be reached to improved semantic analysis and more accurate results. Baatz et al. (2004), with a conceptual point of view, have grouped the possible features as follows:

- Basic features: Physical features of the objects are determined by portraying the real world and imaging quality (simply sensor and illumination). These features define color, texture, and the structures of the objects.
- Topological Features: The features that define the geometrical neighborhood of the objects or the whole scene. E.g. being on the left or right, or being at a certain distance to a certain object, or being at a certain area within the image.
- Environmental Features: The features that define the semantic neighborhood relations of the objects. E.g. a park should 100% be surrounded by urban area.

The process of the image objects can be carried out by specific methods in the base of the classification. For example, when an object is classified as "green area", from the moment on, artificial intelligence may locally be used, and in principle since then, everything performed with this object or its related environment is followed by using "green area" logic. Applying a modified process instead of processing all areas of an image with the same algorithm would be much more suitable. This is one of the prevalent features of the object-based image analysis. The final step in order to carry out the necessary analysis is the phase where the classification is applied to the segments. With this aim, slope or crisp functions can be used. Slope functions define the membership of the objects to a class between 0 and 1 by enabling the fuzzy classification. On the other hand, in crisp functions, the object is faced with the process of either full membership or removing from the membership. In the direction of all these mentioned above, such features as color and neighborhood are used with suitable functions to compose classes.

4. Applications of extraction urban vegetation using remote sensing data

In the first section of the application, the object-based classification results and accuracy values belonging to medium and high resolution satellite image data of the city of Bartın, located in the West Black Sea Region of Turkey, and its surroundings are stated and their final results have been evaluated. In the second section, the segmentation process has been applied to all bands of high resolution satellite image related to a different test area by both using an additional data and without using any additional data and their results have been interpreted. Finally, manual and automated object extraction approaches from high resolution image data have been comparatively analyzed. In addition, the information about the advantages and the capacity of this type of classification is given.

The first test area is the city of Bartın, located in the West Black Sea Region of Turkey, and its surroundings (Figure 3). Medium resolution Landsat 7 ETM+ and Spot XS images of the test area have been subject to the object-based classification (Büyüksalih et al. 2005).

(a) Landsat 7 ETM+ image (b) Spot image

Fig. 3. Medium Resolution Satellite Images of the City of Bartin and Its Surroundings.

Segmentation parameters used for both satellite image data are given in Table 1. The classes created as a result of the classification consist of general classes such as settlement, cultivated area, forest etc. to represent a larger area (Figure 4). The evaluation results of the classification accuracy are given in Table 2 (Oruç et al. 2004).

Level	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**6**
SP	1	5	1	5	10	1	5	1	5	10	15
Color	0.5	0.5	Spectral Difference	Spectral Difference	Spectral Difference	0.5	0.5	Spectral Difference	Spectral Difference	Spectral Difference	Spectral Difference
Shape	0.5	0.5				0.5	0.5				
Compactness	0.5	0.5				0.5	0.5				
Smoothness	0.5	0.5				0.5	0.5				
Segm. mode	Nor.	Nor.				Nor.	Nor.				

(a) Landsat 7 ETM+ image (b) Spot image

Table 1. Segmentation Parameters.

The user and the producer accuracy belonging to the forest and settlement class heterogeneity are high for both image data. In the evaluated results related to the cultivated areas, the classification accuracy assessment results from the Spot image were appeared to be higher. The geometric resolution of the Spot image data being high and the heterogeneity of the detail of the cultivated areas being higher than other classes have enabled the extraction to be better than the other classes (Tunay et al. 2007).

High resolution pan-sharp IKONOS satellite image data belonging to the city of Bartın downtown, which is located in the same test area, has also been subject to the object-based classification (Figure 5). The segmentation parameters used are given in Table 3.

(a) Landsat 7 ETM+ image (b) Spot image (Akçin et al. 2004)

Fig. 4. Classes and Classification Results.

Class Name	Producer's Accuracy %	User's Accuracy %	Kappa Statistic
Cultivated area	64	47	0.51
Forest	92	100	0.90
River	58	100	0.48
Sea	100	100	1.00
Settlement	100	75	1.00

(a) Landsat 7 ETM+ image

Class Name	Producer's Accuracy %	User's Accuracy %	Kappa Statistic
Cultivated area	86	86	0.83
Forest	100	88	1.00
River	85	100	0.78
Sea	100	33	1.00
Settlement	100	100	1.00

b) Spot image

Table 2. Accuracy Assessments Results.

Fig. 5. Pan-Sharpened IKONOS Image (Marangoz et al. 2006).

Level	1	2	3	4	5
SP	10	20	30	40	40
Color	0.5	0.5	0.5	0.5	Spectral Difference
Shape	0.5	0.5	0.5	0.5	
Compactness	0.5	0.5	0.5	0.5	
Smoothness	0.5	0.5	0.5	0.5	
Segm. mode	Nor.	Nor.	Nor.	Nor.	

Table 3. Segmentation Parameters.

Classes created as a result of the classification have been separated more accurately thanks to the high resolution (Figure 6). Accuracy values of each class are quite high (Table 4). The efficiency rate of the extraction of objects about the urban vegetation has been 100%. The only disadvantage for the classification in general was that the extaction could not be achieved clearly due to the road structures and the homogeneity among urban open areas having no vegetation.

Class Name	Producer's Accuracy %	User's Accuracy %	Kappa Statistic
Agricultural	83	86	0.78
Buildings	84	89	0.75
Vegetation	100	100	1.00
River	100	100	1.00
Road	100	73	1.00

Tablo 4. Accuracy Assessment Results.

Fig. 6. Classes and Classification Results (Tunay et al. 2007).

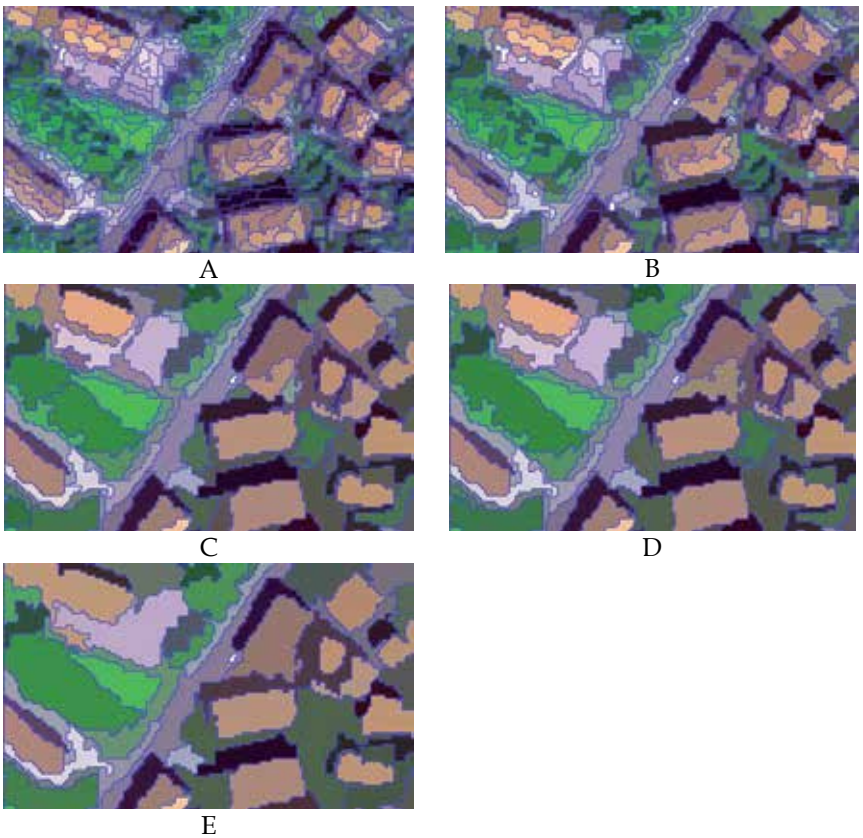
In the application about the city of Zonguldak test area located in West Black Sea Region, Quickbird satellite image has been used (Figure 7). The technical features of the image have been given in Table 5. Quickbird image used has been enhanced by applying pan-sharp algorithm.

Fig. 7. Pan-sharpened Quickbird Image.

Date, Time	23/05/2004, 08:39:55 GMT
Nominal collection azimuth (deg.)	61.0
Nominal collection elevation (deg.)	85.9
Sun angle azimuth (deg.)	139.1
Sun angle elevation (deg.)	64.7
Nadir angle (deg.)	3.9
Image size (pixels in row, column)	24.572 x 25.500
Reference height (m)	265.66

Table 5. Technical Features of the Quickbird Image.

In this part application, two different approaches have been used for the segmentation phase. One of these approaches is subjecting all bands of Quickbird satellite image to the segmentation process without using any other additional data (Figure 8), the other is subjecting the all bands of the same image to the segmentation process by using vector maps of the test area created by photogrammetric methods in 1997 as additional data lying under this satellite image (Figure 9). Scale parameters and segmentation parameters used in both approaches have been given in Table 6 and 7.

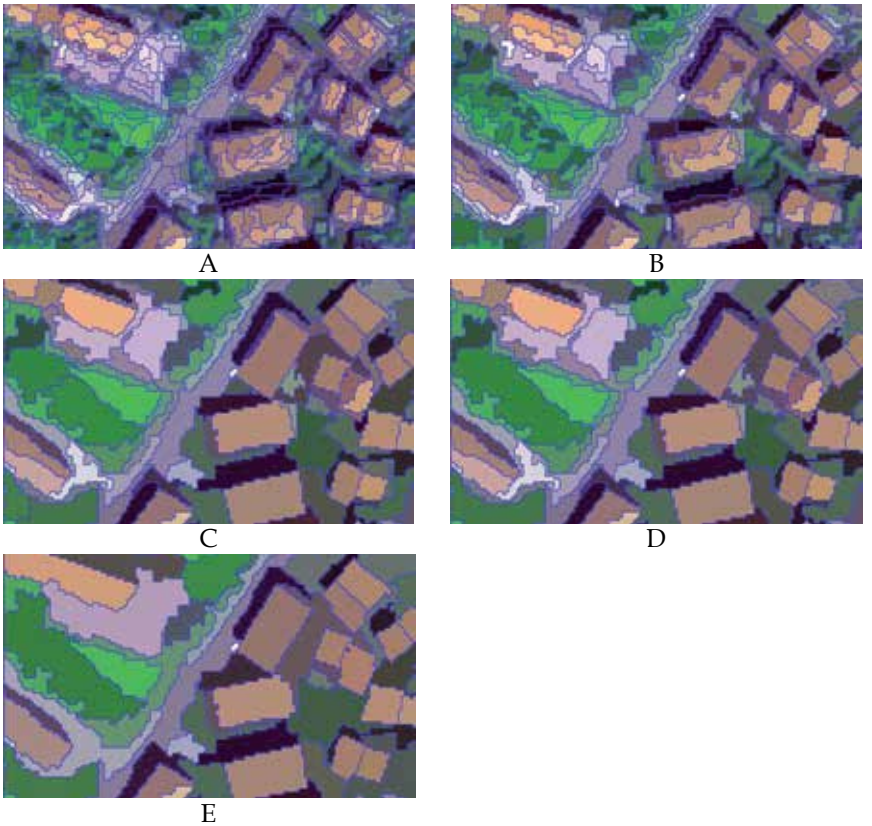


(The Scale Parameter: A = 10, B = 20, C = 30, D = 35 and E = 60)

Fig. 8. Image Segmentation Performed by Using Five Different Scale Parameters.

Level	A	B	C	D	E
SP	10	20	30	35	60
Color	0.5	0.7	0.3	0.5	0.5
Shape	0.5	0.3	0.7	0.5	0.5
Comp.	0.5	0.5	0.5	0.5	0.5
Smooth.	0.5	0.5	0.5	0.5	0.5
Segm. mode	N	N	N	N	N

Table 6. Segmentation Parameters.



(The Scale Parameter: A = 10, B = 20, C = 30, D = 35 and E = 60)

Fig. 9. Image Segmentation Performed by Using Five Different Scale Parameters.

Level	A	B	C	D	E
SP	10	20	30	35	60
Color	0.5	0.7	0.3	0.5	0.5
Shape	0.5	0.3	0.7	0.5	0.5
Comp.	0.5	0.5	0.5	0.5	0.5
Smooth.	0.5	0.5	0.5	0.5	0.5
Segm. mode	N	N	N	N	N

Table 7. Segmentation Parameters.

The parameters chosen in the segmentation process might change the accuracy of the classification. By using vector map, the heterogeneity has been balanced whereas in the application in which vector map was not used, the extraction of the details based on homogeneity have been problematic. This situation results in overlap in the segmentation phase when similar objects are close to each other (Figure 10) and has generally arisen in the building structures within urban texture. Extraction of green areas has been clearly achieved in both cases. Generally, some problems in feature extraction have come up based on the shadow effect. In addition, this situation results in the disappearance of green area objects between the building blocks in the cities in which dense housing are observed. For this reason, a segmentation to be carried out by using additional vector and the classification afterwards give a better result for the extraction of the vegetation in the urban area (Karakış et al. 2005).

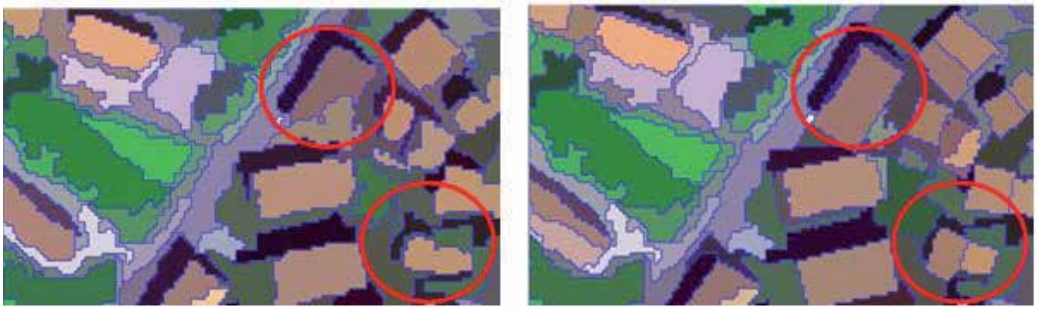


Fig. 10. Segmentation With and Without Vectors Created by the Same Segmentation Parameters (A = Structured With Vector, B = Structured Without Vector).

The classification for the analysis processes has been performed after the segmentation phase. The results of the classification process carried out for the segmentation with vector have been shown in Figure 11.

High resolution satellite images of our day are organized to include panchromatic, multispectral and near infrared bands for the users. The application of these images is essential in the determination of green areas especially about the urban vegetation. The success level of panchromatic images in the automated extraction of the objects is low whereas the success level of these images in the extraction of the objects with the help of an analyst is intermediate. The success level of multispectral images in the automated and manual extraction of image is higher. However, for the green area texture, the distinction between biological and synthetic green cannot be achieved and detection of green areas in shaded areas is problematic. The success level is higher in multispectral images having added near-infrared bands and there is a significant increase in the success level of automated and manual extraction of the objects (Marangoz 2009).

In this context, the object extraction of the city of Zonguldak test area has been performed by using analyst. By the help of the software used, the related objects on the satellite image can be monitored on the screen; the vectorization process is performed using the cursor. All in all, quantitative object extraction which consists of many layers created by the user can be produced easily by setting up the desired topology and editing it. With regards to urban vegetation, using band combinations on Quickbird satellite image, the display of

Fig. 11. The Results of the Object-based Classification Performed by Using Classes and Vector Map.

near-infrared band has been made dominant over the real green band and the most suitable environment has been provided for the vectorization process. The extraction of green areas has been achieved on this image by minimizing the shadow effect and other detail losses and by drawing vector on the edges of the related objects (Marangoz et al. 2007) (Figure 12).

The parameters for the segmentation have been chosen in the first place in the automated object extraction approach carried out for the test area (Table 8). The segmentation has been performed in five different levels, and it has been concluded that the third level has given the most suitable objective form. At this phase, only the green area class has been created and the suitable membership functions have been assigned. In Figure 13, the membership functions have been given. In the designation of these functions, crisp functions have been used to clearly illustrate the areas. In addition, the grey values sensitive to red and blue have been used for the lower and upper limits of the functions. The reason is to reduce the reaction of the other groups of objects given against this function, in addition to the reaction of the objects related to the vegetation given against the function chosen for the near-infrared band.

Green area class created automatically by these segmentation parameters and membership functions has been given in Figure 14.

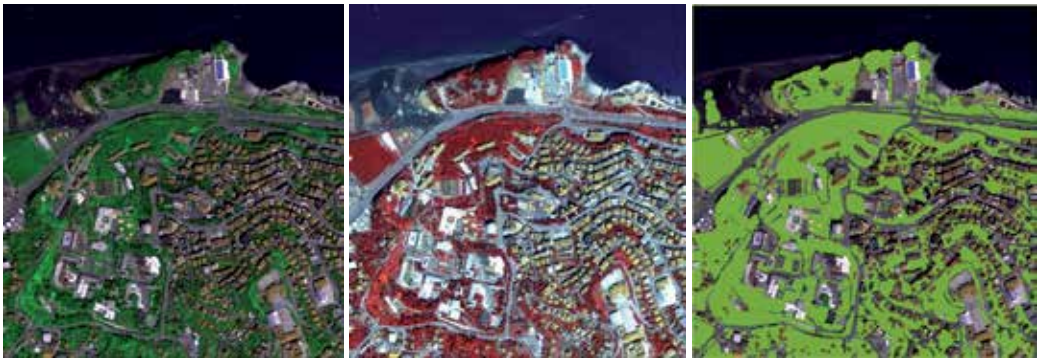


Fig. 12. Real and Artificial Near-Infrared Images of the Test Area and Manual Extraction of Green Areas on the Test Area (Marangoz et al. 2007).

Level	A	B	C	D	E
SP	10	20	30	40	60
Color	0.5	0.5	0.5	0.5	Spectral Difference
Shape	0.5	0.5	0.5	0.5	
Compactness	0.5	0.5	0.5	0.5	
Smoothness	0.5	0.5	0.5	0.5	
Segm. mode	N	N	N	N	

Table 8. Segmentation Parameters.

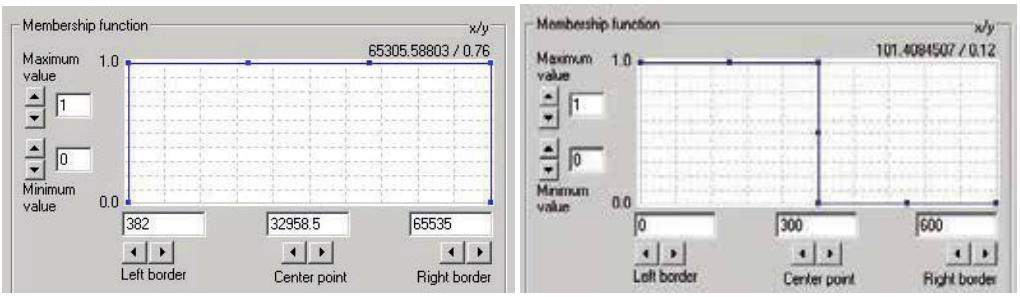


Fig. 13. Membership Functions for Classification; A) Inclusion of the Objects Sensitive To the Near-Infrared, B) Exclusion of the Objects that Are Not Supposed to Be Included in This Class Such as Roads, Buildings, etc, Together with Their Other Spectral Reflection Information.

By evaluating the results of CAD based manual object extraction and automated object extraction in the GIS environment, the amount of the area covered by the related objects on the test area has been calculated. From the analysis conducted, the amount of green area is 340827 m² (approximately 34%) out of the manual extraction of the whole test area whose surface area is 1 million m². In the automated extraction, these areas have been calculated 315301 m². According to the results, it has been concluded that 93% of the result created by the analyst could also be obtained automatically about extraction of green area. In Figure 15, the overlapping image of manual and automated extraction is given in GIS environment.

Furthermore, 7% of information loss has been the case in the automated object extraction according to manual extraction. Limiting the membership functions to the certain values to

prevent confusion of tree and green areas with the shading and other object groups causes problem mentioned above. In order to compensate this deficiency, the automated segmentation that has been performed could manually be interfered in the classification phase. (Figure 16).

Fig. 14. Automated Extraction of Green Areas on the Test Area (Marangoz et al. 2005).

Fig. 15. Overlapping Image of Manual and Automated Extraction in GIS Environment (Red in the below: manual extraction, green in the above: automated extraction).

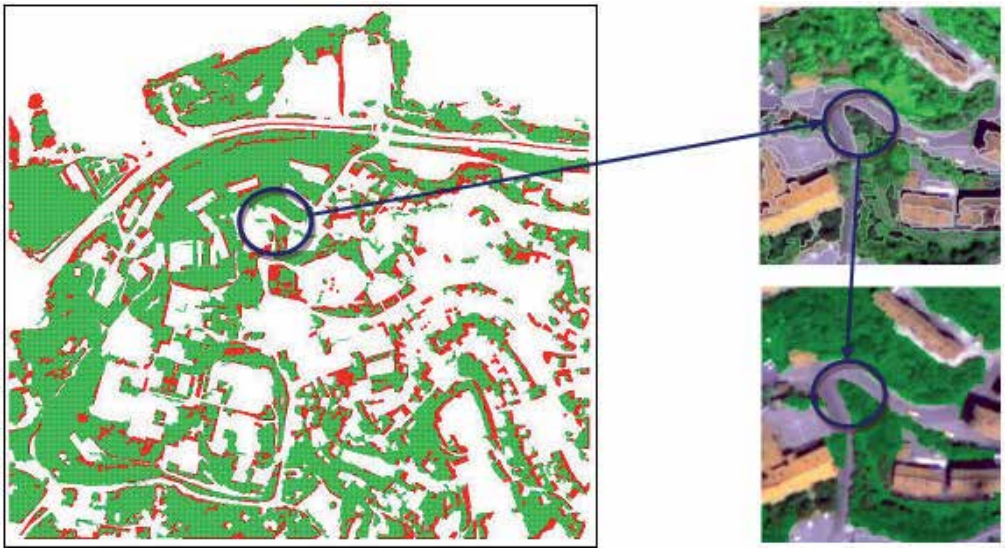
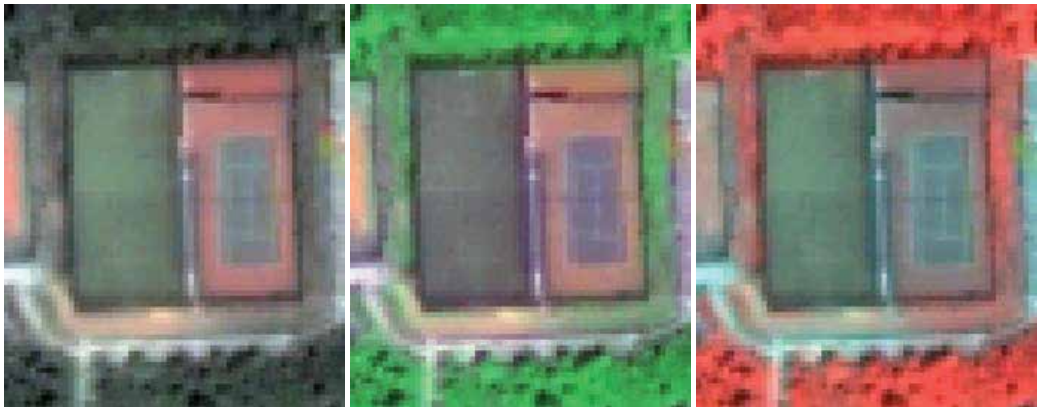


Fig. 16. Creating Natural Class Object Resulting from Manual Interference to the Object Class Which cannot be extracted by Automation (Marangoz et al. 2005).

In both object extraction approaches, the object extractions from the image enhanced by near-infrared band so as to achieve the recognization of biological and synthetic green forms as well as minimizing the information losses. For example, the recognization of a soccer field covered with synthetic turf from the other green objects has been achieved by this means (Figure 17). If the object extractions are to be from a normal color image, to achieve this kind of recognization especially in automated extraction is out of question.



a b c

Fig. 17. Of an Area Including Soccer Field Covered with Synthetic Turf and a Green-Painted Tennis Court; A)Normal Color Image, B)Normal Color Image Enhanced by Near-Infrared, C)Artificial Color Image Enhanced by Near-Infrared (Marangoz et al. 2005).

5. Conclusions

This chapter provides information about urban ecosystem, urban vegetation, remote sensing, extraction of urban vegetation and object-based classification approach. The research focused on the object-based classification approach method with regards to the extraction of urban vegetation, and its results. The detection of the vegetation texture within the urban structure is important for planning and analyses to be carried out. In this context, the resolution qualities of the images and enhancing images suitable for use have been quite beneficial in the selection of the satellite image data. Despite an excessive information content of the image data that is used, the pre-processing and enhancement processes on the raw image are definitely needed for a thorough extraction of this information. The most important stage before the classification is the segmentation phase. The most prevalent parameters in this phase are scale, color and smoothness. Depending especially on the geometric and radiometric resolutions of the satellite image data, the acquisition time also influences the accuracy in the segmentation phase.

The object-based classification results carried out for medium resolution satellite image data achieve high producer and user accuracy values in the extraction of heterogeneous classes such as forest, habitat etc. Increasing heterogeneity on the geometric resolution and details of the satellite images contributes positively on the result of the classification process, in which land use classes are determined in general terms. Another source of data which promotes the accuracy of the segmentation process to be carried out for the high resolution satellite image data is vector maps. By using the vector map as an additional data, the heterogeneity between the objects is balanced and this affects the accuracy of the classification in a positive way. The coverage ratio of the results by automated object extraction of the vegetation related to urban area from high resolution image data to the results by the manual extraction is quite high. Generally, the reasons of inaccurate classification can be given as the conditions of the objects in the used image and the contrast values among them, the existing shadow problem and the inconsistent topography of the test areas. Moreover, it is a known fact that in the eCognition software, worked in the object-based approach and using Region Growing algorithm more success is achieved in the region-based object extraction. In this context, it can be said that not many problems have been encountered in the automated extraction of region-based objects such as vegetation in the test area.

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12

Sustainable Solutions in Development Countries – Lithuania Case

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1. Introduction

The main aim of a town's sustainable development is to match up the economical growth of the town's progress, focusing on a more prudent consumption of natural resources and by maintaining the ecological balance as well as ensuring favorable living conditions for the next generation. The poverty is one of the major obstacles when implementing sustainable development (Ciegis R., 2002). Sustainability is not a digital balance among all three aspects of the conception, their objectives and needs, although it is necessary to co-ordinate them and set prerequisites in order to implement the conception (Danilov-Daniljan V.J.&Losev K.S., 2000). The most important features and requirements of town and regional sustainable development were summarized in Agenda 21 (An Agenda 21, 1998). The conception of sustainable development includes the way to match two different and sometimes contradictory attitudes: "development-progress-grows" and "stability-security-environment" (Danilov-Daniljan V.J. & Losev K.S., 2000). The problems of Lithuanian regions and towns go together with the subsequences of the impact on social life of the town when some of the towns or regions degrade. While other economical processes lead the towns towards stagnation and town or regions become unattractive for investment (Burinskiene M., *et al.*, 2003, Dzemydiene D.& Rudzkiene V, 2002). EU directives constantly highlight the importance of the regions and their equal development. During the last twenty years uneven development has been on the increase. In general, the objective of sustainable development is to protect and improve the quality of life.

Transformation of command economy into market economy has resulted in the rearrangement of economic activities in Lithuania. Changing markets of resources and goods, implementation of new industry technologies were accompanied by the development of small and medium-size business, more extensive international partnership in business and in other activities. All these processes have changed and disbalanced systems of towns, regions and villages, as territorial units, that previously existed. Innovation of industry branches, establishment of joint ventures, improvement of access to financial capital are the phenomena that have strengthened concentration of skilled potential, especially the youth, in major towns of the country. In spite of the efforts to stimulate sustainable development (Strategy of social…, 2002), the occurring phenomena have preconditioned speedier development of some regions and lacking behind of other regions and even occurrence of socially negative locations (Didžiasalis, Rukla).

Implementation of sustainable development policy is one of the most complicated tasks and challenges faced by the global community, the achievement of which is sensitive.In 2003, the Government of the Republic of Lithuania approved the National Strategy for Sustainable Development of Lithuania which emphasises that one of the major tasks of decision-making at all levels of governance is to ensure continuity of social development, integrity of social, ecologic and economic fields, and efficiency of decisions. In the course of the changing economic relations it is not easy to maintain mutual balance and sustainability of processes (Čiegis *et al.* 2008; Viteikienė,M. & Zavadskas E.K., 2007). Theoretically, the sustainable development system is not fully set up, thus often different theoretical aspects and paradigms are used when speaking of sustainable development, and different trends of development theories and individual methodologies for future forecasting are applied (Jakimavičius M. & Burinskienė M., 2007).

Modelling the transition processes in a simplified form can be based on some broad, partly overlapping categories of models: mathematical equation-based, system dynamics, statistical, expert systems (Kauko T., 2007), and/or evolutionary or hybrid. By applying these models, the possibility of discontinuous transformation of quantity into quality (that can arise during the initial transformation phases) should be suggested (Feichtinger G., 1996; Lorenz H.W., 1993). The non-linear dynamic phase is expected when the old system enters a period of crisis. Such a dynamic period can also be observed after an economy has hit the bottom and begun to grow again (Rosser J.B., 2000; Feichtinger G., 1996; Lorenz H.W., 1993).

The goal of sustainable development is to combine economic growth, social progress and sparing use of natural resources, maintaining ecological balance and ensuring favourable living conditions for current and future generations. Development is fostered in a certain territory, in its natural environment, thus it is important to find out reasonable extent and form of development, so that life quality is maintained and negative impact on environment is reduced (Burinskienė M.& Rudzkienė V. 2004, 2007; Kavaliauskas P., 2008). Analysis of the sustainable development must be based on a systematic approach, not only planned but also include the consumption aspect, emphasising sustainable consumption and production. Planning is a political process where plans are drafted, activity directions foreseen, and decisions made by different level politicians.

2. Application of multidimensional statistical methods for direct foreign investment analysis

To describe the social-economic processes and phenomena, large sets of social–economic indicators are necessary. Most of these indicators take the form of time series in data warehouses. This causes some difficulty connected with the establishment of the interrelation structure of these indicators. In addition, many social and human-initiated events deal with incomplete or limited (by nature) information and a complex structure of their interdependencies. That is why the use of statistical methods for the social-economic process analysis and decision-making is not only justified but also indispensable. In describing the socio-economic situation, a great volume of initial data and indicators are used that characterize the development of a process, therefore it is very important to select the most important ones and to consider a small amount of indicators or their groups. Frequently the initial data is transformed so as to ensure the minimal loss of information.

2.1 The model

Investments (like other human-initiated events) are random events in space and time:

a. Observation objects of interest (towns, regions, districts, etc.) are selected, i.e., a sample $O = (o_1, o_2, \ldots, o_N)$. The object of a data set is a unit of data whose features are to be investigated. The objects have respective features (or indicators) $X = (x_1, x_2, \ldots, x_n)$ that describe their attributes. These features are measured within particular time intervals (ranges, e.g., a year interval), $\Delta t = (\Delta t_1, \Delta t_2, \ldots, \Delta t_k)$.
b. Compose an *(N×n×k)* - dimensional matrix $Q_{ij\Delta t}$ that consists of object features in the time intervals being considered, where *i* is the object considered, *j* denotes measured features, and *Δt* is a time interval.
c. When preparing data for a further analysis, we determine the homogeneity of the objects observed by investigating their properties. Cluster analysis belongs to classification algorithms and solves the issue of how to organize the observed data into meaningful structures. The general categories of the cluster analysis methods are: joining or tree clustering, two-way joining or block clustering and k-means clustering. If the clusters are clear heuristically, the methods of variance analysis are usually used. This classification problem can also be solved in other ways: using heuristics or extreme way (Дубров А.М. *et al*., 1998). . Clusters of objects *N* are defined by choosing a fixed time interval *Δt*, and soundness of the clusters formed is verified in other time intervals.
d. When clusters of objects are formed, the structure of features characterizing the clusters is under determination. For this reasons factor analysis methods are selected for the problem's solution. The factor analysis is applied to reducing the number of variables and for detecting a structure in relationships between the variables. Generally, as a method for data reduction, principal component analysis is often preferred, and the principal factor analysis is more frequently used in the case when the goal of an analysis is to detect the structure.
e. Having verified the data adequacy/suitability to the factor analysis, variables that are not suitable for the analysis are found and eliminated. The adequacy of data (variables) for the factor analysis can be verified by the Kaiser-Meyer-Olkin measure of sampling adequacy KMO (Kaiser, H.F. 1958, 1960):

$$\mathrm{KMO} = \frac{\sum\sum_{i \neq j} r_{ij}}{\sum\sum_{i \neq j} r_{ij} + \sum\sum_{i \neq j} \tilde{r}_{ij}} \tag{1}$$

Here r_{ij} is the correlation coefficient, and $\tilde{r}_{ij}$ is the coefficient of partial correlation. If the KMO value is low, then the indicators considered do not apply to the correlation analysis, since other indicators cannot explain the correlation of these indicators. For making the exploratory data analysis, it is recommended firstly to analyse the principal components (Kline, P., 1994). The components obtained in this analysis are not correlated and emerge in decreasing order of the amount of the variance that is explained.

f. To obtain a clear pattern of factor loadings, factor rotation strategies should be applied.

The fundamental theorem of factor analysis is invariant within rotations. The results of rotation, However, to indicate "the simplest solution among a potentially infinite number of solutions that are equally compatible with the observed correlations" (Kim J.O. & Mueller, C.V., 1978) is also essential. The simplest case of rotation is an orthogonal rotation. Typical orthogonal rotation strategies are *Varimax*, *Quartimax*, *Equamax*, and *Orthomax*. The *Varimax* rotation method is the most commonly used orthogonal rotation procedure. The overriding criterion of a simple structure is that each factor should have a few high loadings with the rest being at zero or close to zero (Kline, P., 1994). After clearing the patterns of factors, the influence of individual indicators x_n is evaluated and the factor interpretation is performed.

g. The interdependence of variables (indicators) composing the factors is evaluated and indicators are predicted by forming a multivariate regression equation for time intervals Δt.
h. A multiple regression analysis determines the relationship between several independent variables and a dependent variable. The regression function can be estimated by using the least squares estimation or any other loss function (non-linear estimation). After the regression equation has been estimated, the prediction can be computed for a set of independent variables.

2.2 Model evaluation

The target of the research was to explore, estimate, and apply the use of multivariate statistical models in the analysis and prediction of the state's situation and tendencies for even distribution of the quality of life in Lithuanian towns and regions by paying particular attention to the safety of the society. Social health and security, education opportunity, public health care, versatility of life, personal career abilities, self-expression, community, culture, social life, recreation – all these are treated as a part of the quality of life. In order to estimate the situation and make decisions it is expedient to evaluate and select the main factors that influence the direct foreign investment in Lithuanian towns and regions. Most frequently the factor and component analysis are used for this purpose. These methods make it possible to evaluate the multidimensionality of the essential data and to explain concisely and simply the multivariate structures. They reveal real and existing, but directly imperceptible regularities by means of factors or principal components.

The aim of the factor analysis is to explain the outcome of p variables in the data matrix X by using fewer variables, the so-called factors. These factors are interpreted as latent (unobserved) common characteristics of the observed $x \subset \boldsymbol{R}^n$. In the factor analysis every observed $x = (x_1, \ldots x_n)^T$ can be written as:

$$x_j = \sum_{l=1}^{k} a_{jl} f_l + \varepsilon_j, j = 1, \ldots n; k \le n \tag{2}$$

Here f_l for $l=1,\ldots,k$ denotes the factors; ε_j is the residual of x_j on the factors. According to the logical sequence of problems solved by the factor analysis, the arising problems can be arranged in the following order: the first problem is a robustness, second one – community, third one – factors, fourth one – rotation, fifth one – estimation of factor values, and a sixth one – dynamic models (Дубров А.М. *et al* , 1998).

In the selection process of observation objects of interest a set of 13 social- economic indicators were collected for the research from 12 Lithuanian towns and 43 regions during time intervals of the period from 1996 until 2001 (Counties of Lithuania…,2002). We consider the matrix denotes as $X\ [n \times N]$. The matrix elements x_{ij} illustrate the value of the jth indicator at the ith research object and have particular values and semantics:

$x_{i,1}$ – registered crimes;
$x_{i,2}$– average annual number of employed;
$x_{i,3}$– unemployment rate;
$x_{i,4}$ – natural increase;
$x_{i,5}$ – migration;
$x_{i,6}$ – average monthly gross earnings;
$x_{i,7}$ – sales of industrial production;
$x_{i,8}$ – average real estate price;
$x_{i,9}$– dwelling acquisition;
$x_{i,10}$ – investment in the construction of residential houses;
$x_{i,11}$ – investment in tangible fixed assets;
$x_{i,12}$ – direct foreign investment;
$x_{i,13}$ – turnover of catering,
Where $i=1,2\ldots N$.

Several important issues are considered preparing data for the factor analysis. First, which variables should be included into the analysis. Second, how many variables should be included. A factor cannot be defined by using a single observed variable.

While considering the Lithuanian social-economic indices of 1996-2001, the sample of objects studied has naturally to be divided into two groups: the first group consists of the largest cities and resort towns, and the second one – of regions. To form the groups, we can use cluster analysis methods, however, in this particular case, group boundaries are clear. Substantiation of the division is verified by the hypothesis Ho stating that the average number of direct foreign investment in towns and regions is equal. This hypothesis is verified by the criterion:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{S_1^2/N_1 + S_2^2/N_2}} \tag{3}$$

Where $\bar{x}$ is the estimate of mean, and S is the standard deviation.

Arithmetic means of the direct foreign investment calculated, values of the criterion t, degrees of freedom, and the observed significance level p are presented in Table 1.

The obtained results in Table 1 show that the significance level observed in the years under investigation is lower than 5%. Therefore, we have to reject the hypothesis H_o and to consider the direct foreign investment in towns and regions separately. After evaluating the influence of each variable on the *KMO* measure, we eliminated four variables from the list of indices considered, namely: average annual number of employed, unemployment rate, natural increase, and investments in the construction of residential houses. The KMO measure of the rest variables KMO=0.68, so, we conclude that the data is adequate for the

factorial analysis. For making the exploratory data analysis, it is recommended firstly to analyze the principal components (Kline, P., 1994). The components obtained in this analysis are not correlated and emerge in decreasing order of the amount of variance explained.

Year	*Average number of direct foreign investment in towns*	*Average number of direct foreign investment in regions*	*t-value*	*df*	*p*
1996 m.	451.4	155.5	2.12	44	0.0397
1997 m.	876.7	234.1	3.14	49	0.0028
1998 m.	1384.5	288.0	4.21	48	0.0001
1999 m.	1927.1	415.8	3.97	47	0.0002
2000 m.	2421.1	438.8	4.09	48	0.0002
2001 m.	2412.1	517.5	3.45	50	0.0011

Table 1. Verification results of the hypothesis that the number of direct foreign investments in towns and regions is the same.

The number of factors to be extracted can be determined in a screen plot (Fig. 1).

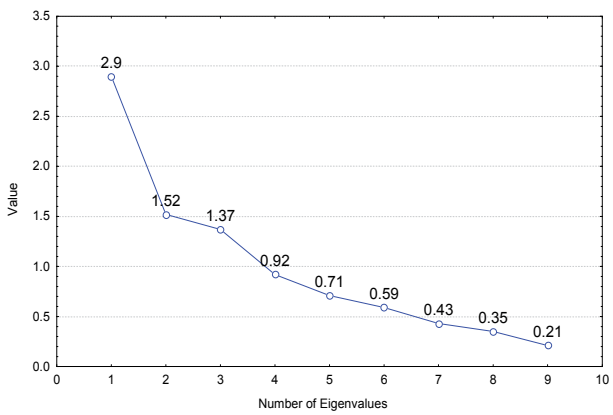

Fig. 1. The rate of change in the magnitude of eigenvalues for the factors.

A large first eigenvalue (2.9) and a much smaller second eigenvalue (1.52) suggest the presence of a dominant global factor. The most widely used criterion for finding number of factors is the *Kaiser criterion* (Kaiser, H.F., 1960), which recommends retaining only the factors whose eigenvalues are greater than 1. The scree plot (Fig. 2) also suggests a maximum of four factors. These four factors account for 64.3% of the whole variance.

After evaluating the number of factors to be extracted, the next logical step is to determine the method of rotation. The overriding criterion of simple structure is that each factor should have a few high loadings with the rest being zero or close to zero (Kaiser, H.F., 1958). In application of this criterion, the *Biquartimax* method was selected as providing the simplest structure solution. When the rotation method is applied, one part of the output from the factor analysis is a matrix of factor loadings (Table 2). A factor loading or factor structure matrix is a matrix of correlations between the original variables and their factors.

Factor Loadings (Biquartimax normalized)			
	Factor 1	Factor 2	Factor 3
Direct foreign investment	**0.66**	0.26	0.02
Migration	-0.09	**0.72**	-0.01
Average monthly gross earnings	0.53	0.03	**-0.67**
Sales of industrial production	**0.84**	-0.28	0.16
Average real estate price	0.13	**0.80**	0.15
Dwelling acquisition	-0.24	-0.17	**-0.85**
Investment in tangible fixed assets	**0.77**	0.22	-0.29
Turnover of catering	**0.81**	-0.24	0.19
Registered crimes	0.33	0.25	-0.23
Expl.Var	2.88	1.51	1.39

Table 2. Factor Loadings. Clusters of loadings are marked

2.3 Interpretation of factors

The meaning of the rotated factors is inferred from the variables significantly loaded on their factors. A decision needs to be made regarding what constitutes a significant loading. The simplest criterion is that factors loadings greater than 0.30 in absolute value are considered to be significant. As the sample size increases, the criterion may need to be adjusted a little downwards. When the number of factors increases it may be adjusted upwards. In general, the larger the absolute size of the factor loading for a variable, the more important the variable is in interpreting the factor. As we can see from results in Table 2, the most significant variables for the first factor are:

- Direct foreign investment

- Sales of industrial production
- Investment in tangible fixed assets
- Turnover of catering

We may therefore state that this factor reflects the growth of economy and the improvement of living conditions of many people. The greatest impact on this factor is made by variables such as *sales of industrial production* (*L=0.84*), *turnover of catering* (*L=0.81*), that reflect the increasing retail trade, *investment in tangible fixed assets (L=0.77),* and *direct foreign investment* (*L=0.773*) which indicates the increasing influence of foreign investment. The second factor reflects the adaptability of people to changing circumstances and it consists of two variables *migration* (*L=0.72*) and *the average real estate price* (*L=080*). The third factor is constituted of variables *average monthly gross earnings* (*L=-0.6*) and *dwelling acquisition* (*L=-0.8*). This factor reflects the improving in Lithuanian economic situation and relation between average monthly gross earnings and dwelling acquisition.

Attraction of the direct foreign investment is especially important for sustainable development of countries which have planned economics proceeding to market economics. Lithuania as well as other countries construes TUI as important capital, export expansion, increase of employment and implementation of innovative knowledge and source of growth of economics. Investment of foreign companies allows gaining an access to new foreign markets for local manufacturers also supplements national budget by income from taxes, improves national trading balance. According to Balasubramaniam et al. (1999) in order to attract TUI a country needs to have high enough educated human capital level and well expanded financial market.

Lithuania, Latvia and Estonia have high enough qualified manpower, but still they are missing capital and their technologies lag behind technologies which operate in developed countries. The attraction of foreign investment is not only a target in Lithuania, but necessity in order to materialize one of the main strategic purposes of the country – to strengthen national economy and improve the living quality of people by entering Europe's trade and capital market. Lithuania became more attractive for foreign investors after joining European Union (EU) and NATO. Harmonization of Lithuania's national law with EU law became as a safety guarantee for foreign investors.

Direct foreign investments are one of the main factors explaining the economic growth potential. In 2009 Lithuania took 47th place in the world by economic ability. Qualified and competitive manpower in Lithuania is very attractive for investors (Schwab, 2011). There are about 20 thousand of high education graduates every year in Lithuania. This index is one of the biggest not only in Eastern Europe, but in EU as well. The average wage in Lithuania is still one the lowest of EU countries. High manpower qualification and low wage level influences attractive proportion between labour quality and expenses for business. Although there is a lack of unqualified manpower in Lithuania and that is a barrier for a development of investment attraction economics. There is a lack of qualified specialists at the moment because of the emigration of manpower as people are looking for a higher salary abroad.

2.4 Hierarchical cluster analysis

The purpose of the cluster analysis in this investigation is finding regions with similar characteristics. Cluster analysis attempts to identify relatively homogeneous groups of cases

(or variables) based on selected characteristics, by using an algorithm that starts with each case (or variable) in a separate cluster and combines clusters until only one is left. In the case when a large number of variables are used for cluster analysis it is recommended to reduce the number of variables before starting cluster analysis procedure. A factor analysis often is used as one of the methods for reducing the number of variables (Bühl A. & Zöfel P, 2000). We will use factor score estimates for the regional classification.

There are two general classes of methods for estimating factor scores. The first class of methods yields approximately a standardized factor score estimate with different properties. Regression approach produces factor score estimates that maximize determinacy (Bollen, K.A., 1989).

$$F = \Phi \cdot \Lambda^{T} \Sigma^{-1} x \tag{4}$$

Here F are the estimated common factors, Φ is the covariance matrix of the common factors, Λ is the matrix of loadings, Σ is the model-implied covariance matrix of the measured loadings. Matrices are based on estimated parameters. Other methods yields factor score estimates that are perfectly orthogonal (uncorrelated) (Krijnen, W. P. *et al*, 1996). Each of the refined methods is imperfect. Regression estimates will be correlated even when the factors are orthogonal, and orthogonal estimates will not maximize determinacy. Having computed the regression estimates of factor scores, the data was partitioned by separate years and performed agglomerative hierarchical cluster analysis. When creating clusters by this method, each case starts out as a cluster. At every step, clusters are combined until all cases are members of a single cluster. Squared Euclidean distance was chosen as the measure of classification. This distance is computed as D(x,y)= $\sum_i (x_i - y_i)^2$;

Agglomerative hierarchical clustering helped to determine the number of clusters. Applying this procedure were determined the optimal number of clusters - five clusters. Dividing the regions into five clusters we obtain such cluster membership (Table 3).

Cluster numbers are marked in brackets. Regions that are out of the listing depend on the first cluster. Evidence for the new faith in the economy of space can be found in the theories of creating regional competitiveness by localized learning, the development of governance leadership and by the development of clusters. Theories of clustering are *par excellence* theories of the economy of space, since they rely on the assumption that geographical proximity between related production units create added value and local competitiveness (Danson M. W., 2000).

The Lithuanian urban system was a very balanced one, if balance is understood as a graduated city-ranging and an equal dispersion of the centers in the territory. But now in Lithuania wealth is becoming increasingly concentrated in the capital as well. This has lifted the position of Vilnius when compared to its situation before regaining independence. The current goal - the ESDP of a polycentric urban system has similarities with the post-war regional planning in Lithuania. Since the 1960s Lithuanian regional planning followed the concept of the universal settlement system, based on Christaller's theory of central places. In the 1970s the paradigm stressed the role of urban centers and their modernizing effect on the periphery. The tools of regional planning have changed completely after the regaining

independence (Schmidt-Thome, Bengs, 1999). The Act on Territorial Planning (1995) defines the levels of territorial planning of the nation, the county and the municipality. All levels can elaborate comprehensive plans and special plans for subsystems, such as water supply or transportation development. The detailed planning is carried out at the municipality level. The Lithuanian Parliament approved the Comprehensive Plan for the Lithuanian territory in year 2002. This Plan was defined on the national guidelines for spatial planning and support the implementation of regional policy (Comprehensive Plan…, 2002). At this moment it is the main document for physical planning and also it has created preconditions for the sustainable development of the whole territory of Lithuania. In year 2002 Strategic Plans for economic sector development were finalized (Long-term Economic Development Strategy …, 2003). The connection of these strategic documents has created the background to implementing the sustainable development of Lithuanian regions. The cluster analysis used for the evaluation of the development of Lithuanian regions allows one to show changes in the 2001 year (Fig. 2, 3).

Regions	1996	1997	1998	1999	2000	2001
1	Ignalinos (2)	Alytaus (2)	Alytaus (2)	Ignalinos (2)	Ignalinos (2)	Ignalinos (2)
2	Kauno (3)	Ignalinos (3)	Anykščių (2)	Kauno (3)	Kauno (3)	Klaipėdos (3)
3	Klaipėdos (3)	Kauno (2)	Ignalinos (3)	Kėdainiai (4)	Kėdainiai (3)	Mažeikių (4)
4	Mažeikių (4)	Klaipėdos (4)	Kauno (4)	Klaipėdos (4)	Klaipėdos (3)	Vilniaus (5)
5	Trakų (5)	Kretingos (2)	Klaipėdos (4)	Kretingos (3)	Kretingos (3)	
6	Vilniaus (3)	Mažeikių (5)	Kretingos (4)	Mažeikių (5)	Mažeikių (4)	
7		Trakų (4)	Mažeikių (5)	Trakų (3)	Panevėžio (5)	
8		Vilniaus (2)	Panevėžio (2)	Utenos (4)	Trakų (3)	
9			Šiaulių (4)	Vilniaus (3)	Utenos (3)	
10			Trakų (4)		Vilniaus (3)	
11			Vilniaus (4)			

Table 3. Cluster membership of regions for factor scores in 1996-2001

The main principles for the regional policy were presented as result of a cross-sector approach. A comprehensive result of this plan in graphic form was expressed in the following main schemes:

- Macro-regional situation of Lithuania,
- Spatial concept of the territory: main territorial structures and principal model.
- Functional priorities of the territory,
- Development of the technical infrastructure (Comprehensive Plan …, 2002).

Fig. 2. Clusters analysis in 1996

Fig. 3. Cluster analysis 2001 year

A comparison of this scheme with schemes of cluster analysis according to the following years allows one to evaluate the sequences of development of Lithuanian regions. For example, Vilnius region from year 1996-2001 had a better position compared with other regions of Lithuania and in 2001 it had reached the highest cluster. From other hand in 2001 Kaunas region became equal to most of Lithuania's regions. The total amount of direct foreign investment for the whole country increased from year to year but in last period foreign investments concentrates in four main regions: Vilnius – capital, Klaipeda – sea port, Mazeikiai – Oil production plant and Ignalina – Nuclear Power Plant. The clusters analysis allows for maintaining this without changing investment policy and creating legal and economic regulations and further foreign investment will be concentrated in the largest city regions and regions with the main industrial plants that are important to the whole country, herewith increasing the gap between larger and smaller town regions that disagree with the directives of sustainable development.

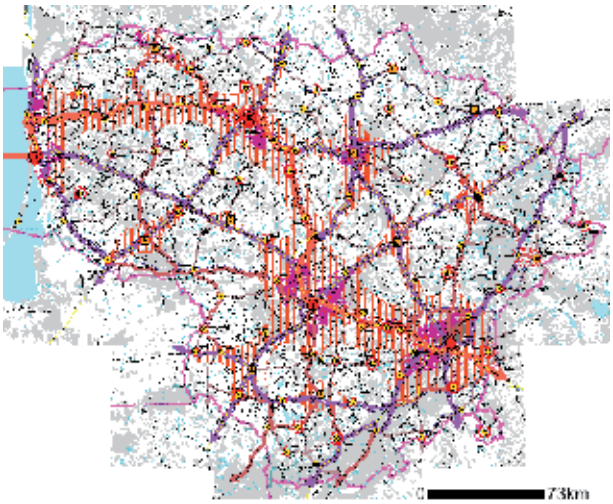

Fig. 4. The main urbanite framework according to the Comprehensive Plan of the Territory of the Republic of Lithuania (Comprehensive Plan …, 2002).

3. Strategy Innovation

In the last decade, the strategy of innovations has become a critical factor of competition in the modern world that undergoes uneven development. Innovation strategy is ability to resume the existing model in such manner that a new value is created for consumers and intermediaries. Innovation strategy is the main way to survive under severe competitive fight and lack of resources. If success of an organisation is defined as a contribution of the organisation into a certain field, for example, national economy, transport, communications, knowledge economy, etc., then innovations become inevitable.

At present, the competitive environment being created and the strategy of development differ from the strategy conception that existed several decades ago. The modern strategy includes the following key topics: knowledge, insight, competence, networks, ecosystems, transformation, and resumption. However, in order to secure rapid development and at the same time to win a competitive struggle, mere knowing of these popular notions and schemes is not sufficient. Unfortunately, it should be recognised that principles and theory of creation of modern strategies are still in the stage of development. Statement that endless process of planning is a strategy would be erroneous in its essence.

Setting of advance assumptions is one of the key conditions for development of innovation strategies. A complex theory states that processes are generated by formation of necessary premises (Kauffman, 1995). What are prerequisites that would condition success of innovation strategy and of all organisations? Usually, when developing or presenting strategies, a complicated artificial system is constructed and contemplations are related to innovations rather than to assumptions that precondition occurrence of innovation strategies. A complicated artificial system is constructed in this was but no efforts are laid to perceive and create conditions for the occurrence of this system. It is considered that successful creation of innovation strategies is aided by the implementation of some presumptions (Davenport, T. & Prusak L., 1992, Strategic Thinking…, 2001).

4. Development of IT (Information Technology) infrastructure of regions of Lithuania

Systematic development of IT infrastructure of Lithuanian regions was started in 1995-1996 when implementing the project KIS Municipality, when the first websites of Lithuanian municipalities occurred on Internet. In 1997, implementing the Phare project, websites of Lithuanian Municipality Association (LMA) were designed; they gave short information on all municipalities – their arms, a short presentation of a region, contacts, a short version in English. The analysis of social-economic data in time from 1996 till 2003 of Lithuania shows that higher developing was reached in regions located close to biggest cities and main plats, important for whole Lithuania economy (Burinskienė M. & Rudzkienė V., 2003, 2004).

The research deals with the territorial units of Lithuania, i.e. regions; it analysis their distinction and peculiarities, and evaluates presumptions necessary for technological progress of municipalities and for successful development of IT infrastructure. The empirical study consists of two parts: the first part analyses qualities that precondition the increase in the unevenness of development of urban and regional municipalities, the second one deal with the presumptions that have influence on uneven development of infrastructure in regions. Carrying out an empirical study the data of the Department of Statistics of Lithuania and the data of Census 2001, also the data of Lithuanian Municipality Association and of the study initiated in 2001 by the *Open Society - Lithuania* were used.

4.1 The initial stage of the study – Changes in prevailing systems of towns, regions and villages

The goal of this study is to find out the key features that are incidental to unevenly developed areas so that the most appropriate innovation strategies are selected with the help of which a higher speed and sustainable development of areas would be stimulated. Modern development brings about transformation of society, which makes people not only undertake intensive learning but also change the way of thinking (Bourdieu, P. & Wacquant L.J.D., 1998; Evers, 2000). If we accept that knowledge is the base for the modern growth of economy, then investment into communication technologies is a critical factor for the spread of knowledge and for the stimulation of active learning. Investment into communications is necessary in order to achieve higher-level know-how and to improve the efficiency of knowledge economy, which, in its turn, would further economic growth.

Basing on the performed calculations 13 indicators have been selected that best discriminate life quality level in towns and at countryside: university education, dwellings completed, municipal budgets revenue, stock of emergency, migration, dwellings uncompleted, morbidity by circulatory system, part of agricultural land in total area of district, towns and regions as per cent in the country's industry, retail turnover in trade and public catering enterprises, direct foreign investment, unemployment rate, and investments in the construction of residential houses. According to the value of *F* criterion, Lithuanian towns and regions mostly differ in the following indicators:

- University education,
- Municipal budgets revenue,
- Towns and regions as per cent in the country's industry,
- Migration.

According to analysis results we could predict that uneven of development of towns and districts evidence not only in economic sphere, but also in knowledge, because indicator which is most discriminating towns and districts is university education. The performed analysis prove the tendencies that educated residents and especially the educated youth want to live in bigger towns, which even increases the gap between potency and knowledge economy of towns and countryside. Negative values of the coefficient at the variable "migration" indicate a decreasing number of residents both in town and at countryside. Lower indicator of region migration is influenced by internal migration when part of residents move from towns to town regions. The present results are just a part of analysis of impact of transition economy evolution on common situation and living conditions. Due to complexity of the object it can be analyzed in various hierarchical levels and time frames.

4.2 The second stage of the study – Preconditions for the development if IT infrastructure in regions

When the key features by which Lithuanian towns and regions are distinct are found out, the second stage is started, which covers assessment if presumptions that precondition successful IT development in regional municipalities. In this stage of the study, one of the studied groups – Lithuanian regions, the set of which is not homogeneous either – was analysed. To assess the progress of IT development at regional municipalities, different criteria are used: overall assessment of IT system state at municipalities; IT budget (percentage of the total budget of a municipality); supply of municipality employees with computers; share of computers connected into the intranet; number of email accounts (percentage of the total number of municipality employees); Internet access – type and speed of connection; quality of information given in municipal portals. This study used the data given in the portal of Open Society – Lithuania. The portal included the methods that were used for the assessment of IT development level of municipalities and with the help of those methods each municipality was given a certain number of points and the general level was assessed taking into consideration the sum of the points under all criteria. Carrying out the study, two suburban regions were eliminated form the set of 40 regions (Vilnius region and Klaipėda region), as these two regions have features that are more characteristic of a town municipality rather than that a region. Although general trends of IT development are positive in all regions, their development is uneven. Assessing development in points, the obtained amount of points differs several times. In solving the question whether changes in the values of IT infrastructure variable tend to be associated with changes in the others, we can use several different statistics. These statistics are: Pearson's sample coefficient of correlation r, the sample coefficient of multiple determination R^2, the coefficient of multiple correlation R, a partial coefficient of determination R_p and a partial correlation coefficient r_p. To assess the relationship between variables (indicators) we calculate the coefficients of multiple correlation R and partial correlation r_p. As in regions the number of people having college education is on the average three to four times higher than that of people having university education, a common index – i.e. the level of education, when the overall number of people having college and university education is 1000 – was introduced for the analysis of regions. Analysis results show that education level has the most significant influence on IT infrastructure (r=0.43, r_p=0.26). Having verified the significance of these indices with the help of t criterion, we see that both indices are significant at the significance level equal to 5 %. The two indices that have significant influence on IT infrastructure are the average

monthly brutosalary (in litas) and the share of agricultural land in the total region's land area (%). The relationship between IT infrastructure and average monthly gross earnings (r=0.34, r_p=0.21) takes the second place, between IT infrastructure and the agricultural land in the total region's area (%) r=-0.35, r_p=-0.27. Although correlation coefficients r, that assess this relationship, are significant when the level of significance is equal to 5 %, partial coefficients of correlation r_p are not significant. Thus, it could be stated that their direct influence on IT infrastructure is not significant. Illustration of the relation between IT infrastructure and general education level of inhabitants of the region (Figure 5) shows that the sample is not homogeneous, thus for further study we will use classification algorithms and will form groups of similar regions.

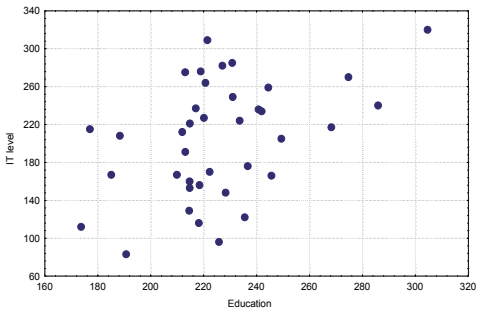

Fig. 5. Scatterplot of education of inhabitants of the region and IT level at regional municipalities

The purpose of cluster analysis in this investigation is finding regions with similar characteristics. Theories of clustering are *par excellence* theories of economy of space since they rely on the assumption that geographical proximity between related production units creates added value and local competitiveness (Danson, 2000).

Applying agglomerative hierarchical clustering procedure the optimal number of clusters - three clusters were determined. Now the goal of the next step is to apply the optimal method for dividing a number of objects into three clusters. The k-means method is the most suitable for this purpose, whereas this method produces exactly k different clusters of greatest possible distinction (Everitt B. S., 1993). Examining the means for each cluster for each dimension we identify the nature of each cluster. The summary of the information is presented in Fig. 6.

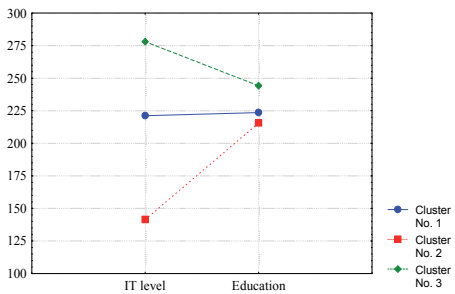

Fig. 6. Plot of means for each cluster of regions

The location of region's groups in Fig.7 represents the IT development of the groups of regions as well as the level of education. Looking at the lines for the third cluster as compared to the first and second clusters in the diagram below, we can found that: a)the members of the third cluster are distinguished by the most developed IT level and the members of the third factor have the best education, b) the level of IT development of the first and second cluster are lesser than the third cluster. The peculiarity of this cluster is the lower level of the education comparing with the third cluster (Fig.7).

Fig. 7. Clusters of the Lithuanian regions identified by the methods of cluster analysis, 2002

The most developed and modern are regions in the top of the diagram and less attractive are in the bottom. Having compared the average differences in inhabitants' education of the clusters with the help of ANOVA method, we see that these differences are significant when the level of significance is equal to 5% (F=3.95, p=0.028). Having studied the unevenness in the development of towns and regions and groups of regions, having found out the attributes that help to distinguish groups of regions and having assessed the quality if discrimination, we see that education of inhabitants if the key attribute by which unevenly developed groups differ.

5. Methodologies and ways for sustainable development insights

Planning their future, public authorities make decisions that will have significant impact on future events and processes. The results of the taken decisions have a long-term effect. The fact that the present-day scientific and technological development allows assessment of the outcome of decisions to be or not to be taken and getting ready for such outcome is very important for the public, politicians, and authorities. Obviously, before making a significant decision it is necessary to assess the aspects of its impact on other processes. Traditionally, such type analyses may be classified into 3 (estimating, if-then planning, forecasting) or 4 classes, namely: forecasting, investigative analysis, presumption and projecting. Forecasting and projecting usually are applied to find out the future situation, and an investigative analysis and presumption may be applied for generating new ideas or opinions on situations with a high level of uncertainty. Among different methodologies it can be achieved using strategy of self-management tools (Paulauskas, S. & Paulauskas, A. 2008).

Successful implementation of the strategy might be expected only if the developed strategy is widely approved by the public. To explain the success or failure of the sustainable development policy, researchers usually focus on technological solution of ecologic problems and the arising difficulties. The strategy is doomed to failure if people at whose decisions are targeted or the staff responsible for the introduction fails to understand the decisions and disapprove them.

Future insights are one of the key measures that could help the public realise its freedom conception through changing the future. Future insights are a new field the emergence of which was to the largest extent influenced by creative and innovative practicing who came with excellent methods and algorithms to satisfy the needs of their clients rather than by scientists/theorists. The key method for insight forecasting is the *scenario* method. A scenario is a plot of potential multiple future versions: from a simple consideration of potential events of unknown future to analytically grounded future shapes linked by complex relations. One of the best-known futurologist, Peter Schwartz, in his book *The Art of the Long View* (1991) stated that practically a scenario reminds of a range of stories written or told according to accurately constructed plot. Stories may express many complex perspectives of event development, while scenarios give them special meaning. The methodology for scenario creation is based on the following main principles: a) reflection on the future and estimation of potential changes, b) as the future is indefinite and only presumptions may be made concerning it, the range of potential future versions is very wide.

Several methods for scenario creation may be singled out, and each of them consists of several variations. For example, P. Bishop, A. Hines ir T. Collins (2007) single out 8 groups of methods for scenario creation. Scientists prefer methods that combine mathematical forecasting methods and human presumptions (Chermack,T.J.& Lynham S.A., 2004; Illés I., 2006). Where a forecast is based only on quantitative data, it is not able to consider the indefiniteness of the future. On the other hand, human opinion contains only a subjective estimation of the future. Therefore, considering that both human presumption and mathematical extrapolation have objective shortcomings, their complex application helps foresee critical events and make more accurate estimation of future trends.

The application of the scenario method is based on several ideas. Mathematical forecasting may be successful only under stable conditions. Due to various factors (economic, political solutions, global condition changes), however, events rarely develop in an expected way. The scenario method solves the task of forecasting by applying the principles of decomposition when individual potential variants (scenarios) of the development of events are singled out (Millett S., 2003; Neumann I. & Overland E. 2004). The whole set of scenarios covers all possible development variants. At the same time, each individual scenario has to present an adequately accurate forecast of the future, and the total number of scenarios should be manageable.

Two stages are singled out when applying the scenario method:

- Development of a comprehensive, still manageable set of scenarios;
- Comprehensive forecasting in the framework of each specific scenario and a possibility to get answers to the questions important for the analysis.

The procedure of estimation by experts allows to combine opinions of individual experts and to formulate a joint solution. In a general case the methodology of estimation by experts is grounded on the following presumptions: a) an expert has accumulated a large amount of rationally processed information (he has sufficient knowledge and experience and may count on his intuition), thus an expert may serve as a source of quality information, b) the opinion of the group of experts hardly differs from the real solution of the problem.

Different methods are applied to get estimations by experts. In some cases an expert works individually, sometimes without even knowing that he/she serves as an expert. This method helps to avoid an influence of the opinion of known authorities (Bardauskienė D., 2007). In other cases experts gather together and discuss a problem, assess the expressed reasoning and reject the wrong one. In some cases the number of experts is strictly fixed and calculated, it must satisfy the presumptions of statistical compatibility methods. Sometimes the number of experts increases in the course of examination.

Forecasting or planning situations or events, the experts usually are given a task: to estimate a problematic and complicated situation and to come up with several possible alternative situation estimations and several versions of a forecast or a plan. When analysing the possible versions, experts assess their importance, inter-relations, and, when planning further actions they may also take account of material and human resources, foresee the period and estimate the financial expenditure.

6. Principles of the scenario construction

Although construction of scenarios is not strictly regulated, such construction incorporates all qualitative and quantitative forecasting methods. The basis for scenarios consists of mixtures of analysis, scenarios usually use data and methods of different fields of science: economics, law, ecology, engineering, etc., they are based on legislation and regulations, discourses, historical analogies.

Validity of scenarios depends on logic and logical links. Several typical parts are characteristic of a scenario:

1. *Introduction* that presents the beginning position, i.e. the present situation, and tells the problems and the relevance of those problems to the decision-maker.
2. *The main part of a scenario* that gives details of one of many possible future ways of development of a problem. This part gives a detailed view of the main *drives, beginning and finishing conditions, main events and episodes*.
3. Comments. Comments draw attention to the main elements of the scenario. They give other development versions that are possible in case of different initial presumptions and conditions of development. They may also describe critical events, pay attention to unexplored fields and emphasise the importance and peculiarities of decision versions.

A methodological basis of scenario analysis is of major importance to decision-making. An analysis of possible scenarios may give a better view not only of potential future events but also of the potential impact of decisions made on the public and environment. Besides, an analysis of scenarios facilitates the estimation of the period for achieving the expected results and the sequence of actions necessary for that. Recently, literature offers a wide range of scenarios that forecast potential trends of society and state development. One of the

best known scenarios are scenarios constructed by Gartner, Inc. in 2005, covering government perspectives and methods in 2020 (Government in 2020 ..., 2005). Four scenarios (Status Quo Development, Free-Enterprise Government, Coverining Phantoms, The Good "Big Brother") were singled out applying the GBN scenario planning method, and those scenarios give a different picture of the role and development of governments, perspectives of regions and provision of public services.

Recently, the European Union has been constructing a number of scenarios of future insights (Schwab P. *et al.* 2003; Four futures of Europe 2004; Lindgren M., Bandhold R., 2003). Scenarios aim at estimating the economic efficiency and competitiveness, and at the same time equity and cohesion. Several alternatives of these scenarios might be singled out:

1. *Supporting scenarios.* Continuation of the processes that currently take place serve as the grounds for this scenarios type. It is based on the structural EU aid and pay regard to common EU regulation norms.
2. *Green scenarios.* These scenarios see agriculture not like a producer but as a countryside conservator. The main drives are policy and management of landscape and soil.
3. *Market scenarios.* These scenarios are based on liberalisation of agricultural market and trade in agricultural products. These scenarios are divided into 2 classes:
   a. Gradual rearrangement of agricultural activities by instilling new methods and improving work efficiency.
   b. Cooperation. According to this scenario, small landowners should cooperate

7. Lithuania's territorial development scenarios and solutions

In 1999, Finnish scientist Jari Kaivo-oja wrote that analysis of the widely applied development scenarios (the Deep Ecology Scenario, the Strong Sustainable Development Scenario, the Weak Sustainable Development Scenario, the Doomsday Scenario and the World Bank "Policy Tunnel" Scenario) revealed that the sustainable development is not a conflict-free concept as the criteria of sustainability (environmental sustainability, economic efficiency and social equality) under many scenarios might be not complied with, and the named global strategies serving as the basis for the concept of sustainable development might even be harmful for developing societies. Sustainability planning based on the analytical positioning of the existing situation is a useful approach towards the formation of the sustainable development policy. This plan was applied when drafting the general plans of municipal territorial planning of the Republic of Lithuania, and at the stage of conceptual framework drafting the following is being defined:

- territorial planning and spatial structure development principles;
- territorial use functional priorities;
- territorial management, regulation, use and protection principles.

The conceptual framework of the spatial development of the district area is drafted for 20 years and it is to be approved at the Municipal Council of a concerned district. For example, analysis and assessment of the current state of the territory of Moletai region revealed that the concept of special development of dwelling areas are conditioned by the following main factors: adverse trends of development of population and socio-demographic structure, changes in the system of population areas are necessary, tourism

potential is not exploited. According to the rules of municipal area general plan drafting, the drafters of a general plan must propose at least two alternatives for developing the planned municipality, i.e. Moletai district. The analysis of secondary sources, the expert analysis and the examination of the received data resulted in two territorial development scenarios.

Status quo alternative. Status quo (the existing situation to be maintained in future, too) on the grounds of the existing urban infrastructure that should be maintained; the existing network of institutions of education, culture, health, social protection, social care should also be maintained but the services being provided and the quality of living environment and public spaces should be improved; promotion of modernisation of agriculture and forestry within the existing limits of land use and landholding system and efforts to keep employment in agriculture. This alternative guarantees the existing service relations and relations between adjacencies, accessibility and continuity of the existing working places and social infrastructure objects.

The implementation of the status quo alternative demands large financial resources of the state and especially of the municipality and plenty of administrating staff with managerial skills. By choosing the status quo alternative essentially efforts would be laid to improve the existing urban administrative structure quality and that would demand vast financial resources. Such dispersion of municipal objects and objects to be supported will determine retardation of development of Moletai district if compared with other districts of Lithuania with the urban structure concentrated to a higher extent as the trends of the decrease of population in rural areas is 2,6 times higher than the average of Lithuania.

The attractiveness of Moletai for investment will be conditioned not only by the development of the existing socio-economic, urbanistic, legal and administrative systems but also by other factors: supply of skilled staff, the level of development of socio-technical infrastructure, the level of professional mobility of labour, clear and specific principles of district development to attract investment. Socio-economic development of Moletai district will also depend on the following external factors: ability and failure of Moletai district and other neighbouring towns (especially Vilnius) and regions of Lithuania to offer better living conditions and activity conditions.

The name threats are not subject to direct management but municipal activities should be directed towards mitigation of outcome of threats. Therefore, the status quo alternative is not perspective with regard to the management of socio-economic and environmental development and territorial organisation.

An alternative of active development is a development which would identify priorities for individual settlements and aim at connecting adjacent settlements. This alternative could be called decentralised concentration.

Drafters of the general plan offer to accept the alternative of active development; the essence of this concept is the following: a) to create a hierarchical system of centres and other residential areas, b) to reduce the prevailing position of de facto centre, Moletai, in the territory of the region, c) to ensure even distribution of the standard of living in the region territory,d) municipal council and administration of Moletai should initiate qualitative and quantitative development of selected and approved local centres, e) adjacent settlements should be connected. Conditions should be created for a single system of administration, institutional, social and engineering provision, also for rational use of land.

Alternative I is maintenance of status quo. The alternative provides for the maintenance of the socio-economic structure of Moletai district aiming at improving the quality of socio-economic environment without making changes in the formed infrastructure network.

Alternative II, also known as *decentralised concentration*. This alternative of district development provides for qualitative and quantitative development of socio-economic infrastructure in the local centres of the district, and promotes sustainable development of the district.

This alternative generates larger socio-economic benefit for the whole district of Moletai in the long-term perspective.

Advantages of the implementation of Alternative I are the following: investment of Moletai district is targeted at improving the public infrastructure and public services aiming at the quality and safe environment for living. Investment of the municipality of Moletai district should be used for the renewal of equipment at health care institutions, introduction of modern information technologies for a more efficient servicing the patients. In this way, accessibility of such services would be improved without making quantitative changes in the network of these institutions. However, the status quo alternative does not promote optimisation of social services in Moletai district which are rather limited at present. The implementation of the status quo alternative could entail the improvement of the education services. This alternative creates conditions for improving the quality of tourism services by making tourist objects more attractive, improving the public infrastructure and information system of the sightseeing objects as well as expanding the range of complex services.

The implementation of all these services would serve as the grounds for the quality improvement of the existing structure and formation of higher standard living environment. However, conditions would not be created for the sustainable development of the district, which would impede the development of the socio-economic potential of the region. Negative demographic and different social trends of the district condition the fact that quality improvement of the existing infrastructure is not efficient in the long-term perspective. The implementation of the status quo alternative would not contribute to the achievement of the main goals of the general plan.

Comparison of the second alternative is better than the first one, as its implementation should result in better accessibility of public services for region's population, as social and institutional provision would be concentrated not only in Moletai town but also in localities. Formation of a hierarchical structure of local centres would reduce the impact of Moletai town on the region. Occurrence of local centres should stimulate their development and increase attractiveness of residential areas, improve living conditions in remote settlements. Quality living environment should stimulate more rapid socio-economic development of the whole region. Concentration of service infrastructure in local centres should narrow the gap between towns and rural areas.

The implementation of the decentralised concentration variant would result in the fact that the increased significance of local centres of category **b, c, d** in Moletai district would condition the improved standard of living in these centres, and the socio-economic development of the centres should stimulate investment in them (Fig. 3). It is probable that the improving living standard and the development of the public infrastructure would have a negative impact on the reduction of population emigration in the long-term perspective.

Having chosen the alternative of decentralised concentration, the municipality of Moletai district should foresee measures for solving socio-economic problems that would ensure a proper development of local centres.

8. Conclusion

When analyzing the socio-economic situation, we have to use much interrelated initial data and indicators that characterize the development of the process. In employing multivariate statistical methods from many possible probabilistic – statistical models, the model that describes the real behavior of the explored set of objects best and that provides substantiated and exact conclusions was obtained.

In order to evaluate the situation and make decisions the described knowledge discovery process enables evaluation of the main factors and selection of the influencing space of the direct foreign investment in the regions of Lithuania. To this purposes the integration of factorial and component analysis methods have been used. These models allowed for the estimation of essential data multidimensionality and a concise and simplified explanation of multivariate structures of data. By means of factors and principal components they displayed the existing reality but directly imperceptible regularities.

After analyzing the factor scores it has been established that the influence of individual cases on the investment was best when using the z–score scale. This allows us to evaluate a dynamic model of the situation that is being considered.

Analysis of clusters results in time from 1996 till 2001 shows that higher development was reached in regions located close to the largest cities and the main industrial plants and are therefore important to the Lithuanian economy. The statistical analysis shows that it is necessary to change investment policies and to create legal and economic directives for investment regulation and without these measures investment will be concentrated in regions nearer to the largest cities and all Lithuania important industrial plants, herewith increasing the gap between cities and peripheral towns as well as their regions all of which opposes sustainable development.

The study has revealed that education of inhabitants is the key attribute that has the greatest influence on IT development and on technological progress of municipalities and discriminates the uneven development of towns, regions. Education level is higher in towns and surrounding regions, inhabitants of such towns and regions are apt to adopt modern IT technologies and stimulate active expansion of e-gov services of municipalities and implementation of new communication methods. The created information networks in their turn have further impact not only in governing quality but also on development of society; besides they increase social and organisational capital.

Transformation of command economy into market economy, that causes migration of higher educated inhabitants to major towns and regions, has resulted not only in economic differences among rural areas of towns but also the knowledge gap that inhibits implementation of modern technologies and spread of knowledge. For successful development of knowledge economy, it is necessary to make the best conditions not only for general education of inhabitants but also for development of their skills and application of life-long learning programmes. Although results of this investment are not seen

immediately, they precondition successful competition in the development of knowledge economy.

The key method for insight forecasting is the *scenario* method. A scenario is a plot of potential multiple future versions: from a simple consideration of potential events of unknown future to analytically grounded future shapes linked by complex relations.

Estimation by experts is understood as a summarised opinion of an expert group drawn on the basis of knowledge, experience and intuition of experts. The goal of estimation by experts is getting, encoding, structural processing and interpretation of knowledge of an expert. The procedure of the estimation by experts allows combining opinions of individual experts and formation of a joint solution. Forecasting or planning situations or events, the experts usually are given a task: to estimate a problematic and complicated situation and to come up with several possible alternative situation estimations and several versions of a forecast or a plan.

In those cases where uncertainty degree is high, scenario analysis becomes the main method for assessing future changes and making rational decisions. All scenarios are analytical and clearly defined constructions of the future that present a set of possible alternatives. Every scenario is based on certain presumptions and conditions. They help a decision-maker to assess the importance of these presumptions and to decide which scenario is most suitable. The goal of scenario method is to look at the functioning and internal links of a complex dynamic system.

The drafters of a general plan must propose at least 2 alternatives for developing the planned municipality, i.e. Moletai district. The analysis of secondary sources, the expert analysis and the examination of the received results resulted in 2 territorial development scenarios: a *status quo* alternative and an *active development* alternative. The implementation of the alternative of active development (decentralised concentration management) would result in higher significance of smaller categorised local centres in Moletai district, which would precondition the improvement of the standard of living in them. Socio-economic development of the centres should stimulate investment in them. It is probable that the improving living standards and the development of the public infrastructure would have a negative impact on the reduction of population emigration in the long-term perspective.

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Part 4

Sustainable Agriculture and Food Security

13

Sustainable Farming Systems vs Conventional Agriculture: A Socioeconomic Approach

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1. Introduction

Intensive-type farming, through the application of high-input systems that offer an increased yield, is known as conventional agriculture. This term is broadly used in the international literature to describe intensive farming (Pacini *et al*., 2003). Over the last two decades, attention in industrialised countries has focused on reducing pollution by fertilisers and synthetic pesticides in conventional agriculture. The concern of society for the environmental problems caused by conventional farming, in combination with the increased demand for achieving sustainability in the agricultural sector and for safe, high-quality foodstuffs, has led to the emergence of alternative farming systems in recent years (Parra-Lopez *et al*., 2007). Especially, the increasing consumers' concern about food safety and environmental pollution escalated the value of Sustainable Farming Systems (SFS), such as Organic and Integrated Farming Systems or Integrated Crop Management (ICM).

SFS is a system that can evolve indefinitely toward greater human utility, greater efficiency of resource use and a balance with the environment which is favourable to humans and most other species (Harwood, 1990). The key aspect to sustainability is the ability to adapt to future potential changes (Hendrickson et al., 2008). Sustainable agriculture refers to an agricultural system that is ecologically sound, economically viable, and socially just. The central objective of both organic and integrated farming systems is the attainment of sustainability. These sustainable farming systems are striving to make the environment an integral part of the production process so as to give priority to issues regarding the proper use of natural resources and to offer assurances for the quality of produced foodstuffs (Tovey, 1997). Nevertheless, integrated and organic farming systems have several differences concerning their origin, the practices they implement, their association to the existing system of knowledge and information dissemination and their links with the traditional supply chain (European Commission, 2003).

Organic agriculture is a sustainable way of farming without chemical inputs during cultivation whereas integrated farming system is a sustainable way of farming which falls somewhere in between the conventional and the organic farming system. Organic and integrated agriculture are the sustainable farming systems that have been developing noticeably during the last decade.

A simple, concise and fairly descriptive definition of organic agriculture is the following: "Organic farming is a production method that focuses on the protection of the environment. It avoids the use of chemical inputs, such as fertilisers and pesticides" (Abando and Rohnerthielen, 2007). The concept of organic farming, institutionalised via the E.U. regulation 2092/91, is based on eliminating the use of purchased chemical inputs while maximising the use of on-farm inputs and biological control techniques instead of pesticides (Tzouvelekas et al., 2002).

Integrated crop management is the restrained and proper use of agricultural chemicals and fertilisers which is achieved through a combination of biological and chemical cultivation methods having as a result the reduction in input costs (Morris and Winter, 1999). According to IOBC[1], Integrated Crop Management (ICM) is a farming system which integrates natural resources and regulation mechanisms into farming activities to achieve maximum replacement of off-farm inputs and secures sustainable production of high quality food through ecologically preferred and safe technologies. It also sustains farm income, reduces the sources of environmental pollution currently generated by agriculture and maintains the multiple functions of agriculture (European Commission, 2003).

Organic farmers have been under a subsidy scheme for a period of 5 years and have received acre payments, whereas producers in integrated management have not been directly subsidised. Nevertheless, in the case of certain countries (eg France, Germany, Finland, Portugal, Greece) the ICM-type schemes receive support under specific agri-environmental measures in the context of EU Regulation. In Greece, in the reporting period of the present study, organic peach farmers received 900 €/ha/year, while integrated peach farmers received an average of 77 €/ha/year to cover part of the cost of ICM implementation.

The knowledge requirements differ for the three types of farming, with organic farming making a radical break from conventional farming knowledge networks and effectively requiring the development of a new Research and Development (R&D) and advisory system. ICM needs more targeted R&D within the existing advisory system, whereas conventional farming relies to the traditional R&D and advisory system (Harwood, 1990). Regarding the type of technical assistance which is available for organic and ICM versus conventional farmers in Greece, integrated farming has developed a considerable network of scientific support by the private sector and more targeted R&D within the existing advisory system, in recent years. On the contrary, organic farming has relied to the advice given by private certification bodies and the limited role of the public sector, not having succeeded in developing a considerable R&D and advisory system. In fact, it turns out, from the results of this research, to be the main inhibiting factor in the decision to adopt organic farming.

[1] International Organisation for Biological and Integrated Control of Noxious Animals and Plants.

The certification of organic products in Greece is supervised by a national certification body (AGROCERT) under the Ministry of Rural Development and Food. It sets standards based on EU Regulation 2092/91, which must be met by the private certification bodies that are actually supervising organic farms. With regard to integrated farming, however, there is no common legal framework in the EU which binds each country to meet common standards for the certification of products of integrated farming systems. AGROCERT produced two national standards (AGRO 2-1 & 2-2.) in which all the certification requirements are described in detail.

In the EU-27, the total area of sustainable farming systems has now exceeded 12.1 million hectares, 55% of which is the share of organic and 45% the share of integrated crop management (Willer et al., 2008, ZMP, 2008). In Greece, in 2008, organic farming covered an area of 69,201 hectares and integrated management an area of 29,232 hectares, corresponding to 2.2% and 1% respectively of the total agricultural area of the country. The share of permanent crops is particularly high in relation to total cultivated area and includes fruit trees, olive trees and vines, grown under organic or integrated management system. Peach trees occupy about 30% of the total area under integrated management, followed by the cultivation of olive trees (27%). There are numerous crops that are being organically produced in Greece such as cereals, forage crops, olive and fruit trees. However, the most important crops from an economic and environmental point of view are olives, vines and fruit trees (e.g. peaches).

In Greece, organic farming has already been implemented for 16 years and integrated farming for 9 years. A significant increase of area under Sustainable Farming Systems was observed in the entire implementation period. The intensity of main crops at each region, relative to the use of chemical inputs, is an important adoption factor of the two systems. Thus, organic farming is applied mainly at regions with less intensive crops and integrated farming is applied mainly at regions with more intensive crops, like peach crop that requires many applications of chemical inputs.

In Greece, there is an unequal adoption rate of organic and integrated farming among the regions of Greece at both NUTS-2 and NUTS-3 levels. The distribution of integrated farming among regions is more unequal than the distribution of organic farming at both NUTS-2 and NUTS-3 levels. The type of crops, the policy support for Sustainable Farming Systems and the different extension services between the two systems explain the differences at the development of integrated and organic farming among the regions. The revealed differences point out the need for diversification of policies among the regions of Greece regarding the sustainable farming systems.

On an international level, there is limited research comparing the three farming systems, since most papers study each system separately or make comparisons between two systems only. Nieberg and Offermann (2003) compared the economic performance of conventional and organic farms in Europe and concluded that organic farming has become an economically attractive sustainable farming system in several European countries, despite the fact that its yields are significantly lower compared to conventional farming (by an average of 30-40%). One of the most decisive factors of profitability is the attainment of higher producer prices in organic farming (a difference of over 50% compared to conventional farming). A basic parameter for the economic success of organic farming is the specific subsidies for organic crops, provided within the framework of the Common Agricultural Policy. These subsidies

represent a share of 15 to 26% of the profit in Germany, Denmark, Austria and Switzerland. Although on average in the EU, the profit of organic farms is similar to that of conventional farms, very significant variances do appear, both among the organic farms of a country and among EU countries. This variance in the average profitability of organic farms ranges from -20 to +20% of the average profitability of conventional farms.

Swezy *et al.* (2007) compared conventional, organic and integrated tobacco production over a 6-year period in the USA. The yields in integrated and organic farming were lower compared to conventional farming by 19.4 and 34.3%, respectively. The average production costs were higher in integrated and organic farming compared to conventional farming by 28% and 60%, mainly due to the lower yields (and also due to the increased labour cost in organic farming). However, when this comparison is made based on total production cost per unit of land, they are only higher by 3 and 5% in integrated and organic farming compared to conventional farming. The statistical analysis was carried out using analysis of variance, which is a method that was also adopted in the present research.

The higher production cost in sustainable farming is a factor that justifies the demand for higher prices of the products. In fact, the increase in production cost is higher than the increase in producer prices, and consequently a gap is created, which possibly discourages some farm managers from becoming involved in sustainable agriculture. In addition, the environmental cost has not yet been incorporated in the prices of conventional products; while such a development is expected to help bridge the above-mentioned gap (Swezy *et al.*, 2007).

Parra-Lopez and Calatrava-Requena (2006) compared conventional, organic and integrated olive farming in Spain, according to the Multi-Criteria Decision Making Theory (MCDM) and using the Analytic Hierarchy Process (AHP). Based on the results of the overall yield from the three systems, they arrived at the conclusion that integrated and organic farming have a higher value compared to conventional farming of 10% and 19%, respectively. They refer to the total economic value that alternative farming systems offer for the whole of society and include their technical, economic and environmental functions. These values can be used as a guide in order to estimate a fair level of compensation, in relation to society, for producers of sustainable farming systems.

Pacini *et al.* (2003) evaluated the economic aspects of the sustainability of organic, integrated and conventional farm management systems in Italy. It was found that gross profit was higher for organic (subsidies included) rather than conventional farming. This was the only statistically significant difference observed among the three systems.

A recent comparative study on the cherry tree sector in Greece examined whether organic production is capable of offering satisfactory benefits to producers and concluded that conventional production is profitable, in contrast to organic production that is only profitable when subsidised (Tzouramani et al., 2008).

On the other hand, integrated farming in most countries of the European Union, results in lower variable production cost, mainly due to the reduced expenses for agricultural pesticides and fertilisers. As regards the price of products, its increase is the exception rather than the rule in the EU. The price of ICM products, in the majority of systems, does not differ from the price of relevant conventional products. In any case, however, there is an advantage linked to the marketing of these products and this fact, in the long-term, may have a positive impact on gross income (Granatstein, 2000). Gross profit remains almost the

same as conventional farming in 44.4% of integrated farming systems, it is increased due to the non-variable gross income and the reduced variable production cost (which is mainly related to the reduced cost for pesticides and fertilisers) in 22.2% of systems and it is reduced in 33.4% of integrated farming systems (European Commission, 2003).

Additionally, it is noticeable that while economic incentives have played a significant role in inducing some managers of farms to adopt sustainable farming systems, there are others who grow organic even in the absence of subsidies. Managers of organic farms can be of at least four types: organic hopefuls, frustrated, pragmatic, and committed, each having a shared viewpoint but giving expression to it in different ways. Managers of conventional farms can be of at least two types: never really considered organic farming or have seriously considered it (Fairweather et al., 1999).

A review of the literature on the decision making process concerning the adoption or not of organic farming does not reveal a clear dominance of economic or environmental motives. Some research results indicate the significance of economic motives in the decision to switch from conventional to organic farming. It has been noted, in Germany for example, that producers turning organic, do so motivated by economic rather than environmental factors (Bruckmeier et al., 1994). It appears that in the UK as well, with prices of organic produce being higher than prices of conventional output by about 50 to 100%, higher income from the sale of organic produce is a significant motivation to adopt organic farming practices (Lampkin. and Measures, 1995). Another research finding supporting this argument indicates that about 1/3 of organic farmers intend to switch to conventional farming, if the financial support given to organic farming be withdrawn (Fairweather and Campell, 1996).

On the contrary, other results underline farmers' environmental consciousness as a major motive for the adoption of organic farming. In several countries, research shows that organic farmers rank environmental protection higher than economic returns (Milder et al. 1991, Storstad and Bjorkhaug, 2003). The protection of natural resources is a parameter that affects farmers' decision to adopt organic farming as they are interested in maintaining soil quality at a high level (Fairweather, 1999). In addition, they appear to show great awareness in matters of environmental pollution, degradation of water resources due to conventional farming and the existence of residues in foodstuffs (Mc Cann et al., 1997).

Meanwhile, an ideological framework for organic farming is emerging and can be seen as a guiding paradigm for the expansion and dynamic development of the agricultural sector (Allen and Kovach, 2000). In studying the ideological motivation of organic farmers, reference must be made to an objective laid down by organic farmers concerning their self sufficiency and autonomy from the agricultural input industry (Verhoog et al., 2002). In a research carried out in Ireland it was found that producers are primarily motivated by ideology when switching to organic farming (Willer and Gillmour, 1992). In the Netherlands, the majority of producers who turned organic were mainly motivated by their beliefs regarding a notion of ecosystems (Duram, 2000). However, in recent years the ideological undercurrent characterising organic farming seems to be fading away (Rigby and Caceres, 2001). The knowledge about the negative effects of conventional farming on the health of producers and consumers constitutes a significant motivation for farmers to adopt organic farming methods. For instance, farmers' apprehension in Norway about the negative implications conventional farming has on the quality of life and social welfare led to the adoption of organic farming (Storstad and Bjorkhaug, 2003).

Research results in England regarding integrated crop management provide a ranking of reasons leading to the adoption of this type of farming as follows: demand for safer and better quality foodstuffs, reduction of input costs and environmental protection. In contrast, an important factor explaining the lack of interest in this system is economic uncertainty during the transitory period (Park et al., 1997). It is for this reason that measures aiming at the reduction of such uncertainty must be part of a strategy to promote integrated crop management. In addition, 87% of conventional farmers believe that integrated crop management protects the environment, hence, recognise its environmental dimension, whereas 50% considers that production costs are significantly lower due to the reduction in input costs (Morris and Winter, 1999). In the Netherlands, 15% of conventional farmers have the option to participate in integrated crop management without having to make any major transformations in the production process (Vereijken and Royle, 1989). Approximately 50% of conventional farmers who do not intend to implement integrated crop management state that it is because they lack the required technical knowledge, whereas 41% because of shortage of data on the input-output relationship. It is worth noting that 61% of English farmers consider the lack of experience in the methods and techniques of integrated crop management as the main inhibiting factor for its adoption (Morris and Winter, 1999).

The comparison between a sustainable farming system and conventional agriculture is essential to understand how farmers choose between farming systems and what their motivations are (Fairweather, 1999). However, existing research focuses on conventional, organic and integrated farming separately, examining the advantages and disadvantages of each one system and not in relation to the other two. So far, very limited research has been done to investigate all three systems simultaneously, for among other things it is rather difficult to obtain secondary data and/or to collect primary data. Yet, the evolution of each system must be seen relatively to the others, because any advance in one is closely linked to the developments in the other two. A comprehensive approach which includes all three systems is likely to give new insights in this matter.

The objective of this chapter is to analyse, in socioeconomic terms, all three farming systems, namely, organic, integrated and conventional agriculture. The chapter analyses certain parameters related to the management of organic, integrated and conventional farms. It examines the economic results of the three farm types and the necessity of a specific subsidy being granted for organic and/or integrated farms. Specific tasks of the research are to examine the characteristics of organic, integrated and conventional farm managers. The differences between the managers of the 3 farm types are examined in relation to age, educational level, reasons for becoming involved in alternative farming systems and their training. In addition, the attitudes of farm managers to economic and environmental aspects of sustainable farming systems are examined. Finally, another task of this research is finding those specific elements which determine organic and integrated farming and also classifying the sustainable farming systems on the basis of farm managers' viewpoints regarding farm economics and environmental protection.

2. Methodology

The primary data were collected using a questionnaire and through face-to-face interviews with the managers of conventional, organic and integrated farms. More specifically, as regards the two sustainable farming systems, it is worth noting that only certified organic

and integrated management farms, according to the official data of the Ministry of Rural Development and Food and AGROCERT, participated in the present study. The applied method of data collection for the three different groups of managers was: the population for organic peach farms, stratified random sampling for integrated peach crop management, and simple random sampling for conventional peach farms. The primary research was carried out in 2007. The peach sector was selected, for it is the only sector in which all three agricultural production systems have been implemented since 2001.

During the period under study, the organic farms were 58 and they all took part in the present research. Integrated crop management is almost exclusively practised by cooperatives (or producer groups). Therefore, cooperatives are the research strata under study in this case. A stratified random sampling procedure was used which corresponds to the objectives of this research, for it offers more accurate estimates of the various parameters for the same number of population units, (Hansen et al., 1993). Sampling errors are smaller and this is the result of the homogeneity that this method can preserve in the various population strata (Särndal et al., 2003).

In the simple random sampling procedure, sample size for conventional agriculture, was determined on the basis of the following equation:

$$n = N(zs)^2 / \{Nd^2 + (zs)^2\} \quad (1)$$

Where: n is the sample size, N is the population size, z is reliability, d is the confidence interval and s is the standard deviation calculated for a preliminary sample. Minimum sample size was calculated as n=99. The chosen final sample size was n=100 farms.

The calculation of sample size in the stratified random sampling procedure that was used for integrated crop management was done with the help of the Neyman sampling distribution (Särndal et al., 2003).

$$n = (\Sigma N_h s_h)^2 / \{N^2 D^2 + \Sigma N_h s_h^2\} \quad (2)$$

Where: n is the sample size, N is the population size, D the standard error (D=d/z), z is reliability, d is the required accuracy, s_h is standard deviation in each stratum that was calculated with a preliminary sample. Minimum required sample size n=93. The chosen sample size was n=100 farms which is more than the minimum requirement.

Based on the above, the final sample was set to 258 peach farmers, 100 of which were conventional, 100 were integrated and 58 were organic farmers. The selected sample consisted of conventional, organic and integrated management peach farmers who were located in all peach producing areas of the country. Following the preliminary test, the final questionnaire was used to collect data through direct (face to face) interviews with the selected producers who were also the managers of farms.

The statistical analysis was performed using the SPSS v.15. Parametric and non-parametric statistical analysis methods were used to resolve various research problems, since a different method had to be applied, according to the characteristics of each problem and the nature of the data and variables. The statistical data analysis methods that were used can be summarised as follows:

- One-Way Analysis of Variance.
  - Tukey's HSD Post Hoc Test (Tukey's Honestly Significantly Different Test).
- Independent Samples t-test.
- Kruskal-Wallis H (with a Monte Carlo simulation technique).
- Mann-Whitney U (with a Monte Carlo simulation technique).

The first two methods involve parametric techniques, while the other two are non-parametric statistical techniques.

The one-way analysis of variance is a parametric statistical method which provides the opportunity to examine the hypothesis that the mean values of various populations are equal. It is recommended for use when there are more than two samples, and the aim is to compare the mean values. The accuracy of the diagnosis is considered to be the most important reason for applying this particular method (Katos, 2004).

The application of post hoc analysis is required when the result of the analysis of variance is found to be statistically significant and permits numerous comparisons of mean values. Tukey's HSD (Honestly Significantly Different) criterion was used, which is considered to be one of the safest to test all the comparisons that can be made among the levels-values of the independent variable. Tukey's HSD test was used to carry out the necessary "correction", which takes into account the number of comparisons when estimating the statistical significance. One of the main tasks of this model is to examine whether the relevant *Y* variable presents a different behaviour at the three levels of the categorical variable *X*. Using the *F*-test as a basis, the null hypothesis of the following equation was examined: H_0: $\mu_1=\mu_2=\mu_3$. If this specific hypothesis is rejected, the research question becomes which of the μ differ from the rest. For this purpose, all the comparisons of the mean values are applied in pairs. The multiple tests which occur in the case of alternative farming systems are of the following type: H_0: $\mu_1=\mu_2$, H_0: $\mu_2=\mu_3$, H_0: $\mu_1=\mu_3$.

In the present paper, the t-test was used in cases where the research question only referred to the two types of farming (e.g. integrated and organic farming). In these cases, the test was performed between a categorical variable, with two categories, and the numerical variables under study. The null hypothesis is H_0: $\mu_1=\mu_2$ and the alternative H_1: $\mu_1\neq\mu_2$. The null hypothesis is rejected when, according to the result of *t* test, the observed level of statistical significance *p* is lower than a particular level of significance (a=0.05). In this case, the mean values of the numerical variable under study differ between the two alternative forms of agriculture. In addition, Levene's *F*-test was performed in order to examine the equality of the variances. When the test showed that the variances are equal (p>0.05), then an estimation was made using the model of equal variances; on the other hand, when the variances were unequal (p<0.05), the estimation was made using the model of unequal variances.

The Kruskal-Wallis test is a non-parametric equivalent test of analysis of variance; it was mainly used to examine the statistically significant relation between a categorical variable (with three categories) and ordinal variables. The categories of the variable are the integrated, organic and/or conventional management of agricultural production. Due to the fact that more than two groups are compared, the issue of post-hoc multiple comparisons emerge once again; in this case, they are conducted using the Mann-Whitney U test. The additional post hoc correction is made by dividing the level of statistical significance with the number of comparisons performed.

Finally, the Monte Carlo simulation technique was used for the Kruskal-Wallis and Mann Whitney U methods. A thousand normality tests were carried out and the level of statistical significance *p* was calculated for each one. Then, the mean value of these 1000 *p*-values was estimated, as well as the lower and upper bound of the confidence interval (selected confidence level 95%) for the mean values, based on the 1000 *p*-values. The estimates of the *p*-values, according to the Monte Carlo simulation technique result from the repeated sampling of the data in order to acquire empirical distribution parameters and achieve a greater reliability of the results (Harwell and Serlin, 1994).

3. Results and discussion

According to research results, the managers of conventional and integrated farms present a similar age distribution. On the other hand, organic management is characterised by a lower percentage of older producers (21% are over 55 years), compared to integrated (41%) and conventional farming (43%). Organic farmers, in their vast majority, are middle aged, since 76% are aged 36-55 years, while the relevant percentage in integrated and conventional management is 48% and 47%. On the contrary, the percentage that corresponds to younger producers, appears to be very low in organic management (3.4% are <35 years) compared to conventional and integrated management (10% and 11%, respectively). The structural weakness of the age of farmers in Greece seems reduced in organic farming; however, the latter presents obvious weaknesses in attracting young organic farmers (<35 years). Nevertheless, all the above-mentioned differences were not found to be statistically significant (Table 1).

Age	**Conventional**		**Integrated**		**Organic**	
	No.	**%**	**No.**	**%**	**No.**	**%**
< 35	10	10.0	11	11.0	2	3.4
36-45	26	26.0	24	24.0	20	34.5
46-55	21	21.0	24	24.0	24	41.4
> 55	43	43.0	41	41.0	12	20.7
Total	**100**	**100.0**	**100**	**100.0**	**58**	**100.0**
Results of Kruskal-Wallis test: $\chi^2 = 4.144$, d.f.= 2, p = 0.126 Monte Carlo simulation technique: p = 0.124 Confidence Interval (Confidence Level 95%): Lower bound: 0.118 Upper bound: 0.131						

Table 1. Age of managers in alternative farming systems

As regards the educational level of farmers, the Kruskal-Wallis statistical test showed that there are significant differences among the managers of alternative farming systems that are identified, according to the Mann-Whitney U test, between the managers of organic farming and the managers of the other two agricultural production methods (Table 2).

Indeed, as we can see in Table 2, about 1/3 of organic farm managers belong to the two higher educational level categories, while the relevant percentage in integrated and conventional management is only 9% and 6%, respectively. It is remarkable to note that 45% and 43% of managers in integrated and conventional management respectively, have not attended secondary school, while the relevant percentage is only 14% for organic farming.

Education	Conventional		Integrated		Organic	
	No.	%	No.	%	No.	%
Primary School	43	43.0	45	45.0	8	13.8
Lower Secondary School	25	25.0	25	25.0	18	31.0
Upper Secondary School	26	26.0	21	21.0	12	20.7
Vocational Training	3	3.0	3	3.0	4	6.9
Tertiary Education	3	3.0	6	6.0	16	27.6
Total	**100**	**100.0**	**100**	**100.0**	**58**	**100.0**

Results of Kruskal-Wallis test: $\chi^2 = 24.983$, d.f. = 2, p = 0.000
Monte Carlo simulation technique: p = 0.000 Confidence Interval (95%):
Lower bound: 0.000 Upper bound: 0.000
Results of Mann-Whitney U test:
$z^{INT-CON}$ = - 0.285 (p=0.776) (Monte Carlo: p = 0.772) (C.L [i]: p = 0.764-0.781)
$z^{ORG-CON}$ = - 4.462 (p=0.000) (Monte Carlo: p = 0.000) (C.L.[i]: p = 0.000-0.000)
$z^{ORG-INT}$ = - 4.514 (p=0.000) (Monte Carlo: p = 0.000) (C.L.[i]: p = 0.000-0.000)

[i] Confidence Limits

Table 2. Educational level of managers in alternative framing systems

The overwhelming majority of managers are professional farmers. However, there are significant differences among the managers of alternative farming systems, as regards the percentage of income from non-farming activities. On the average, this percentage amounts to 37.3% for conventional farms, 30.5% for integrated farms and 22.8% for organic farms. The distribution of managers, based on the percentage of off-farm income, presents statistically significant differences among the alternative farming systems, with a statistical significance level *a*=0.05 (Kruskal-Wallis test). Based on the Mann-Whitney U test, these differences are however only identified between organic and conventional peach farms (Table 3). Indeed, the managers of twice the number of organic peach farms compared to conventional ones (48.3% as opposed to 24%) do not have any off-farm income. Similarly, off-farm income exceeds on-farm income in 41% of conventional and only 24% of organic farms. The percentage for integrated management is somewhere between those two figures, but presents no statistically significant difference with either of the two (Table 3). It is therefore obvious that the organic and integrated management of peach farms is practised on a professional basis, rather than occasionally and that the managers of sustainable farming systems financially depend on their farms to a great extent.

As regards the reasons that urged producers to become involved in farming, about 1/3 of organic managers state they did it for the income, in contrast to conventional and integrated management, where only 1/5 of farmers mentioned income as the cause. The lack of any alternatives was the main reason for becoming involved in farming for approximately 3 out of 10 producers in conventional management, 2 out of 10 producers in integrated management and only 1 out of 10 producers in organic management. A conscious choice of living was the most important reason for the three groups, while family tradition was the primary cause for 24%, 22% and 14% respectively of managers in organic, integrated and conventional farms (Table 4).

Furthermore, another important element is the fact that farm managers have substantial experience in the peach tree sector, since they have been working with this crop for over 20

Percentage of F.I.[i] from sources outside the Farm %	Conventional		Integrated		Organic	
	No.	%	No.	%	No.	%
$P^{ii} = 0$	24	24.0	38	38.0	28	48.3
$0 < P^{ii} < 25$	17	17.0	14	14.0	6	10.3
$25 \leq P^{ii} < 50$	18	18.0	12	12.0	10	17.2
$50 \leq P^{ii} < 75$	28	28.0	24	24.0	10	17.2
$75 \leq P^{ii} < 100$	13	13.0	12	12.0	4	6.9
Total	**100**	**100.0**	**100**	**100.0**	**58**	**100.0**

Results of Kruskal-Wallis test: $\chi^2 = 8.113$, df= 2, p = 0.017
Monte Carlo simulation technique: p = 0,017. Confidence Interval (95%):
Lower bound: 0.014 Upper bound: 0.020
Results of Mann-Whitney U test:
$z^{INT-CON}$ = - 1,547 (p=0.122) (Monte Carlo: p=0.124) (C.L[iii]: p=0.118-0.131)
$z^{ORG-CON}$ = - 2,845 (p=0.004) (Monte Carlo: p=0.004) (C.L.[iii]: p=0.003-0.005)
$z^{ORG-INT}$ = - 1,443 (p=0.149) (Monte Carlo: p=0.150) (C.L.[iii]: p=0.143-0.157)

[i] Family Income [ii] Percentage [iii] Confidence Limits

Table 3. Distribution of farm managers based on the percentage of off-farm income

Reason	Conventional		Integrated		Organic	
	No.	%	No.	%	No.	%
Family tradition	14	14.0	22	22.0	14	24.1
Way of life	36	36.0	38	38.0	18	31.0
Lack of alternatives	29	29.0	22	22.0	6	10.3
Satisfactory income	3	3.0	4	4.0	12	20.7
Additional income	18	18.0	14	14.0	8	13.8
Total	**100**	**100.0**	**100**	**100.0**	**58**	**100.0**

Table 4. Reasons for which conventional, integrated and organic farm producers became involved in farming

years, on average. It is worth noting that 76%, 87% and 90% of the organic, conventional and integrated farms have been involved in this particular sector of agricultural production for over 15 years. In order to examine whether the farm managers in alternative farming systems differ, as regards the mean duration of their involvement in the sector, the one-way analysis of variance method was used, since, inter alia, Levene's test showed that the homogeneity of variance hypothesis is satisfied ($p>0.05$) (Table 5).

As we can see in Table 5, the results of the *F* analysis of variance test showed that there is a statistically significant differentiation ($p<0.05$) among the farm managers in alternative systems, as regards the average duration of their involvement in peach tree farming. Statistically significant differences were identified between organic farm managers and the producers of the other two systems of agricultural production (post hoc Tukey's HSD test). Indeed, the farm managers in conventional and integrated agriculture have, on average, an additional experience of 7 years in the peach sector, compared to organic farmers. However, the average number of years shows that there is valuable experience among the farm managers in all three systems of agricultural production.

Duration	Conventional		Integrated		Organic	
	Mean±St.Er.	St Dev	Mean±St.Er	St Dev	Mean±St.Er	St Dev
Years	29.31[b]±1.231	12.97	29.15[b]±1.16	11.60	22.28[a]±1.297	9.37
Homogeneity of variance test: Levene Statistic = 2.132, d.f.[i] =2, d.f.[ii] = 255, p=0.121 *Results of one-way analysis of variance:* F=7.932, d.f.[i] =2, d.f.[ii] =255, p=0.000 Results of Post hoc Tukey's HSD analysis: $P_{INT-CON}$ = 0.995, St.Er.: 1.740, M.D.[iii]: -0.160 (95% C.L.[iv]: from -4.35 to 4.03) $P_{ORG-CON}$ = 0.001, St.Er.: 1.788, M.D.[iii]: -7.034 (95% C.L.[iv]: from -11.35 to -2.72) $P_{ORG-INT}$ = 0.001 St.Er.: 1.691, M.D.[iii]: -6.874 (95% C.L.[iv]: from -10.96 to -2.79)						

[a,b] Means followed by a different letter present a statistically significant difference
[i] Among the groups [ii] Within the groups [iii] Mean difference [iv] Confidence Limits

Table 5. Mean duration of involvement in peach tree farming

At the same time, through the application of the independent sample t-test, it was found that the managers of organic and integrated farms do not present a significant difference, as regards the years of their involvement in this particular sustainable farming system. More specifically, as we can see in Table 6, Levene's test showed that there are unequal variances (p<0.05), and therefore this estimation refers to this particular case.

Average Duration	Integrated		Organic	
	Mean ± St.Er.	St. Dev.	Mean ± St.Er	St. Dev.
Years	5.27[a]±0.13	1.25	5.59[a]±0.36	2.73
Results of statistical t-test: Levene's homogeneity of variance test: F = 27.321, p= 0.000 Estimation of unequal variances: t= 0.832, d.f.= 70.97, p= 0.408, M.D.[i]: 0.316, St.Er.= 0.380 (95% C.L.[ii].: from -0.441 to 1.074)				

[a] Means followed by a different letter present a statistically significant difference
[i] Mean difference [ii] Confidence Limits

Table 6. Duration of farm manager involvement in the integrated/organic peach farming

The average farm, both organic and integrated, has been certified as regards the relevant system for more than 5 years. Therefore, the managers of integrated and organic farms in the sample do not only have long-term experience in peach farming, but also extensive experience in the application of integrated and organic management practices, respectively.

As regards the farm managers' distribution, it is worth noting that the majority of integrated farm managers (68%) have been involved in integrated peach tree farming for 6 years, while the remaining managers of integrated farms in the sample have been certified for a period ranging from 2 to 5 years. The majority of organic farmers have been certified in organic farming for 5 or more years (66%), while the remaining managers of organic farms (34%) have been practising organic farming for a period ranging from 2 to 4 years. In fact, 42% of the organic farms have been certified in organic farming for over 6 years.

Considering training of farm managers, the number of seminars per year presents a significant difference between the average organic and integrated farm (t-test: $p<0.05$). The calculation was made using equal variances, taking into account the result of the Levene test ($p>0.05$). The producers in integrated management attend on average, 5 seminars per year, which are usually organised by the certification consultant. On the contrary, in organic farming, training is not as organised as in the case of integrated farming, and thus managers of organic farms attend on average 1 seminar per year, mainly organised by the certification body (Table 7). It should be mentioned, however, that it is possible that differences also exist in the quality of the provided training.

Frequency of seminars	**Integrated**		**Organic**	
	Mean ± St.Er.	**St. Dev.**	**Mean ± St.Er.**	**St. Dev.**
No of seminars	4.66[b]±0.10	0.98	1.03[a]±0.14	1.08
Results of statistical t-test: Levene's homogeneity of variance test: F = 0.001, p= 0.978 Estimation with equal variances: t= - 21.665, d.f.= 156, p=0.000, M.D.[i] = -3.63, St.Er.= 0.167 (95% C.L.[ii].: from -3.956 to -3.295)				

[a,b] Means followed by a different letter present a statistically significant difference
[i] Mean difference [ii] Confidence Limits

Table 7. Number of seminars per year for managers of integrated and organic farms

According to farm managers, integrated crop management is the appropriate use of fertilisers, pesticides, fungicides and herbicides (34.5%), through programming, management and control of the agricultural production process (34.3%). The quality of products (16%) constitutes a main element which the integrated crop management, followed by the reduction of production costs (6.1%), certification (4%), protection of the environment (3.5%) and protection of producers' and consumers' health (1.6%) (Table 8).

Main elements	**Frequency of elements' appearance in the definitions**	**Percentage %**
Appropriate use of inputs	147	34.5
Programming, management and control of production process	146	34.3
Quality of products	68	16.0
Reduction of production costs	26	6.1
Certification	17	4.0
Protection of environment	15	3.5
Health and quality of life of producers and consumers	7	1.6
Total	**426**	**100.0**

[1] according to the order of appearance in the definitions of farmers of all the three farming systems

Table 8. The basic elements[1] of integrated crop management, according to farm managers

Farm managers consider that the appropriate use of inputs (mainly fertilisers and pesticides) constitutes a basic component of the ICM system. However, they do not refer to the protection of the environment as a main element of the system. Farm managers may offer a hint about environmental protection through their statement for the use of inputs, but there is no clear assertion about the contribution of integrated crop management to environmental protection.

As regards organic agriculture, farm managers consider that it implies the non use of synthetic inorganic inputs (mainly fertilisers and pesticides) (40.8%) and this results to environmental protection (33.4%). In this case, there is a clear statement for the contribution of organic farming in environmental protection. Additionally, according to farmers, organic farming leads to the production of safe agricultural products, which protect consumer health (21.6%) (Table 9).

Main elements	Frequency of elements' appearance in the definitions	Percentage %
Non use of synthetic inorganic inputs	138	40.8
Environmental protection	113	33.4
Safe products which protect the health and improve the quality of life of consumers	73	21.6
Alternative way of pest management	14	4.1
Total	**338**	**100.0**

[1] according to the order of appearance in the definitions of farmers of all the three farming systems

Table 9. The basic elements[1] of organic farming, according to the definition of farmers

The classification of alternative farming systems according to farmer's opinions for the economics (profitability without subsidies) of farms shows that there is a statistically important diversification for integrated farmers, as they consider that integrated outperforms conventional, which outperforms organic farming. The classification of alternative farming systems is the same for organic farmers, but there is a statistically significant difference only between organic and integrated management. For conventional farmers the rank between conventional and integrated farming changes but the difference is not important. The diversification is important for organic management, for conventional farmers consider that organic farming has the lowest profitability in comparison with the other two types of farming (Tables 10-13).

Alternative Farming Systems	Mean Rank of Conventional Farmers	Mean Rank of Integrated Farmers	Mean Rank of Organic Farmers
Conventional farming	2.55	1.88	2.03
Integrated farming	2.32	2.97	2.38
Organic farming	1.13	1.15	1.59
Results of Friedman statistical t-test: N^{i} =100, N^{ii} =100, N^{iii} =58, $(\chi^2)^{i}$ = 28.533, $(\chi^2)^{ii}$ = 167.780, $(\chi^2)^{iii}$ = 18.345, d.f. = 2, p = 0.000 *Monte Carlo simulation technique:* p = 0.000 Confidence Interval (95%): Lower bound: 0.000 Upper bound: 0.000			

[i] Sample of conventional farmers [ii] Sample of ICM farmers [iii] Population of organic farmers

Table 10. Classification of alternative farming systems according to the farmer's attitude for the economic results (without the specific subsidies for organic/integrated farms)

Alternative Farming Systems	Mean Rank of Conventional Farmers	Mean Rank of Integrated Farmers	Mean Rank of Organic Farmers
Conventional farming	1.54	1.03	1.45
Integrated farming	1.46	1.97	1.55
Results of Friedman statistical t-test: N^{i} = 100, N^{ii} = 100, N^{iii} = 58, $(\chi^2)^{i}$ = 0.605, $(\chi^2)^{ii}$ = 88.360, $(\chi^2)^{iii}$ = 0.621, df = 1 p^{i} = 0,443, p^{ii} = 0.000, p^{iii} = 0.431 *Monte Carlo simulation technique:* p^{i} =0.514, p^{ii} =0.000, Confidence Interval (95%): Lower bound ^{i}: 0.504 Upper bound^{i}: 0.523 Lower bound ^{ii}:0.000 Upper bound^{ii}: 0.000			

^{i}Sample of conventional farmers ^{ii}Sample of ICM farmers ^{iii}Population of organic farmers

Table 11. Statistical test for the examination of classification between conventional and integrated agriculture according to the farmer's opinion for the economic results (without the specific subsidies for integrated farms)

Alternative Farming Systems	Mean Rank of Conventional Farmers	Mean Rank of Integrated Farmers	Mean Rank of Organic Farmers
Conventional farming	2.00	1.85	1.59
Integrated farming	1.00	1.15	1.41
Results of Friedman statistical t-test: N^{i} = 100, N^{ii} = 100, N^{iii} = 58, $(\chi^2)^{i}$ = 100.000, $(\chi^2)^{ii}$ = 49.000, $(\chi^2)^{iii}$ = 1.724, df = 1 p^{i} = 0.000, p^{ii} = 0.000, p^{iii} = 0.189 *Monte Carlo simulation technique:* p^{i} =0.000, p^{ii} =0.000, Confidence Interval (95%): Lower bound^{i}: 0.000 Upper bound^{i}: 0.000 Lower bound^{ii}:0.000 Upper bound^{ii}: 0.000			

^{i}Sample of conventional farmers ^{ii}Sample of ICM farmers ^{iii}Population of organic farmers

Table 12. Statistical test for the examination of classification between conventional and organic agriculture according to the farmer's opinion for the economic results (without the specific subsidies for organic farms)

Alternative Farming Systems	Mean Rank of Conventional Farmers	Mean Rank of Integrated Farmers	Mean Rank of Organic Farmers
Integrated farming	1.87	2.00	1.83
Organic farming	1.13	1.00	1.17
Results of Friedman statistical t-test: N^{i} = 100, N^{ii} = 100, N^{iii} = 58, $(\chi^2)^{i}$ = 54.760, $(\chi^2)^{ii}$ = 100.000, $(\chi^2)^{iii}$ = 24.897, df = 1, p = 0.000 *Monte Carlo simulation technique:* p = 0.000 C. I. (95%): Lower: 0.000 Upper: 0.000			

^{i}Sample of conventional farmers ^{ii}Sample of ICM farmers ^{iii} Population of organic farmers

Table 13. Statistical test for the examination of classification between integrated and organic agriculture according to the farmer's opinion for the economic results (without the specific subsidies for integrated/organic farms)

On the other hand, farm managers of all three farming systems have a more clear attitude regarding environmental protection, for they classify, with an important diversification, organic first, integrated second and conventional farming third (Tables 14 and 15).

Alternative Farming Systems	Mean Rank
Conventional farming	1.00
Integrated farming	2.00
Organic farming	3.00
Results of Friedman statistical t-test: N^{i} = 100, N^{ii} = 100, N^{iii} = 58 $(\chi^2)^{i}$ = 200.00, $(\chi^2)^{ii}$ = 200.00, $(\chi^2)^{iii}$ = 116.00, df = 2, p = 0.000 *Monte Carlo simulation technique:* p = 0.000 Confidence Interval (95%): Lower bound:0.000 Upper bound: 0.000	

[i]Sample of conventional farmers [ii]Sample of ICM farmers [iii]Population of organic peach farmers

Table 14. Classification of alternative farming systems according to the farmer's attitude for the protection of environment

Alternative Farming Systems	Mean Rank
Conventional farming Integrated farming	1.00 2.00
Integrated farming Organic farming	1.00 2.00
Results of Friedman statistical t-test: N^{i} = 100, N^{ii} = 100, N^{iii} = 58 $(\chi^2)^{i}$ = 100.00, $(\chi^2)^{ii}$ = 100.00, $(\chi^2)^{iii}$ = 58.00 df = 1, p = 0.000 *Monte Carlo simulation technique:* p = 0.000 Confidence Interval (95%): Lower bound: 0.000 Upper bound: 0.000	

[i] Sample of conventional farmers [ii] Sample of ICM farmers [iii] Population of organic peach farmers

Table 15. Statistical test for the examination of classification between 1st – 2nd and 2nd -3rd alternative farming system according to the farmer's attitude for environmental protection

In addition, the potential diversification of the attitude of farm managers on environmental aspects of alternative farming systems is examined. As regards the viewpoint on the negative impacts of conventional farming on the environment, organic and integrated farm managers differ on the intensity of its acceptance; with organic farmers showing the highest acceptance.

The majority of integrated farm managers (56%) neither agrees nor disagrees with the viewpoint that integrated farming protects the environment, in contrast with the majority of organic farmers who disagree (76%). Organic farmers (93%) consider that organic farming is the only alternative for environmental protection. On the contrary, about 50% of integrated farm managers disagree with this point of view.

The majority of ICM farm managers (64%) consider that integrated crop management incurs a balanced protection to the environment and to the quality of agricultural products, whereas an equivalent percentage of organic farmers neither agree nor disagree with this viewpoint.

ICM farm managers (86%) consider that integrated differs from conventional farming, whereas the majority of organic farmers consider that it doesn't differ. In addition, the intensity of rejection of the opinion "organic is the same with integrated" differs between the two groups of farm managers; organic are more informed about the differences (93% of organic farm managers disagree very much, against only 35% of integrated farm managers).

Organic farm managers have very high preference on both sustainable farming systems (76% agree very much and 24% agree) against conventional agriculture. This fact is explained by the abhorrence of organic farmers for conventional farming. The intensity of acceptance of both sustainable farming systems by ICM farm managers is much lower (19% strongly agree and 81% agree). Finally, farm managers of both sustainable farming systems disagree with the viewpoint of the adoption of organic and integrated farming for only economic reasons. However, the intensity of rejection is much higher for organic farmers.

The examination of these organic and integrated managers' attitudes regarding the economic and environmental aspects of alternative farming systems was conducted through the statistical test Mann-Whitney U. According to the results, there are statistically significant differences in all cases (Table 16). In most of these cases, this diversification refers to the intensity of acceptance or rejection of each viewpoint.

Viewpoint	**[i] Mann-Whitney U**	
	z	**p**
CON[ii] incurs negative impacts on environment	- 7.169	0.000
INT[iii] protects environment adequately	- 7.619	0.000
ORG[iv] is the only alternative farming system for the environmental protection	- 7.281	0.000
INT[iii] incurs a balanced protection to the environment and to the quality of agricultural products	- 6.737	0.000
INT [iii] differs from CON[ii]	- 6.000	0.000
ORG[iv] is the same with INT [iii]	- 7.067	0.000
I prefer both ORG[iv] and INT [iii] against CON [ii]	- 7.014	0.000
My decision for the adoption of ORG and INT is induced only by economic reasons	- 5.592	0.000

[i] Monte Carlo simulation technique (confidence intervals 95%) confirms in all the case the statistically important results in Mann-Whitney U test.
[ii] Conventional [iii] Integrated [iv] Organic

Table 16. Examination of statistically important diversification of organic and integrated farmers' viewpoints on environmental and economic aspects of alternative farming systems

It is also noticeable that 97% and 98% of organic and integrated peach farmers intend to continue using the selected sustainable farming system. Only 3% of organic farmers will change over to integrated farming and 2% of ICM farmers will change over to organic farming. So there is evidence that there is not a competitive relationship between organic and integrated farming. On the other hand, 43% of conventional peach farmers intend to adopt integrated farming in the next years and only 2% of conventional peach farmers intend to adopt organic farming. So, there is also strong evidence of expansion of integrated crop management in the following years.

The production cost per unit of land, of the average conventional farm is 837 €/str[2]. The production cost of the average integrated farm is lower by 17.4% in comparison with the average conventional farm. On the contrary, the production cost of the average organic farm is higher by 23.9% and 49.9% in comparison with conventional and integrated farms, respectively (Table 17).

The higher production costs in organic farms are mainly due to labour costs, which are 446 €/str, an amount much higher than the respective expenditure in the conventional and integrated crop management (206 €/str). In contrast, land costs do not differ among the average conventional, integrated and organic farm (Table 17).

Production cost	Conventional		Integrated		Organic	
	Mean	St Dev	Mean	St Dev	Mean	St Dev
Land cost	50.86[a]	3.92	50.77 [a]	3.38	50.85[a]	7.26
Labour cost	206.89[a]	79.44	205.89[a]	79.92	445.93[b]	156.35
Variable capital cost	209.60[b]	66.85	150.78[a]	41.46	222.63[b]	100.49
Fixed capital cost	346.42[b]	324.65	250.55[a]	171.86	288.3[a,b]	188.76
Other capital cost	23.07[a]	12.40	33,45[b]	12.11	28.99[b]	12.22
Capital cost	579,09[b]	360.51	434,78[a]	197.56	539.93[a,b]	287.25
Production cost	836,84[b]	402.37	691.45[a]	217.32	1036.72[c]	400.14
Average production cost[1]	0.333[a]	0.275	0.340[a]	0.297	0.709[b]	0.736
Average variable cost[1]	0.129[a]	0.078	0.121[a]	0.108	0.277[b]	0.252
Average fixed cost[1]	0.205[a]	0.208	0.220[a]	0.203	0.432[b]	0.399

[a,b,c] Means followed by a different letter present a statistically significant difference
[1] euro/kg

Table 17. Statistical significance of the differences between the average production cost of alternative farming systems (in €/str)

Capital costs of the average organic and integrated farm are 540 and 435 €/str, which are lower by 6.8% and 24.9% than conventional farms (on average 579 /str). More specifically, fixed capital costs of the average farm under organic and integrated management are 288 and 251 €/str; lower by 16.8% and 27.7% than the respective expenditures of conventional farms (on average 346 €/str). The variable capital costs are 223 €/str on the average organic farm, higher than the average conventional farm by 6.2%. On the other hand, the respective expenditure of the average farm under integrated management is 151 €/str, an amount lower by 28.1% in comparison with the average conventional farm (Table 17). The total expenditure for fertilisers, pesticides, fungicides and herbicides has been reduced in organic and integrated management by 21.5% and 36.8% respectively in comparison with conventional agriculture (105 and 84 €/str on average organic and integrated farm, respectively, against 134 €/str in conventional farms). Regarding integrated crop management, the reduction of these costs in comparison with the conventional management is 39.6% for fertilisers and 35% for pesticides, fungicides and herbicides. This finding is the result of the reduced use of synthetic fertilisers and pesticides in ICM in comparison with

[2] 1 stremma = 0.1 hectare

the conventional agriculture. As in the other European countries, fertilisation and pest management are the main fields of ICM implementation in Greece as well. It has also been observed that in most cases in Europe integrated agriculture is associated with a reduction of production costs due to reduced expenditure for fertilisers and pesticides. As regards organic farms, the reduction in these costs in comparison with conventional farms is important but not very high (18.7% for fertilisers and 23.2% for pesticides) because of both the relative high prices of organic fertilisers and pesticides and the necessity for high quantities of these organic inputs.

The average cost of production is estimated to 0.333 €/kg for the average conventional farm, 0.340 €/kg for the average ICM farm and 0.709 for the average organic farm (Table 17). This cost is only 2.1% higher in integrated in comparison with conventional farming, for the reduction in cost production is compensated by similar reduction in output (yield in kg). Organic farms have, on average, more than twofold average production cost in comparison with conventional and integrated farms, due to both higher production costs and lower yield.

The average fixed cost of production is estimated to 0.205, 0.220 and 0.433 €/kg for the average conventional, integrated and organic farm (Table 17). It is higher by 7.3% in integrated compared with conventional farms and is about twice that of organic farms compared with farms under the other two farming systems.

However, the average variable cost of production is lower in the average integrated farm (0.121 €/kg) compared with conventional farms (0.129 €/kg). This is the result of the higher reduction in expenditures for fertilisers and pesticides than the reduction in yields. On the contrary, the average variable cost of production of organic farms is much higher (0.276 €/kg) compared with conventional farms.

Levene's test that was used to examine the homogeneity of the variances in alternative farming systems, in relation to production costs, showed that this hypothesis is valid in all cases ($p>0.05$). The results of the *F* analysis of variance test showed that there are statistically significant differences concerning all the categories of production costs, except the land costs. The post hoc Tukey's HSD analysis was carried out for the accurate identification of the differences between the three groups. According to the results, statistically significant differences are identified between the average organic farm and the average conventional and integrated farm, as regards the labour cost. Variable capital cost differs between the average integrated farm and the farms of the other two types of farming systems mainly due to less expenditure for fertilisers and pesticides. Fixed capital and total capital cost differ only between the average integrated and conventional farm. Regarding total production costs, statistically significant differences are identified among all the three farming systems. Finally the average fixed, average variable and average total cost of production differ only between organic farms and the farms of the other two types of farming (Table 17).

Concerning the economic results, the focus is on a comparison of the average organic, integrated and conventional farm. When the specific subsidy for organic/integrated farm is not taken into account (Table 18), the average integrated farm makes a profit of 110.7 €/str, which is 8.8% less than the profit of the average conventional farm (121.4 €/str). The specific subsidy for integrated management is relatively low (7.7 €/str), and results in a further reduction (almost elimination) of the difference in profit with an average conventional farm

of about 2.5%. The difference in profit between integrated and conventional management is very small, since the lower production costs in integrated management are also coupled with a lower gross income, due to the low price increase and the relatively reduced yield compared to conventional management. On the other hand, the average organic farm makes a loss without the specific subsidy that is equal to 79.9 €/str. In this case, the loss occurs since, despite the higher gross income (which is due to a larger price increase compared to the reduced yield), production costs increase to a greater extent compared to conventional and integrated farms, mainly due to the higher labour costs. The specific subsidy for organic peach tree farming (90 €/str) turn the losses of the average organic farm into a profit of 10.1 €/str, which is still much lower (92%), however, than the profit presented by the average conventional and integrated farm.

The gross margin of the average conventional farm is 635.7 €/str, while it is lower for the average integrated farm by 70.7 and 78.4 €/str, with or without the specific subsidy, a difference that is equal to 11.1% and 12.3%, respectively. The gross margin of the average organic farm, without the specific subsidy for organic farming is lower by 83.5 and 5.1 €/str (13.1% and 0.9%) respectively, in relation to the average conventional and integrated farm. The subsidy for organic farming changes this relation, since the average organic farm now presents a higher gross margin by 1% and 13.7%, compared to the average conventional and integrated farm.

In addition, the farm income of the average conventional farm is 465.1 €/str, while in the case of the average integrated farm it is lower by 6% and 7.7%, with and without the specific subsidy. In contrast, the farm income of the average organic farm, both with and without the specific subsidy for organic farming, is higher by 25.8% and 6.4%, respectively, compared to the average conventional farm. Similarly, it is higher by 33.8% and 15.3%, compared to the average integrated farm.

The farm family income of the average conventional farm is 352.1 €/str; it is lower by 2.6% and 4.8% for the average integrated farm, with and without the specific subsidy. On the other hand, the farm family income of the average organic farm, without the subsidy for organic farming, is lower by 11.1% and 6.7% compared to the average conventional and integrated farm, respectively. The specific subsidy for organic farming changes this relationship, since the average organic farm consequently achieves a higher farm family income by 14.4% and 17.5%, compared to the average conventional and integrated farm.

The land income of the average organic farm without the specific subsidy is negative (-29 €/str.), but becomes positive with the subsidy and amounts to 61 €/str, which means it exceeds the relevant rental costs (approx. 51 €/str.). Labour income is higher in organic compared to conventional and integrated farm management, both with (approximately 40%) and without (11.5% and 15.6%), the subsidy, while it is similar for conventional and integrated management. However, even more important is the labour income per 8 hours, and its comparison with current wages. It is 49.3 €/str in conventional management; in integrated management it is 48.1 €/8hrs and 46.9 €/8hrs with and without the subsidy (2.5% and 5% lower, respectively, than in conventional management). In organic management, it is 35 €/8hrs and 29 €/8hrs with and without the specific subsidy for organic farms, respectively, i.e. lower by 28.2% and 41.2% compared to the average conventional farm. Current wages are approximately 32 euros/8hrs, therefore, they are less than the labour income/8hrs at the average conventional and integrated farm. However, concerning the

average organic farm, labour income/8hrs exceeds current wages, only in cases where the specific subsidy for organic farming is included in gross income.

The return on capital was estimated at 9.5% for the average conventional farm, 10.1% and 9.8% with and without the subsidy respectively for the average integrated farm, and only 4.3% and 1.3% for the average organic farm, with and without the organic farming subsidy, respectively.

Levene's test that was used to examine the homogeneity of variances in alternative forms of agriculture, in relation to economic results, showed that this hypothesis is valid in all cases ($p>0.05$). The results of the *F* analysis of variance test showed that there are statistically significant differences (when the specific subsidy is not taken into account) concerning the profit, land income, labour income/8hrs and return on capital ($p^1=0.011$, $p^2=0.011$, and $p^3=0.001$, respectively) (Table 18).

Economic Result	Conventional		Integrated		Organic	
	Mean	St Dev	Mean	St Dev	Mean	St Dev
Net Profit	121.40[b]	436.48	110.71[b]	377.16	- 79.91[a]	510.37
Gross Margin	635.66[a]	376.03	557.25[a]	351.08	552.20[a]	495.78
Farm Income	465.11[a]	374.43	429.34[a]	363.00	494.89[a]	457.80
Farm Family Income	352.11[a]	381.15	335.21[a]	357.36	312.91[a]	437.30
Land Income	172.26[b]	436.57	161.48[b]	377.12	- 29.05[a]	511.33
Labour Income	328.29[a]	414.39	316.60[a]	381.72	366.02[a]	444.46
Labour Income/8hrs	49.34[b]	57.63	46.87[a,b]	67.04	29.01[a]	37.36
Return on Capital (%)	9.46[b]	10.88	9.82[b]	15.82	1.28[a]	17.33

[1] without the specific subsidy for organic/integrated management
[a,b,c] Means followed by a different letter present a statistically significant difference

Table 18. Statistical significance of the differences between the average economic results[1] of alternative farming systems (in €/str)

With the addition of the specific subsidy however, the only observed statistically significant difference is the one related to the return on capital. The post hoc Tukey's HSD analysis was carried out for the accurate identification of the differences between the three groups. The statistically significant differences are identified between the average organic farm and the average conventional and integrated farm, as regards profit, land income and return on capital; as regards labour income/8hrs, differences are only observed between organic and conventional farms (Table 18).

4. Conclusions

Taking into consideration research results, it is concluded that organic and integrated crop management are applied by managers on a professional basis. Farm managers present a significant economic dependence on their farms. Managers of organic farms were found to be of a relatively higher educational level, compared to managers of conventional and integrated farms. However, the structural weakness related to age distribution of farm managers, although reduced in the case of organic farming, is nevertheless observed in both sustainable farming systems, since the latter seem to be unable to attract younger farm managers.

It is also concluded, that exists a difference among non-conventional producers in terms of their attitudes towards economic and environmental aspects of organic and integrated farming. Organic farmers appear more sensitive to the environmental impact of conventional agriculture, whereas the attitude of those practicing integrated farm management is influenced more by economic factors compared to organic farm managers.

The definition given by producers in Greece for integrated farm management is similar to that given by producers in England, but differs significantly from the definitions that exist in most EU countries, given that environmental sensitivity is one of the two most frequently occurring arguments in their definitions of integrated farming. Thus, it is for that reason thought necessary to turn to a system of farm managers' education and training with a clearer orientation towards environmental protection.

On the contrary, in the case of organic farming the environmental message is more evident in relation to integrated farm management. Farm managers in all three systems of agricultural production rank organic farming as the most effective production system in environmental protection. Attitudes, however, differ regarding the economic performance of this system, for farm managers of all the three types of farming believe that organic farming has the lowest profitability in relation to the other two systems. Greater emphasis is therefore required to be placed on educating organic farmers in economic issues, such as the efficiency in the use of productive resources and the potential for improving financial results and farm economic performance.

Regarding production expenditures per unit of land, they differ among the three types of farming, for they are reduced in integrated farms compared to conventional farms and augmented in organic farms. In integrated crop management, the reduction in production expenditures is caused by fewer expenses for inorganic inputs, whereas in the organic farms increased expenditures are due to higher labour expenses.

Economic results were not found to differ significantly between conventional and integrated farms. On the contrary, organic farms without the specific subsidy show lower profitability, labour income, land income and capital return compared to conventional and integrated farms. The specific subsidy for integrated crop management is low and does not seem to play a major role; the economic results do not also seem to justify a subsidy for this sustainable system, except if it is only provided for a transitional period. Therefore, the policies for promoting integrated crop management should firstly consider measures to reduce the average age of farm managers and secondly attempt to raise awareness among consumers, so that in the long-term, higher prices are achieved compared to conventional agriculture.

On the other hand, the specific subsidy for organic farming determines the profitability of the average organic farm, has a major and decisive impact on land income, labour income/8hrs and net income; it also increases the return on capital and leads to a reversal of the relation with the other two farming systems, as regards gross margin and farm family income. It is therefore concluded that a potential elimination of the subsidy for organic farming in the peach sector will cause a major deterioration in the economic results of organic farms, compared to conventional and integrated ones. Consequently, if the majority of organic farms continues to operate with the existing economic inefficiency, the provision of a subsidy for this sustainable farming system is considered to be essential.

The policies to promote organic farming should mainly aim at reducing the production cost, increasing the yield and providing training for managers of organic farms. Additionally, the subsidies for organic farming primarily (and for integrated management as well) could also be treated as a measure that would reward farm managers for achieving environmental improvements. Such a decision would depend on the goals set at an agricultural and environmental policy level.

Another conclusion from research results is that the development of the two sustainable agricultural systems does not proceed in a competitive manner and that under present circumstances there is a trend for further expansion of integrated farm management. In the current conditions of economic crisis sustainable agricultural systems can offer an alternative path for the Greek rural economy. An essential requirement, though, is that agricultural policy makers will address the weaknesses that have emerged from the investigation of producer attitudes towards economic and environmental issues, that is to improve the economic performance of organic farms on the one hand and the environmental protection in integrated crop management on the other.

Finally, the appraisal of farms employing different production technologies, in terms of sustainability, gives important information to the decision makers. If the goal of sustainability is to run through the core of agricultural policy, then, policy measures should aim at the promotion of both sustainable farming systems. At the same time, taking advantage of the know-how regarding sustainability that has been building up in the best performance farms, can offer the necessary drive towards sustainable agricultural development.

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14

Improving Food Security Risk Management for Sustainable Development

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1. Introduction

The world is facing a complex challenge to reduce poverty and foster sustainable development. Food and nutrition security, compounded by climate change, bio-energy demand and rapidly rising food and energy prices is putting sustainable development on reverse gear. Achieving the Millennium Development Goals (MDGs), to which world leaders and development partners have collectively signed on, is at stake. To address food and nutrition insecurity and hence contribute to MDG achievement, there is a need to support the development of nationally owned policies and strategies. Such strategies needs to be supported by appropriate analytical tools and operational approaches incorporating recent technological developments. Current practices of developmental and humanitarian interventions require the integration of the various tools such as vulnerability and risk analysis, agricultural monitoring, food security early warning, environmental assessments, and resource mobilization activities. In this regard national governments, development partners and the humanitarian community need to address food insecurity with appropriate programmes that: (a) respond to the immediate humanitarian requirements of communities affected by natural and man-made shocks; (b) build the resilience and adaptation capacity of poor communities that include institutional support in building subnational, national and regional strategies to deal with the growing frequency of emergencies.

2. Risk and food insecurity impact on sustainable development

Any sustainable development effort is compromised by emergencies if not addressed timely. During emergencies, poor households are unable to continue to engage in economic activities that build and preserve household assets and enable sustainable development. Under such circumstances household vulnerability to future risks increases, trapping them Communities facing recurrent emergencies will be more vulnerable to future shocks and as a consequence they will not be able to effectively participate by themselves in any sustainable developmental efforts. In the absence of appropriate and functioning safety nets and risk management systems, poor households will have limited options to cope with emergencies and hence their involvement in sustainable development is curtailed.

To cope with emergencies and acute food shortages households may engage in short term strategies that are unsustainable and which often compromise the long term development objectives (UNICEF and NEPAD, 1992). Such strategies may include: increased fire wood sale leading to increased deforestation; divest productive assets; stress sale of livestock; consume seeds; pull children out of school; migrate looking for jobs often in less productive sectors; and migration to urban centers or neighboring countries becoming refugees. Furthermore recurrent droughts could increase the competition for pasture and water increasing the potential for conflicts. At the same time national governments and their development partners will be forced to divert their development funds to respond to emergencies forgoing investment in longer term development.

In conclusion, food emergencies threaten lives and livelihoods; disrupt long-term development and expose communities to future disasters. A comprehensive strategy that addresses the immediate food needs of households while ensuring support to longer term sustainable development is critical. Development partners and the humanitarian community need to work together to provide coordinated support to National Governments to implement appropriate strategies.

3. Risk assessments – Understanding the risks - Food security information management

Large scale emergencies that overwhelm national response capacities and require external humanitarian intervention often occur in poor countries with limited financial and technical resources. Decision making and strategic planning is hampered by the lack of reliable information on food security factors; poor infrastructure and weak government institutions; compounded by the lack of clear policies and strategies to address food insecurity and risk management. In this paper we focus on risk management. A key component of a good risk management system is the availability of timely and reliable information. There is a need to invest in a food security information system which will enhance decision making and strengthening national Emergency Preparedness and Response Capacity.

Establishing an effective food security risk management capacity requires a comprehensive understanding of the various risk factors that impact on food security. Risks need to be identified, assessed and monitored. A comprehensive food security risk analysis and monitoring system should provide information that allows for answering questions such as who are the food insecure and vulnerable; where they live; why they are food insecure and vulnerable; what intervention options are most appropriate. It is important to identify and understand the various food security hazards and vulnerabilities at sub-national level; identify knowledge gaps and national capacities; identify the temporal and spatial distribution of hazards both historical, current and expected ones; identify the magnitude, frequency and duration of the hazards; assess which of the hazards can be reliably predicted.

The various aspects of risk management need to be integrated using appropriate risk assessment tools that need to be developed. The tools should enable the integration of possible impacts of various natural hazards, such as floods, droughts and earthquakes with socio-economic and vulnerability factors. Risk assessment and monitoring is comprised of the following main elements: risk knowledge; hazard monitoring and early warning; needs

assessment; and communication. Assessments of risks require systematic collection and analysis of various data sets and should take into account the dynamics and variability of hazards and vulnerabilities from processes such as urbanization, rural land-use change, environmental degradation, climate variability/change. As such the main components in developing a comprehensive risk analysis should include:

- Risk identification and development of risk, hazard and vulnerability maps through comprehensive food insecurity risk and vulnerability analysis;
- Food Security Risk Monitoring systems based on key indicators identified above to provide early warning;
- Needs assessments during emergencies;
- A food security information management platform incorporating the latest advances in Geographic Information Systems (GIS) and spatial technology; and
- Capacity building of national and regional institutions

Essentially a food security risk management information system should include the following:

- Indicators that represent the three widely-accepted dimensions of food security (availability, access, utilization) and the risks to them;
- Identified geographical areas and communities that may be facing or will face immediate acute food insecurity;
- Information on the main causes of food insecurity and risks to livelihoods and the extent (or magnitude) to which households will be affected;
- Information on various risk management efforts that governments, communities and households dispose of to avoid or mitigate food insecurity situations;
- Tools for early detection of risks and how information on the available measures to address potential adverse impacts; and
- A comprehensive contingency plan, to support advocacy and resource mobilization efforts and market interventions, such as local purchase of food.

4. Food security risk and vulnerability analysis

In poor and disaster prone countries where external humanitarian interventions are often required, a comprehensive understanding of the national food security policy and disaster response strategy is an important factor in the development of a food security assistance framework. In this regard a Comprehensive Food Security and Vulnerability Analyses (World Food Programme, 2006) is required to identify the main causes of food insecurity and risks to livelihoods and understand the extent to which households and communities could be affected; identify various risk management efforts that governments, communities and households undertake to deal with food shortages; and provide opportunities for early detection of risks to livelihoods and how to address them so that potential adverse impacts can be minimized. A comprehensive food security and vulnerability analysis should contribute to:

- Building national capacity in food security information management and emergency preparedness;
- A road map for food security interventions;
- Strategy formulation in food insecure provinces and localities;

- Humanitarian interventions to be targeted effectively; and
- Efficient national resources allocation by governments

When undertaking a comprehensive food security analysis there are core analytical steps that are used. Here below is a summary of some of the key steps:

- **Secondary data analysis**: Using available data sets preliminary vulnerability and hazard analysis is undertaken. This requires acquisition of all relevant secondary data including socio-economic and environmental data. Secondary data analysis will enable development of household and community vulnerability profiles. It will identify geographical areas at risk as well as areas that may require further investigation through primary data collection. A key output of this process is the creation of geo-database at a national level and also identification of priority geographical areas that need further study.
- **Vulnerability, hazard and livelihood zoning**: Secondary data analysis will enable the production of vulnerability, hazard and livelihood zone maps at the sub-national national level. Hotspot areas that would require monitoring will be identified and relevant indicators selected. The outputs depend on the availability of data.
- **Primary data collection**: Very often secondary data analysis may not be adequate to answer all the relevant questions on food security. Primary data collection may be required to fill the gaps. Geospatial data analysis can be used to help the design of the survey. The use of Smart phones, handheld computer devices and a Global Positioning System device (GPS) improves field data capture and analysis. By geo-referencing the data it will be easily integrated when undertaking vulnerability and risk analysis.
- **Risk mapping**: By integrating secondary data analysis with primary data analysis hazard, vulnerability and risk profile maps are produced.
- **Geospatial data management and dissemination**: A geospatial information management and data exchange platform should be developed and maintained. All the relevant data and analysis will be managed and effectively shared with users.

In undertaking risk analysis, the first step in this process would be to assess if there is any relevant work done at the country level and identify partners both national and international. It is also important to assess the local capacity and institutions in the area of remote sensing, GIS and risk analysis. A risk analysis framework needs to be established and a step by step process that includes spatial data identification, analysis and dissemination of results.

5. Hazard, vulnerability and risk mapping

There are the two components of risk analysis, these are hazard and vulnerability each of them can be assessed separately and integrated to provide risk factors. Assessment and monitoring of risks requires systematic collection and analysis of various data sets and should take into account the dynamics and variability of hazards and vulnerabilities from processes such as climate change, land use change, environmental degradation, political and socio-economic changes. The maps should provide:

- Identification of the main hazards their frequency and magnitude
- Defining a common standard of presentation of hazards and vulnerabilities

- Developing exposure maps and when possible define trigger factors of the hazards
- Mapping socio economic factors
- Mapping of vulnerabilities and their magnitudes

Data layers need to include climatic factors, land use maps, environmental hazards, political factors and socio economic vulnerabilities. The various data sets should be integrated in a GIS environment and processed to establish how poor people make their living and what their coping capacities for dealing with risks. Such analysis provides a better context for interpreting food security information and the impact of shocks or hazards on people's lives. Livelihood zones and risk maps can then be established with composite indices of hazards and vulnerabilities. This is useful for geographical targeting of zones exposed to certain hazards and vulnerabilities. Such analysis will provide the basis for emergency response and shock preparedness strategies.

6. Baseline mapping and national capacity

The first step in the process is the identification and acquisition of the various data sets that are necessary for food security and vulnerability analysis. The various data sets need to be organized according to the type of data as well as the temporal and spatial scales. These data sets will be integrated to support the various types of analysis including food security monitoring. The specific activities in identification and data collection should include the following:

- Assess the national capacity in geospatial infrastructures, which include methodologies, datasets, technologies, policies, and human resources, under which data and/or tools are made available to users.
- Identify users and partners with similar needs in terms of data infrastructure and analysis requirements
- Identify the necessary data sets, where to find them and develop a strategy for collecting them
- Collect all the relevant data sets and create a standardized databases disaggregated at sub-national, regional and national levels. Databases may also include information products (e.g. text documents; photos; tabular data; maps; statistics; earth observation data)
- Inventory and compilation of relevant sources of data and information, metadata catalogues and information directories, information networks, and institutions.

7. Food security monitoring and early warning systems

A food security monitoring system is needed to assess on regular basis the food security status of a given population and provide timely information that would allow timely intervention. That means all the three aspects of food security (availability, access and utilization) should be monitored comprehensively. Appropriate food security variables or indicators associated with availability, access and utilization are selected and monitored. A food security monitoring system constitutes a continuous assessment of food security indicators to detect major changes in food security trends and advice on the likely occurrence of food crises ahead of time. Such warning should, in principle, trigger timely and appropriate preventive responses. The specific objectives and setups of food security

monitoring systems could vary from country to country but in general they should address the following:

- To identify geographical areas and communities that will be affected by food insecurity
- To identify main causes of food insecurity and indicate the extent to which households will be affected
- To identify factors affecting the food security status of households and community
- To trigger contingency planning and Emergency Needs Assessment
- Regularly assess nutritional status of people in the most severely affected areas
- Support advocacy and resource mobilization efforts

Some of the selected indicators may be classified as early, stress or late depending on the lead time between the indicators and their outcome.

At the national level often there already exist various monitoring systems under different government ministries or supported by UN, NGOs or international partners. Examples include:

- Agricultural Information Systems - Agricultural production patterns and performance, trade, inputs, farming systems, and rural income levels.
- Health and Nutrition Information Systems
- Climatic Information Systems - Topography, landform, soils, climate, water availability, land use, land suitability and productivity, land tenure, irrigation, and infrastructure.
- Early Warning Systems - crop production, agricultural production forecasts, estimates of stock levels, food requirements, imports and exports and information on household income
- Market Information Systems - agricultural input and commodity prices, marketing opportunities, and other information relevant to improving the functioning of agricultural markets.
- Vulnerability Analysis and Mapping Systems - Risk factors to which vulnerable population groups are exposed.

At present the institutional linkages between the different players (meteorological services, planning ministries, agriculture departments and humanitarian institutions) is weak or is on ad hoc basis.

Africa is currently heavily dependent on ad hoc early warning and monitoring systems that are run by various international agencies, NGOs and UN agencies (NEPAD, 2003). Such systems are often not integrated into national and regional strategies and may not be sustainable. There is a need for promoting an African led framework ensuring standardized approaches across countries and regions. The many institutional problems which limit the effectiveness of national food security information and early warning systems can be summarized as follows:

- Lack of appropriate food security policies and political commitments. Food security may not often be priority of governments which lack clear policies and regulations on food security and humanitarian interventions;
- Poor integration into government structures. Typically, data collection and reporting functions remain separated among several ministries;

- Separation of data collection activities from policy-making processes. People who collect and report food security data typically have no independent decision-taking responsibility;
- Problematic relationship between donors and governments. Donors provide technical support and funding for national systems, but governments have their own priorities;
- Existing systems generally operate with little coordination among themselves;
- Lack of institutional memory. Systems are rarely institutionalized, due to high staff turnover in government, donors and NGOs, combined with a "project" approach to early warning; and
- Emergency response dominates long term planning. Political enthusiasm and donor support for early warning systems tends to be high in the aftermath of a famine but then steadily evaporates year by year.

To address the above mentioned gaps it will be important to establish a framework under AUC/NEPAD by building on existing systems and capabilities. The key objective will be to consolidate regional early warning information systems where they exist, and initiate new ones in regional organizations where such systems are not available. Thus, integrating Africa's regional organizations' information systems will be the mechanism through which information will be fed into the AUC/NEPAD.

8. Application of new technologies

With recent advances in GIS, satellite technologies and Information Technology, geospatial data is becoming widely available for civilian use. Satellite data, computing capacity, and GIS software are becoming more and more affordable and accessible. The humanitarian community is quickly adopting these latest technological developments and tools to support humanitarian decision making through improved availability of timely and reliable information. New computer-based information and communication technologies are available that can significantly improve the analytical efficiency and the effectiveness of communicating results. Each country should carefully examine the new technologies and select those that can improve the operational efficiency of its system and meet national objectives within the existing resource constraints.

Space borne systems and related technologies and applications are quickly developing as new generations of satellites are rapidly becoming available for peaceful uses. Earth Observation (EO) applications provides advanced tools that enhance the collection, storage, analysis and integration of spatial/geographic data with related non-geographic information collected from ground surveys and stored in databases. The humanitarian community is currently using various types of EO products to support field level activities such as agricultural monitoring (crop and pasture), disaster assessments (such as flood extents) and operational planning.

For example as a result of technological developments and availability of satellite information, agricultural monitoring capacity is improving rapidly. Using latest satellite technologies we are now able to monitor more accurately cropped areas, crop development and estimate yields and production. Through integrated monitoring of crop models, water requirement satisfaction index, vegetation vigour and field reports crop and pasture conditions can be monitored more effectively (Brown, 2008). Crop failures can be identified

several weeks before the end of the agricultural season providing early warning information. It is now possible to estimate the level of expected production by mid-growing season. Depending on the analysis appropriate decision options could be taken. If the information indicates crop failure, further assessment will be initiated on whether humanitarian intervention would be required and trigger response planning. On the other hand, if analysis indicates exceptional surplus harvest then the decision could be to initiate a marketing strategy to avoid market failure.

In summary emerging applications of remote sensing for food security monitoring and risk analysis offers opportunities for improving the effectiveness of humanitarian decision-making. Remote sensing applications require field level validation and verification to be operationally viable. Once such applications are developed the challenge becomes how to integrate such information to support humanitarian decision-making more effectively. In the current humanitarian response model interventions to agricultural failure are planned following crop assessments at the end of the growing season. If such information would be used it will be possible to provide the necessary assistance in a timely manner, directly contributing to the sustenance of livelihoods.

9. Earth observation

One of the challenges in designing and operating food security and early warning systems is to ensure that the system is capable of providing up to date and continuous data to guarantee up to date information for policy makers and decision makers. This is a particular challenge when assessing the spatial impact of climatic conditions and human interventions, both on the short as the long term. While information collected in the field is indispensible, extensive field data collection is expensive and mostly done only at particular moments in time. As such it does not provide the comprehensive spatial and temporal overview required for an effective early warning system. Field data, in combination with satellite imagery provide however a very powerful resource. The specific advantages of satellite imagery are its timeliness, frequency and large continuous spatial extent whereby entire areas are covered at once at regular (and known) time intervals. In addition to these characteristics earth observation may play a particular role in standardizing data collection routines increasing objectivity and transparency of the system.

Space agencies have launched in the past several satellites which provide images of the earth at various time intervals and spatial detail. Space agencies further ensure the availability of satellites and related imagery for the future through comprehensive space programmes. It is expected that both quality and quantity of available imagery will increase significantly. Due to the different satellite characteristics, earth observation may contribute to various components in early warning such as the development of baseline information on land cover, as part of the methodology to generate agricultural statistics, continuous monitoring of weather and vegetation condition, among others.

10. Dissemination – Establishing a platform

The strength of an integrated food security information system would be its capacity to continuously provide national and international decision-makers with adequate, reliable, sustained and meaningful monitoring results focused on changes (magnitude of changes)

and trend analysis. The use of mapping software embedded into a GIS environment (at the lowest administrative level possible) would undoubtedly help decision-making to focus on priorities. Several other information products could be proposed, including monthly bulletins to inform the donors and the humanitarian community, more frequent internal reports, radio or television broadcasts, insertion into local press, fax, internet, etc. Questions related to language, formats and media to be used should be locally resolved.

The main goal of an integrated platform is to create a standardised but decentralised spatial information management environment that would enable individual countries, Regional Economic Communities, the New Partnership on African Development (NEPAD), the African Union Commission (AUC) and other partners to access geo-referenced food security databases and cartographic products from a variety of sources. The potential system includes tools and protocols for creating standards that can be used by various users. This supports and strengthens the appropriate use of spatial information and facilitates the collaborative efforts to increase accessibility to relevant food security and vulnerability information. Using this platform practical applications that allow analysis of food security and monitoring trends providing regular updates to guide humanitarian responses will need to be developed as well as data sharing mechanisms to be put in place. In summary a spatial tool should have the following attributes:

- A 'spatially enabled' database built on 'Object-Oriented Modeling' principles so as to incorporate the notion of geographic feature inherency
- A set of standard feature attribution and classification schemes for the most common geographic layers. This will be developed so as to comply with any pre-existing and authoritative standards in use
- A digital field data collection tool reflecting the database structure and feature classification scheme discussed above
- Guaranteed access to earth observation data, to ensure a continuous data stream to allow for monitoring climatic conditions and its effect on crop and pasture condition and the environment
- An online data archiving and querying interface, and the necessary routines to automatically ingest the acquired data into the system
- A set of training packages for field data collection and data archiving.

Africa is currently heavily dependent on ad hoc early warning and monitoring systems that are run by various international agencies, NGOs and UN agencies. Such systems are often not integrated into national and regional strategies and are not sustainable. There is a need for promoting an African led framework ensuring standardized approaches across countries and regions.

11. Policy framework – AU/EU partnership

Over the last decade, Africa and the EU have developed strategies and policies that enhance their cooperation. The 2007 Lisbon Summit marked a milestone in this cooperation where the African Union and the European Union formulated a strategic partnership. To implement this cooperation the First Action Plan 2008-2010 was adopted in 2007 and reiterated in the 2011-2013 Action Plan (African Union and European Commission, 2011). The Action Plan outlines 8 Areas for strategic partnership. The areas that have been

identified include among others Food Security, Climate Change, and Information Management. Under the Science and Information Management component the Global Monitoring for the Environment and Security (GMES) initiative and Africa Action Plan has been developed. This framework provides an excellent opportunity for partnership between Africa and EU including the private sector in Africa and the EU. To further strengthen the partnership between Africa and EU and in particular in the area of GMES, the Belgian Presidency of the EU Council hosted a High Level Conference "Space for the African Citizen" on the 16th of September, 2010. The main conclusion of the conference was a call for further collaboration between Africa and the EU and in particular calling for enhanced partnership and knowledge sharing between EU agencies and their African counter parts (Belgian Presidency to the EC Council, 2010). It is expected that the support programmes defined within the GMES framework will lead to improved access to earth observation data, improved decision making and strengthened Africa capacity to exploit remote sensing data for regional and continental decision makers (African Union and European Commission, 2011). These initiatives, in close collaboration with the private sector, technical and scientific partners and government agencies, could be build on to further integrate the various mentioned system components to design an integrated system supporting effective decision making on food security.

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15

Three Totally Different Environmental/GDP Curves

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1. Introduction

When one wants to communicate there are rhetorical suggestions that will increase one's chances to succeed in convincing the other part. If an easy, intelligible and ultimately elegant model to explain a phenomenon is presented, the chances to reach deeper into the centre of perception of a recipient will increase, compared to wrapping the same thing in perhaps more exact mathematical formulas. To make a point, one of the more complex explanations I have come across, when it comes to environmental-economic relations, is from Perrings dealing with long term sustainable development and biodiversity. It will probably elucidate what I mean. He says;

If $\#K_j(t+s) < \#K_i(t)$ *and* $f(K_j(t+s)) \succ f(K_i(t))$ *there exists an opportunity set* $K_i'(t)$ *such that* $\#K_j(t+s) = \#K_i'(t)$, *with* $f(K_i(t)) \in K_i'(t)$. *By the axiom of weak independence* $f(K_j(t+s)) \chi K_i'(t) \setminus f(K_i(t)) \succ f(K_i(t)) \chi K_i'(t) \setminus f(K_i(t))$, *and by the axiom of focus,* $f(K_j(t+s)) \chi K_i'(t) \setminus f(K_i(t)) \sim f(K_j(t+s)) \chi K_j(t+s) \setminus f(K_j(t+s))$. *It follows that* $f(K_j(t+s)) \chi K_i'(t) \setminus f(K_i(t)) \sim K_j(t+s)$, *and by transitivity of* $\succ K_j(t+s) \succ f(K_i(t)) \chi K_i'(t) \setminus f(K_i(t))$. *Let* $K_i''(t) = K_i(t) \setminus K_i'(t)$. *If there exists* $K_h(t+s) \sim K_i''(t)$, *then by the axiom of focus* $K_j(t+s) \chi K_h(t+s) \succ f(K_i(t)) \chi K_i'(t) \setminus f(K_i(t)) \chi K_i''(t)$. *Hence,* $K_j(t+s) \chi K_h(t+s) \succ (K_i(t))$. *The proposition states that a sufficient condition for sustainability of a reachable opportunity set that does not offer the same freedom of choice as the current opportunity set is for that set to be augmented by a range of choice of equal size and (present) value to that lost from the current opportunity set.* (Perrings 1989 p 108)

From the context one can understand that he tries to say that natural resources have to increase over time if we shall be able to talk about development in the sense of progress. If they are kept at a constant level we can only reach a stationary state of the economy. The above is a mathematically totally correct picture of the situation. The problem might be to find the correct values for all components of the equation.

Another way is to lessen the factors in the argumentation. But the down-side of minimalism is often that one reduces or hides parameters that could influence the outcome. So there is a trade-off between ease of communication and 'full' understanding. But simplicity is obviously a 'trick' to facilitate the possibility of reaching the opponent's ears. If one can present credible arguments that *a* causes *b* it is much easier than trying to start with the all the considerations of reality. So in all scientific textbooks we can very often find the interaction or relationship between two parameters presented as a graph in a diagram with

two axis. The literature of Sustainable development and Sustainability is no exception (Dearing 2007). Here we can find a lot of environmental curves which the authors use to ease the transferring of 'knowledge'[1]. Coarsely they can be divided into two major clusters. The environmental 'real world' curves and the environmental 'causative' curves. The former are diagrams with 'real' figures and normally with a spatial or temporal x-axis. Examples are the degradation of the ozone layer against latitude and the CO_2 concentration in the atmosphere over time. The second group uses the x-axis trying to find the effect *a* has on *b* and from there a cause to environmental improvement or deterioration.

One of the most well-known and straight-forward of this second group is the so called Environmental Kuznets Curve (EKC). It contains the two parameters Gross Domestic Product (GDP) and environmental 'problems'. The purpose is to explain what will happen to the environment when income in a country changes. With a World Bank report from 1992 that used an Organization for Economic Co-operation and Development (OECD) report from 1991 as its foundation, creative economists has presented the inverted U-curve as the 'liaison' or the explanation to environmental problems and how to solve them – more growth. But with different environmental discourses (Dryzek, 1997) due to different pre-analytic vision there are people who look at this relationship in a different way. The EKC has been challenged by 'environmentalists' who use the concept of limits to growth as the starting point. By using the same parameters and their own arguments and/or findings a more or less exponential curve has been the result. I have chosen the term Environmental Daly Curve (EDC) as a connotation for this graph. But if one reads the World Commission on Environment and Development's report *Our Common Future* (WCED 1987) or as it is also called the Brundtland report from 1987 and exercises the same categories and a little bit of creativity one can generate a contradictory curve compared to Kuznets' curve, a nearly upright U which I will call the Environmental Brundtland Curve (EBC). As I wish to be pedagogic the text is here presented graphically with Gross Domestic Product (GDP) as x-axis and environmental 'problems' as the y-axis.

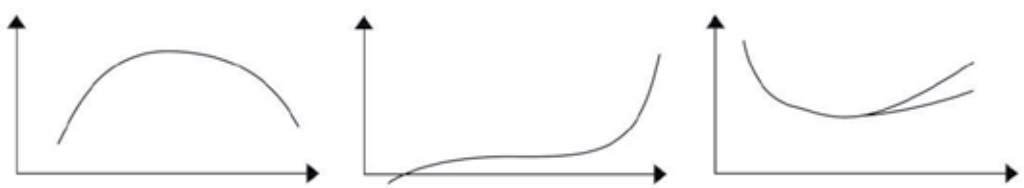

Fig. 1. Three different environmental curves. From left EKC, EDC and EBC

So in the 'value free' scientific world we now have three different curves who all claim they have the 'right' explanation to what economic growth does to the environment in the end – a benign, malign or problematic result on the ecosphere respectively.

Logically it seems impossible that they all can be right. But could they all partly be on the 'true' track? Could it be that they unintentionally use spatial, temporal or political limitations and from these particular findings make (wrongly) general conclusions? The purpose of the study is to see if there is a possibility to reach some sort of reasonable standpoint.

[1] The most famous ones are probably the graphs presented in Meadow's *The limits to growth* created from their computer-based *World3*-model (Meadows et al., 1972).

1.1 Methodology

The theoretical and scientific frame-work for this essay is actor theory and more specific the model of professor Söderbaum (Söderbaum 2008) which says that humans prefer to find answers that are consistent or compatible to their existing worldview or ideological orientation. They more easily accept facts that strengthen their beliefs they already have.

The Environmental Kuznets Curve concept (GDP and environmental 'problems' as the categories) will be the analytic tool. The model originates from the American economists Simon Kuznets who found that economic inequality changes with economic development. With income per capita as the x-axis and inequality as the y-axis, the relation takes the form of an inverted U. First inequality increase with income but after a certain level it is decreasing. Some economists saw the same relation (the inverted U) between environmental stress and income and named it (due to its similar appearance) the *Environmental* Kuznets Curve. So with these two categories (environmental stress and GDP) I will investigate what sort of correlation other scholars have found. From the arguments in the Brundtland report and Ecological Economic literature I will draw an Environmental Brundtland- and an Environmental Daly Curve respectively, and then compare the three of them with empirical findings. This will be supplemented with results from other authors and by using their arguments in a discursive analysis structure. The ambition is to find out what the different curves tells us about sustainability in connection to economic growth

1.2 Definitions

Environmental stress. As the study scrutinizes a lot of literature it could be that a particular author uses the concept in his/her own way, but in my opinion it is understood as nuisances in the ecosphere. In the case of EKCs with GDP as the x-axis I think it is fair to limit the concept to unnatural levels of 'waste' in the ecological system (Radetzki 1992).

Gross Domestic Product. It is meant to be the value of the production of goods and services in a country that is traded on a registered market at the end-user level. The contribution from the public sector is their salaries. As explained below this concept could be calculated in three different ways. They are supposed to come to the same result in monetary terms, but the content is totally different. It must also be mentioned that when written, GDP is understood as per person in a country.

2. Environmental curves

The WCED report put forward a number of what they call 'strategic imperatives' as a guideline for humanity if we wish to enter the path toward sustainable development. One of them is a renewal of continuous economic growth. This is, according to the same report, conditional to our capability to enhance the resource base and reorienting technology for better efficiency without further erosions of planet Earth's ecosystem so that it can continue to be the source of progress upon which development depends. This thread of a connection between the environment's capacity and the wish for economic progress is as old as political economy. Malthus, Ricardo and Mill all, but for different reasons, discussed the problem and saw limitations (Daly 2007; Hermele 1995; Pearce 1993). In the 1960s and 70s, advocates for different world-views or stakeholders tried to articulate arguments to convince the audience that the equation between economic growth and a continuous flow of resources

from the ecosphere is feasible and perhaps even more important, trustworthy. Others struggled to show that it is an impossibility (Andrén 2004; Cherni 200;, Mäler 1993). There are even groups who see a viable economic system with continuous growth as a prerequisite for a 'living' ecosphere or solving the problem (Andrén 2004; Booth 2004; Friman 2002; Stern Internet).

The starting point of the discussion about growth and environmental relations and the following political process was the experiences of development side-effects in the 1960s. One of them was the so called "acid rain" due to the use of fossil fuel with high sulphur content that was used as a source for energy. Economical interests (forests and man-made constructions) were at risk (Porter 2000). So the first step was to increase the height of the chimneys to 'put' the unwanted material higher up in the atmosphere to decrease concentration. But it also meant that neighboring nations, down-wind, had to pay a price (Porter 2000). So now "acid rain" was an international issue and the real background why Sweden (down-wind) pushed so hard for an international environmental conference under the supervision of the UN. Politicians acted due to economical reasons (WCED 1987) and perhaps also the thought that the realization that the new environmental consciousness that emerged during the 1960s could result in votes in the next election. When one looks at the following negotiations between states it is hard to find any coupling between high GDP, environmental awareness and the proponent for reduction of the emissions. During the talks, the United States and the United Kingdom (countries with high GDPs) opposed official pledges of emission cutbacks. And as Porter continues "The protocol came into force in September 1987, but it lacked the adherence of three major exporters of acid rain: the United States, the United Kingdom, and Poland, which together represented more than 30 percent of total world emissions of sulfur dioxide." (Porter 2000) But could they get any support from the scientific world?

2.1 The Environmental Kuznets curve

The Word Bank's annual Development report from 1992 has the subtitle *Development and the Environment*. Here they present their view on the status of the human environment – both the natural surroundings and the living standard. There were 6 graphs. Fig 2 is just one example of the two inverted U's presented. Their findings are mainly based on the OECD report *The State of the Environment* from 1991. Note that the original has absolute numbers on the y-axis and a logarithmic scale as the x-axis.

The empirics presented were used by some economists as an inspiration to explain that GDP at a high level was beneficial not only to better living conditions but more important to the natural environment in general (Brännlund & Kriström, 1998; Dasgupta, 1994, Grossman & Krueger, 1995; Mäler 1993; Panayotou 1993; Vogel, 1999). The main support of this view has come from proponents of the free market as the best solution for an ever increasing standard of living. They argue that a free market will provide increasing economic growth as the mean for higher and higher welfare. Representatives from this group will be found in the larger companies and in the political establishment. They either make more profit or get more room for political reforms by higher GDP. And then it is hard for them to see that their mean (GDP) could be harmful to environment. A collective "label" for these actors is "Business-as-usual". They want the socio-economic foundation to be unchanged. They like it as it is.

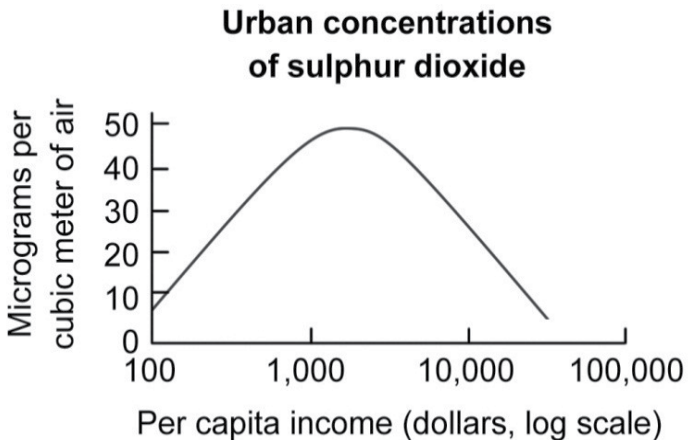

Fig. 2. The World Bank graph. Source: World Bank 1992

The curve became one pro-argument for 'Business-as-usual' to be sufficient, to explain how economic growth is not only compatible to a 'green' future but even could be instrumental to an improvement of the ecosphere, that they are mutual reinforcing. Stakeholders for this group presented a theory or graph that was baptized as the Environmental Kuznets Curve (Fig. 3).

According to this, where the x-axis is the economic activity measured as GDP and the y-axis is environmental stress, measured as unwanted substances in the environment, ecosphere problems presented graphically take the shape of an inverted U, i.e. that it is the mid-income countries who have the most negative impact on the environment (Booth 2004, Daly 2007, Mäler 1993). The father of the concept, Panayotou gives the 'logical' explanation:

"At low levels of development both the quantity and intensity of environmental degradations is limited to the impacts of subsistence economic activity on the resource base and to limited quantities of biodegradable wastes. As economic development accelerates with the intensification of agriculture and other resource extraction and the take off of industrialization, the rates of resource depletion begin to exceed the rates of resource regeneration, and waste generation increases in quantity and toxicity. At higher levels of development, structural change towards information-intensive industries and services coupled with increased environmental awareness, enforcement of environmental regulations and higher environmental expenditures result in leveling off and gradual decline of environmental degradation." (Panayotou 1993 p 1)

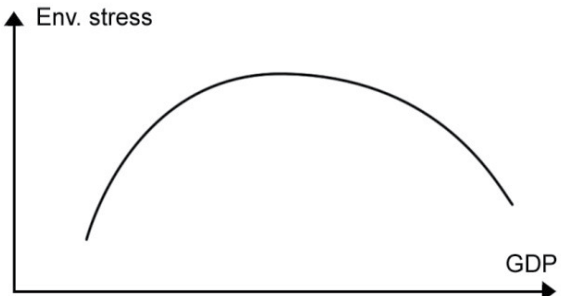

Fig. 3. Environ. Kuznets Curve EKC

But his conclusion about the causes of less impact on the environment is aggregated to or interpreted as, one single cause – economic growth. Two other pioneers, Grossman and Krueger, say in their article quite unconditionally that;

…we found no evidence that economic growth does unavoidable harm to the natural habitat. Instead we found that while increases in GDP may be associated with worsening environmental conditions in very poor countries, air and water quality appear to benefit from economic growth once some critical level of income has been reached. The turning points in these inverted U-shaped relationships vary for different pollutants, but in almost every case they occur at an income of less than $8000 (1985 dollars). For a country with an income of $10,000, the hypothesis that further growth will be associated with deterioration of environmental conditions can be rejected at the 5 percent level of significance for many of our pollution measures. (Grossman and Krueger 1995 pp 370-371)

In contrast to this statement of confidence in their own research I think it is appropriate to present the result from Stern's article. Measured in 1990 US$ value, the theoretical turning point for sulfur was according to Panayotou 3,137$, Shafik 4,379$, Torras 4,641$, Grossman 5-6,000$, Cole 8,232$, Selden 10,500$, Kaufmann 14,730, List 22,675$ and Stern 101,166$. The lower values, except Panayotou, are from cities and from Cole and onwards for countries. (Stern Internet). The only conclusion it is that this is hard to measure in a 'robust' way.

But this coupling between high GDP and less environmental burden, became the accepted theory in most influential economic circles and reported to the political decision makers at least in rich countries. (Andrén 2004, Dasgupta & Mäler 1994, Hermele 1995, Mäler 1993, Porter 2000, SOU 1993:16, SOU 2000:7). And it was a welcome one. In the mid 1970s, the believers in the free market and perpetual economic growth could only accuse the environmentalist for being wrong, as they did not included the unlimited human creativity to solve problems in their equation (Dryzek 1997, Friman 2002). With the Kuznets curve the business-as-usual group had the empiric 'evidence' that they also were the ones who were right – economic growth was the real guardian angel for the environment.

The reasons it was accepted are twofold. First it was 'comfortable' for politicians in the OECD area to get arguments that their primary choice of policy – economic growth, and that a high level of GDP was beneficial to the natural environment. They could continue with Politics-as-usual that was so liked by the constituencies, at least in wealthier parts of the world. Secondly it fit very well into neoclassical political economic theory – diminishing marginal utility and increasing marginal costs, the environment will with richness become a more 'preferred' commodity (Andrén 2004, World Bank 1992).

One of the strongest proponents in Sweden of the overall benefits of economic growth is Professor Radetzki. He will be my representative for the 'Business-as-usual' group and how they present their arguments. Over the last 20 years or so he has published a number of articles and books telling us not to worry about changes in the natural environment. He means that if streets are noisy and even full of unpleasant particles we can built shopping malls with soft music and filtered air. If the seas where we want to swim are polluted we go to man-made swimming pools instead. (Radetzki 1991)[2] When it comes to the Kuznets curve

[2] Translated to English "The technical progress gives increased opportunities to create micro-environments which are better fits to human needs than the natural surrounding, or isolates us from a worsening macro-environment. A somewhat banal example is swimming pools that protect the

his position is quite clear. In his book *Den gröna myten* (*eng.* The Green Myth) he makes a table where he presents the inherent $ value per kilogram for different commodities starting with crude oil and steel with a value of 0.15 and 0.2 US dollar per kilo and ending with a military jet fighter, a soft ware program from Microsoft and a telecommunication satellite with price tags per weight of 6,000, 20,000 and 40,000 in that order. But in first place, being the 'best value for money' is banking services which gets an infinitely sign (∞) for the amount of US$/kg. One starts to wonder why the person being the clerk or provider has only about 800 to 1000 US/kg body weight in annual salary. (What is included in a salary is different for different countries, this is a Swedish example.)

These are the empiric 'evidence' that a high tech production is less resource intensive per unit of GDP and so the more developed the less stress on the environment is the story line. In his own words; "The table is illustrating the falling intensities of basic raw material and environment when societies advance, economically as well as technically." (Radetzki 2001 p 57). He means that with a higher value per kg, less environmental resources are required per $ value.

What he doesn´t elaborate is the amount of fossil fuel the military jet fighter is going to use to be useful and the energy used by all computers using the software and the environmental burden when they are worn out[3]. Or how much emissions that were produced to send the satellite up into orbit?

Finally it would have been valuable to know how much resources the banking clerk needs and how much waste that is generated, for him or her to be able to provide the services, as the services do not come by itself. Anyhow his conclusion is that it works the 'Kuznets' way.

The funny thing about the graph (see Fig. 4 p 288) is that Prof. Radetzki states the World Bank 1992 as the source (Swedish: *Källa*) and that it gives us the outfalls for the years 1960(A) and 2000(B) even though the latter time was 8 years after the World Banks publication and as you can see in Fig 2 p 285, were without any data for year 2000. Furthermore the World Bank graph (see above) uses *absolute* values of *urban* concentrations as the y-axis, whereas Radetzki utilizes the *relative* measure of environmental stress per $ GDP and ends up with a cross *country* data (Swedish: Tvärsnittsdata för länder) [all my italics]. Another peculiar thing that could be read from the chart is that we do not have to worry at all as time seems to heal all problems. As seen in the graph, for all income levels the ecosphere stress will be reduced over time (B is always less than A). But all this argumentation about the salvation of economic growth to the environment, over 70, pages ends abruptly by an explanation that it is only a hypothesis due to technical progress – that in theory it is in principle a possibility. But his own conclusion is;

I underline ' in principle' as in reality the economical growth, even in the richest countries, anyhow so far has requested increasing inputs of, and put pressure on, natural resources and the environment. (Radetzki 2001 p 80)

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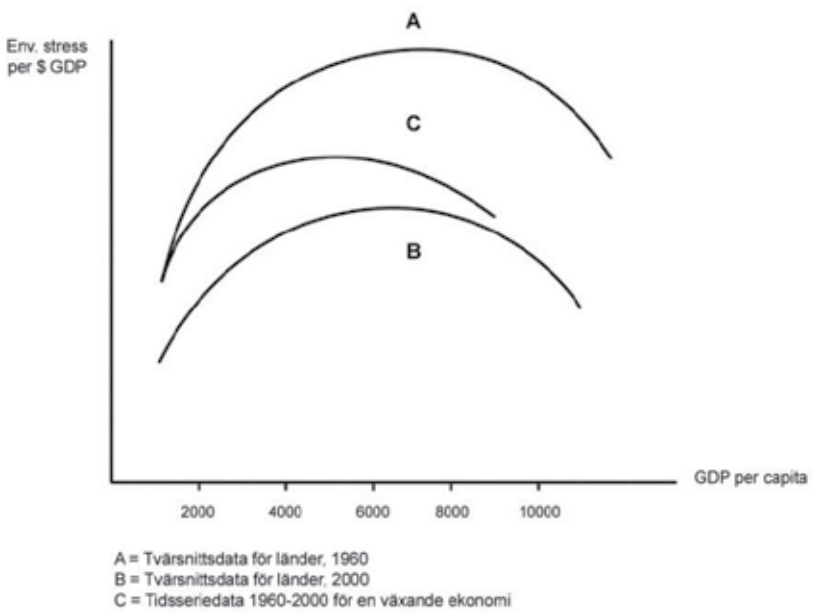
swimmers from jellyfishes, unpleasant variations in temperature and befuddlement of see water. Another is encapsulated shopping malls who give the purchasers the opportunity to avoid rain, noise and exhaust gases from the streets (p 53)

[3] Yet today's highly touted "information technology" hardware is based on the water- and energy-intensive and highly polluting manufacture of silicon chips. Clark (2002:28)

So even though GDP has increased in all OECD countries since 1991, Prof. Radetzki admits that 10 years later (2001) that economic growth is a burden to the natural environment. And he is not the only one when looking at the real world that finds that EKC has very limited support.

It is quite obvious that the debate about the robustness of the EKC-theory is concentrated to the last third part of the graph (where more economic growth is beneficial to the environment). Both environmentalists and Prometheans[4] seem to agree that low conventional GDP is less harmful to the environment. I have not found any statement in the opposite direction presented by these two groups. For the survivalist discourse it is obvious that "an ecosystem can support more human at subsistence level than it can with any greater quality of human life." (Dryzek 1997). The point made by 'Friends of the GDP'-movement was that economic growth after a certain level of GDP will not increase the load on the environment. They have the price mechanism solving the problem (Barnett and Morse 1963, Beckerman 1974, Simon and Kahn 1984, Dryzek 1997.)



Källa: World Bank, 1992.

Fig. 4. The Radetzki graph. Source Radetzki 2001 p 55

A lot of authors have criticized the hypothesis (Andrén 2004, Perman and Stern 2007, Vogel 1999). One of the more odd ones is the above cited Mäler. When alone he is a supporter (Mäler 1993, Mäler 1994) but together with others, being a co-writer (Arrow et al 1995) he becomes definitely more skeptical. The good thing about the Science article by eleven well known scholars is that it summarizes what has been said about the hypothesis by many. The main points are that:

[4] Prometheans is a label for people how see Business-as-usual as the best guaranty for continues welfare.

1. The curve applies to a selected set of local pollutants only, not for the accumulation of waste or long term and more dispersed stress which are often increasing functions of income
2. It has not been uncovered for resource stocks, only for emissions of some pollutants
3. The limited findings cannot be applied to environmental quality in general
4. It doesn´t imply that economic growth is sufficient to improve the environment or that growth effects on environment can be ignored or that the ecosphere is capable of supporting indefinite economic growth
5. It does not say anything about temporal or spatial displacement
6. For the limited cases where emissions have declined with rising incomes it has been due to local institutional reforms, and
7. The solution to environmental degradation lies in such institutional reforms that would compel private users of environmental resources to take account of the social costs of their action. The inverted U-relation is evidence that this has happened in some cases. It does not constitute evidence that it will happen in all cases or that it will happen in time to avert the important and irreversible global consequences of growth.

What has been successful is local initiatives of new laws, the change of production and new strategies to make a state less vulnerable to oil supply (Lindmark 1998, OECD 1991, Porter 2000, SOU 2000:7, World Bank 1992). In the OECD area we could see a lot of environmental laws being put into force in the 1960s and 70s. We had the first 'oil crises' in the beginning of the 1970s so we gave incentives to energy-saving initiatives and new energy technology – the nuclear plant (Mäler 1993). The OECD countries' main concern was not the environment, we wanted sustained economic growth. And that was solved by *political* restrictions on the GDP-creating 'bad' production. Active environmental politics is the major cause to environmental improvements, not GDP *per se*. Even the World Bank, who is the theoretical father of the concept, writes.

In some cases environmental quality improves as income rises. /…/ Some problems are observed to get worse as the income rise. But this is because no incentives yet exist to change behavior. /…/ When societies have decided to enforce a change – through regulations, charges, or other means – environmental quality has improved. /…/ Past patterns of environmental degradation are not inevitable. Individual countries can choose policies that lead to much better (or worse) environmental conditions than those in other countries at <u>*similar*</u> *[my underlining] income level /…/ The adoption of environmental policies and the investments and the technological innovations by such policies imply that the environmental mistakes of the past do not have to be repeated.* (World Bank 1992 pp 39-41)

But without the backing of appropriate policies, even the most environmentally helpful technologies and practices will not necessarily be applied, unless they are more productive than existing methods. /…/ Rising incomes and technological advances make sustainable development possible, but they do not guarantee it./…/ Effective environmental policies and institutions are essential. (World Bank 1992 pp 42-43)

So the presenter of the 'facts', the World Bank, conclude that it is policies, not the GDP that make the difference. The conclusion of the World Bank is supported by background material from the OECD, which it is worthwhile to quote at length as it shows how business-as-usual economists 'twist' information from the report. It is quite obvious also that the OECD means that there is political action behind the improvements.

Over the last two decades, control strategies and technologies have been developed in OECD countries for reducing the emissions and concentrations of traditional air pollutants (SO_2, NOx, CO, PM, VOC, O_3). They include: Restriction i.e. use of highly polluting fuels and limits on the sulphur, lead and benzene contents of fuels; - Flue gas treatment after combustion stationary sources, especially from power plants as well as certain large industries, emission controls on motor vehicles. Such control strategies and technical progress have been combined to substantially reduce air pollutant emissions in many countries, against a backdrop of growth and structural change in economies and energy demands. /…/ In spite of the above successes, urban pollution continues to be a problem because: VOC and NOx emissions have generally increased compared with the early 1970s; Ambient air quality standards and guidelines by the WHO for NO_2 and O_3 are still exceeded in many OECD countries; - The air quality in some cities and densely populated regions, especially in the south of Europe, is still deteriorating. The main reasons are that pollution control regulations are not strong enough, or not vigorously enough enforced, and that energy and transport policies do not emphasize energy savings and substitutions capable of offsetting the effects of economic growth. Further, large-scale and international air pollution over the past two decades, air quality has become a concern at rural and remote sites in long-range transport of air pollutants; These increased levels of large-scale air pollution have exerted greater stress on forests and other natural ecosystems, soil, inland waters and crops. Lastly, newly emerging problems also add to the challenges of providing for cleaner air: More and more toxic pollutants (e.g. cadmium, benzene, radon, asbestos) are being released into the atmosphere. – Available evidence shows that indoor air may be of considerably lower quality in many instances than outdoor air, and that people may be exposed to much higher levels of traditional and toxic trace air pollutants than was originally believed, since they spend about 90 per cent of their time in buildings or vehicles. (OECD 1991:49)

So by discriminatory reading innovative economists create the Environmental Kuznets Curve with GDP as the x-axis and use the World Bank and OECD reports as their sources. But this view that a more active environmental policy approach would be beneficial is partly confirmed by UNEP. But they go a little bit further; they talk about a social paradigm shift

Means must be found to tackle the root causes of environmental problems, many of which are unaffected by strictly environmental policies. Resource consumption, for example, is a key driver of environmental degradation. Policy measures to attack this issue must reduce population growth, reorient consumption patterns, increase resource use efficiency and make structural changes to the economy. Ideally, such measures must simultaneously maintain the living standards of the wealthy upgrade the living standards of the disadvantaged, and increase sustainability This will require a shift in values away from material consumption. Without such a shift, environmental policies can effect only marginal improvements. (UNEP 1999:xxix)

Resource consumption is another word for GDP as the production must be bought to be a part of GDP. Other (sarcastic) ways to solve the problem are changed technology (other raw materials and/or procedures without known future consequences today), displacement (reallocate the production plant to less rigorous countries) and the temporal solution, hoping that it will take time before the law makers interfere (It has taken politicians more than 100 years to start to react to warnings about increased CO_2 levels[5]). Or as Arrows puts it;

Where the environmental costs of economic activity are born by the poor, by future generations or by other countries, the incentives to correct the problem are likely to be weak. (Arrow et al 1995 p 520)

[5] NASA (Internet)

But one of the most cynical is the one from Nobel laureate Beckerman who in a very arrogant way put forward a recommendation for the ones who are suffering from environmental stress and less development;

… if you want a better environment in general and, in particular, reasonable access to clean drinking water, adequate sanitation and an acceptable urban air quality, you have to become rich. (Beckerman 1995 p 25-6)

Just to sum up the Kuznets controversy I would like to put forward one peculiar statement used in an official survey to give the reader an insight to the different quality of arguments used in the debate. This is what the Swedish Parliament's official survey has to say:

Different studies indicate that a higher income or GDP level can create the conditions for a better environmental quality. However, factors other than income or GDP level as such are important in explaining the turning point. In the Scandinavian countries, for example, the point in time seems to coincide with the turning point rather than the GDP level. (SOU 2000:7 p 128)

2.2 The environmental Brundtland curve

After coming across the concept of EKC and after reading the WCED-report it was a little bit surprising, when making some sort of summary of the arguments there. For the relationship between GDP and environmental stress when drawing a curve using the same analytic frame as for EKC, the graph became close to an upright U. This is just the opposite of the World Bank's Kuznets curve. In the Brundtland report there is very little empiric material and no curve drawn. One has to draw conclusions from the text. But the story line in the WCED-report is quite clear. The poor destroy their environment and the rich theirs (Dryzek 1997)

The most straight forward citation is that "poverty is a major cause for environmental problems" (WCED 1987 p 364). Their activities (deforestation, overuse of marginal land leading to desertification and urbanization) are so intense and so far reaching that it is 'a major global plague' (WCED 1987 p 28) according to Brundtland. The view seems to be that as they are poor they have to prioritize activities that satisfy their most basic needs at the price of environmental quality. And they are many so the total impact is immense. Brundtland stresses 'that the links between poverty, inequality and environmental degradation formed a major theme in the analysis and recommendations' (WCED 1987:xii)

When it comes to the high income part of the World the report is not so categorical but that could be for tactical reasons. In a politically correct way the report is mostly vague and uses words like *sometimes* and *may* when it describe the link between growth – environment and they use the phrase "those not in poverty" instead of "rich" (WCED 1987 p 8 & 55). A typical sentence is

Thus today's environmental challenges arise both from the lack of development and from the <u>unintended</u> consequences of <u>some</u> forms of economic growth. (WCED 1987 p 29, my under linings)

But it is quite clear that the commission also sees a link between production and environmental impacts. But then again they do not say who owns the facilities. But for the purpose of this study it is a question of the link between GDP and environmental degradation and by definition it is the production that creates the GDP. The two 'empiric' paragraphs that show that WCED also see production as an agent for green problems will be:

Industrial production has grown more than fiftyfold over the past century, four-fifths of this growth since 1950. Such figures reflect and presage profound impacts upon the biosphere /.../ Much of the economic growth pulls raw material from forests, soils, seas, and waterways. /.../ We have in the past been concerned about the impacts of economic growth upon the environment. We are now forced to concern ourselves with the impacts of ecological stress – degradation of soils, water regimes, atmosphere, and forests – upon our economic prospects. (WCED pp 4-5)

In some parts of the world, particularly since the mid-1950s, growth and development have vastly improved living standards and the quality of life. Many of the products and technologies that have gone into this improvement are raw material- and energy-intensive and entail a substantial amount of pollution. The consequent impact on the environment is greater than ever before in human history. /…/ Into every year we now squeeze the decades of industrial growth – and environmental disruption Greater attention to resource efficiency can moderate the increase, but, on balance, environmental problems linked to resource use will intensify in global terms. (WCED pp 31-32)

And from the report one can quite easily indentify the major investors (owners of the production). As an example the report says:

- *In 1983 chemicals accounted for roughly one-fourth of the stock of foreign direct investment in manufacturing in developing countries by companies from four leading countries – Japan (23 per cent) the United States (23 per cent) the United Kingdom (27 per cent) and the Federal Republic of Germany (14 per cent)*
- *Agriculture, mining and other extractive industries accounted for 38 per cent of the stock of US investment in developing countries in 1983, 29 per cent of the stock of Japanese investment in 1983, 21 per cent of the total FRG investment in 1981 – 83 and 9 per cent of the stock of UK Investment in 1978*
- *Eighty to ninety per cent of the trade in tea coffee cocoa cotton forest products, tobacco, jute, copper, iron ore, and bauxite is controlled in the case of each commodity by the three to six largest Transnationals.* (WCED p 85)

There is also indirect "proofs" that WCED sees conventional economic growth as a stress on the environment. They see the necessity to change in the content or the quality of economic growth but at the same time see a renewal.

The world must quickly design strategies that will allow nations to move from their present, often destructive, processes of growth and development onto sustainable development paths. Critical objectives for environment and development policies that follow from the concept of sustainable development include

- *reviving growth*
- *changing the quality of growth*
- *conserving and enhancing the resource base,*
- *merging environment and economics in decision making* (WCED p 49)

Sustainable development involves more than growth. It requires a change in the content of growth, to make it less material- and energy-intensive and more equitable in its impact. These changes are required in all countries as part of a package of measures to maintain the stock of ecological capital, /…/ The process of economic development must be more soundly based upon the realities of the stock of capital that sustains it. This is rarely done in either developed or developing countries. (WCED p 52)

Whereas the World Bank and Kuznets advocates are clear that an increase in GDP in low income countries will result in a significant boost in negative environmental impacts the

policy recommendation from Brundtland (WCED 1987) is just where the economic growth must happen if we are going to have a sustainable development. And this is also surprising as Brundtland wants the World Bank to take an active role in the creation of a renewal of economic growth in low income countries

As Environmental Brundtland Curve is my invention, one cannot find any articles about the subject that either support or reject the hypothesis. But there are reports in line with the idea. UN Environmental Programme (UNEP) writes;

The continued poverty of the majority of the planet's inhabitants and the excessive consumption by the minority are the two major causes of environmental degradation. The present course is unsustainable and postponing action is no longer an option. (UNEP 1999)

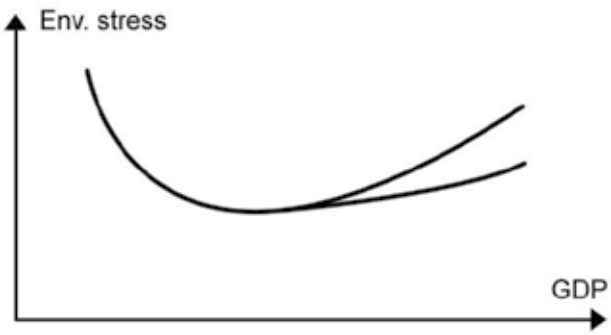


Fig. 5. Environ. Brundtland Curve (EBC)

WCED means that there are signs that the rich have made some improvements from a quite high level of environmental impact. WCED means that technological improvements have made production cleaner and consumption waste less harmful. So there is hope and it is called eco-modernization. The believers in this concept mean that ingenious inventers will solve technical problems as they occur and politicians will change unsuitable institutions when societal development so requires. Environmental taxes are one example. That hope is drawn as the split in the graph. Depending on how creative people with power will be, the curve will turn different ways.

In the Environmental Sustainability Index (ESI) report from Yale University there are also only two parties involved when it comes to environmental stress – the poor and the 'rich'. The rich are causing a negative impact due to pollution pressures of industrialization. What the poor are doing is not specified, just that poverty creates stress (ESI 2005). There is also some support, also without being very precise, in a few other UN documents.

Poverty and environmental degradation are closely interrelated. While poverty results in certain kinds of environmental stress, the major cause of the continued deterioration of the global environment is the unsustainable pattern of consumption and production, particularly in industrialized countries, which is a matter of grave concern, aggravating poverty and imbalances. (Agenda 21 § 4.3)

The General Assembly, … Concerned about the environmental impact of the irrational and wasteful exploitation and consumption of natural resources, particularly those of developing countries, and

about the fact that such exploitation and consumption represents a threat to these countries in their exercise of their permanent sovereignty over their natural resources. (Resolution 3326 (XXIX) Report of the Governing Council of the UNEP 16 Dec 1974)

In the last paragraph it is perhaps more a case of developed nations that exploit the developing country that is the cause, rather than the low income country itself.

The only statements one has to judge their standpoints are to be found in WCED's and UNEP's reports where it is in both cases mentioned that poverty causes deforestation and desertification. There is no empirical 'evidence' presented, just a description of the way they see the reality in the country-side of poor countries. In the case of WCED their own arguments have been scrutinized in an earlier article (Bratt 2009) and been found inconsistent.

As I have stated above (in the EKC section) there is no support among Environmentalists or Prometheans for the view that the poor are a major cause of environmental degradation. In WCED's own enumeration they see climate change, ozone depletion, 'toxic' production, hazardous waste, deforestation, desertification, acidification, loss of biodiversity, drinkable water deficiency, ground water depletion, environmentally unsound energy production, the possibility of nuclear war and the mismanagement of the commons as our main ecological problems. Out of all this the low income actors have a part in deforestation and desertification according to WCED. This deforestation is not what other authors conclude. Humphreys is one of them. He is using a UN document as his source when making his table (see Table 1 p 295) (Humphreys 2006).

There are, as seen, a lot of causes so it is hard to say that the poor are causing deforestation. Consider also that illegal logging is not included. Consider also that the developed world has been clearing land for the last 2-3 millenniums for agricultural reasons. Today a few of us replant a monoculture domestically but uses Third World tropical and Monsoon forest to cover our 'needs'. Where is the morality? Consider also that deforestation is a cause of desertification.

But one can also add that the influential background paper produced by Shafik and Bandyopadhyay (1992) used in the World Bank report that became the very foundation for the concept of a Environmental Kuznets Curve, found that among the 10 indicators tested two were about deforestation and "Both deforestation regressions showed no relation between income and deforestation" (Stern Internet).

One can also argue that first of all, the poor pay their price for what is degraded, they internalize their part, but do developed countries do that? Secondly a part of the poor's deforestation is due to survival, but why do we take their trees – at least it is not a survival question for us.

When it comes to desertification a thorough research made by Lambin based on 132 carefully selected case studies came to the conclusion that 'A recurrent and robust broad factor combination implies the interplay of climatic factors leading to reduced rainfall, agricultural growth policies, newly introduced land-use technologies, and malfunctional land tenure arrangements' (Lambin et al 2006 p 340) is the main cause. The category 'poor people' is not mentioned in the paper as a driving factor.

But WCED has a point if it means that due to the poor's weak negotiation position they have to accept the dominant global economic order and see their land being exploited in an

environmentally unfriendly way. If that is what they mean, who shall then be accountable for the harmful emissions and devastating production patterns in a GDP/Environment-diagram? And when we displace our production due to more favourable conditions, both monetarily and a more or less non-existing environmental legislation who is then the moral polluter? I hope Brundtland understands that in this analytical framework I do not consider that the ecosphere degradation is caused by the poor. They might be the agent 'employed' by us.

Underlaying causes								
Direct causes	1	2	3	4	5	6	7	8
Replacement								
By commercial plantations	X					X	X	
Planned agricultural expansion	X	X				X	X	
Pasture expansion	X	X				X		
Spontaneous colonization		X	X	X		X	X	X
New infrastructure						X		
Shifting agriculture			X	X				X
Modification:								
Timber harvesting damage	X		X		X		X	
Overgrazing			X		X			
Overcutting for fuel			X		X			
Excessive burning				X	X			
Pests or diseases					X			
Industrial pollution					X		X	

The column headings for underlying causes are:

1. Economic and market distortions
2. Policy distortions, particularly inducements for unsustainable exploitation and land speculation
3. Insecurity of tenure or lack of clear property rights
4. Lack of livelihood opportunities
5. Government failures or deficiencies in intervention or enforcement
6. Infrastructural, industrial or communications developments
7. New technologies
8. Population pressures causing land hunger

Table 1. Diagnostic framework: Relationships between selected direct and underlying causes of deforestation and forest degradation

2.3 The environmental Daly curve

But there is also a third group, the environmentalists, who have contested the idea of an environmental Kuznets curve. In their world view there are ultimate ecological limits to economic growth (Bratt 2006). For this group there is a positive correlation between growth and ecological degradation and if a curve is drawn it will probably be more geometric than arithmetic. In his book *Ecological economics* Daly (Daly 2004) presents the optimal scale

diagram (Fig. 6) that includes the "Marginal disutility curve" (MDU) as the lower curve which in his words shall 'reflect the increasing marginal costs of growth, as more natural capital is transformed into manmade capital' (Daly 2004 p 21). For the sake of conformity this is the curve I have baptized as the Environmental Daly Curve.

Daly says himself that he was inspired by Stanley Jevons marginal thinking about work and wages and transferred it to cost and benefits with economic growth versus the environment by using the neoclassical idea of diminishing benefits and increasing costs of consumption and production respectively (Daly 2004). Personally I prefer to date the creation of the thought of confines to monetary progress to The Club of Rome's publication of their contribution to a discussion, *The limits to growth* by Meadows et al. 1972 By this book the social paradigm of Neomalthusianism's were introduced to a wider audience. Here the modern (computer-based) theoretical foundation of a new thinking about the relationship between economic growth and Nature's capability to support it was shaped – that there are ecological restrictions to economical development. I write theoretical as it was a computer created model of explanation to what *could* happen if humanity continued its pecuniary valuating development track at an even higher speed. As it was a prediction about the future there were no empirical facts (it was based on historical facts). This volume was followed by a series of 'green' change-direction books, like *A blueprint for survival* (1972), *Global 2000 Report to the President* (1980) just to mention a few. But it was Daly who drew the line or graph – the marginal disutility curve.

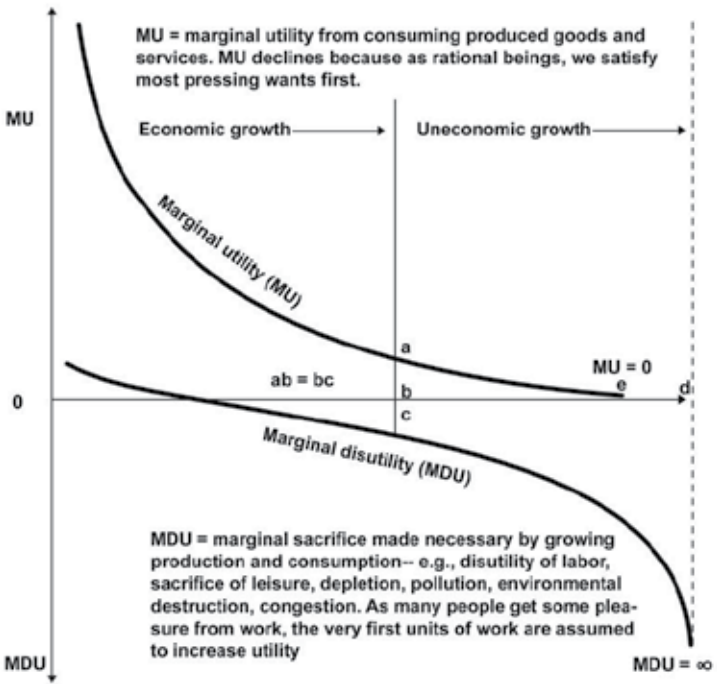


Fig. 6. The optimal scale diagram. Source: Daly 2004 p 20

A fundamental rule in neoclassical microeconomics is that an optimal level is reached when marginal costs are equal to marginal benefits. This is the most optimal scale of micro-

economic activity (Mankiw 2008). That is *ab* = *bc* in fig 6. In macroeconomics such rules do not apply as there is no opportunity costs of growth as macroeconomics deal with what the neoclassical economists consider to be the whole – the economic system. But keep in mind it is the Marginal *disutility* curve that is comparable to the other Environmental curves so we should not be looking at the optimum point but what will happen if we go too far out to the right. The costs of increased economic activity became higher than the benefits. At the end of the day point *d* in the figure 'where an ecological catastrophe is provoked, driving MDU to infinity' (Daly 2004 p 21). And remember, in Daly's case he has drawn the value of disutility downwards. If we cleanse his graph and use the same frame-work as Kuznets' it will look like figure 7. Supporters of this correlation between GDP and environmental stress are actors with the world-view of eco-system limits, that Nature has laws that humans have to obey. Devotees are to be found in the "green" movement and among criticizers of neo-classical economic theory.

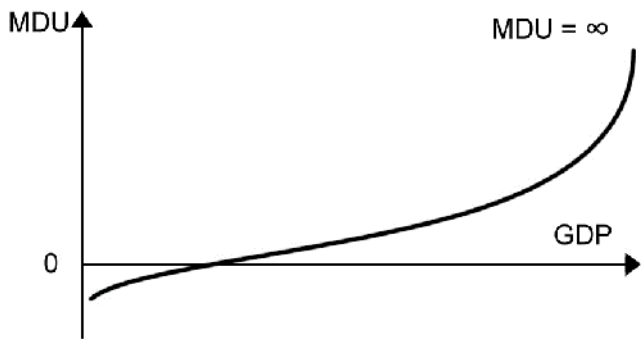


Fig. 7. Environ. Daly Curve (EDC)

Daly means as long as the economical system is a part of the whole Earthly system that the model is valid. For ecological economists the economic system is a subsystem to the ecosphere. They have another world view (Bratt 2006). But then again as long as this subsystem was minor in relation to the ecological system, as in old days, still we didn't have to worry about marginal costs. As Daly puts it "In this 'empty-world vision', the environment is not scarce and the opportunity costs to expansion of the economy is insignificant" (Daly 2004 p 17) There was always another place to go to – to seek subsistence like the Europeans did in the mid 19th century when they left starvation for the 'promised' land in the West which was Arcadian except for a 'few' indigenous Indians. Today the World is 'full'. We don't have other places to go to. There is no empty space; there are no 'rooms to let' (see fig. 8). When resources are diminishing we have to take the consequences. Today there are opportunity costs when exceeding the sustainable level of consumption. In addition to welfare (which to a greater extent goes to the 'North'), the economical system creates ecological and social burdens on society, who in turn, due to the high material welfare, creates an overburden of waste with subsequent environmental problems in the 'full world'.

But Daly is not alone looking at the world in this way. There is support to be found in 'official' reports for an environmental Daly curve.

But the same processes that have produced these gains have given rise to trends that the planet and its people cannot long bear. /.../There are environmental trends that threaten to radically alter the planet, that threaten the lives of many species upon it, including the human species. (WCED 1987 p 2)

Certain environmental problems seem to have a clear-cut, positive relationship with GDP per capita. This is due to the continuing high cost of reducing pollution and the fact that the impact of the pollution is not yet especially obvious (SOU 2000;7)

Resource consumption, for example, is a key driver of environmental degradation. /…/ A tenfold reduction in resource consumption in the industrialized countries is a necessary long-term target if adequate resources are to be released for the needs of developing countries. /…/ The modern industrial economies of North America, Europe and parts of East Asia consume immense quantities of energy and raw materials, and produce high volumes of wastes and polluting emissions. The magnitude of this economic activity is causing environmental damage on a global scale (notably climate change) and widespread pollution and disruption of ecosystems, often in countries far removed from the site of consumption. (UNEP 1999)

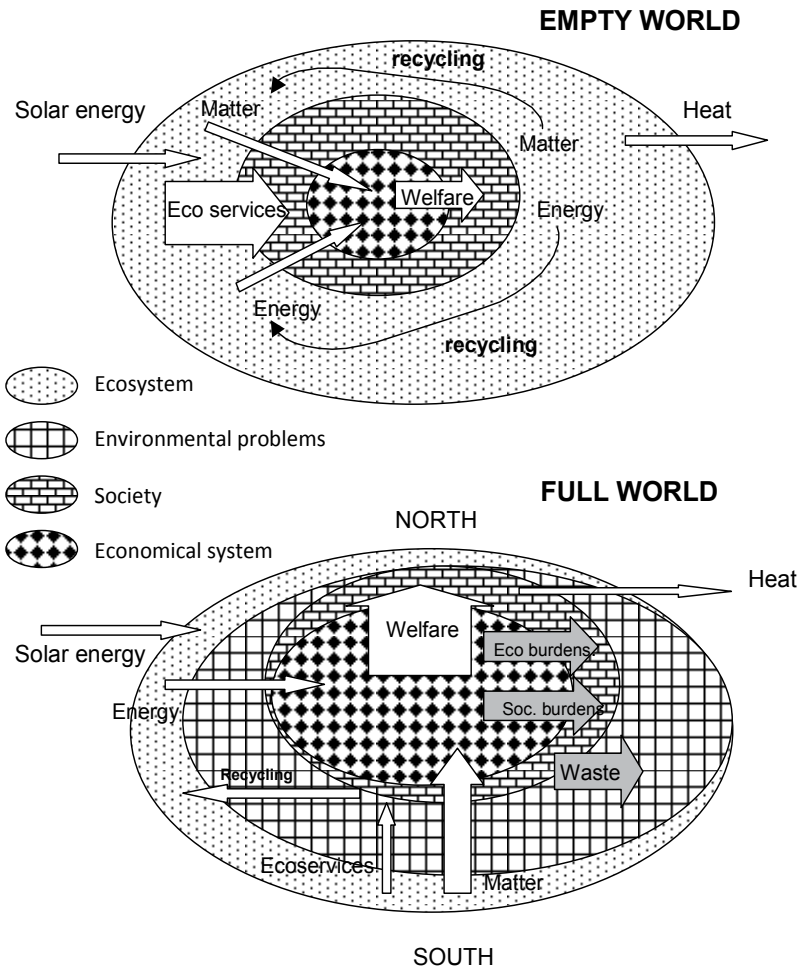


Fig. 8. Daly's worlds. Source: Bratt (2006)

According to UNDP's 1998 Human Development Report, the 20 percent of the world's people in the highest-income countries account for 86 percent of total private consumption expenditures – the poorest 20 percent for a minuscule 1.3 percent. (Porter 2000)

3. Empiric

As the major environmental problems as defined by WCED are global to their character my empiric findings will include the whole planet. Let's first look at the development of the Gross World Product. There is a more or less steady increase during the last three decades, a period when for most people environmental problems became a reality.

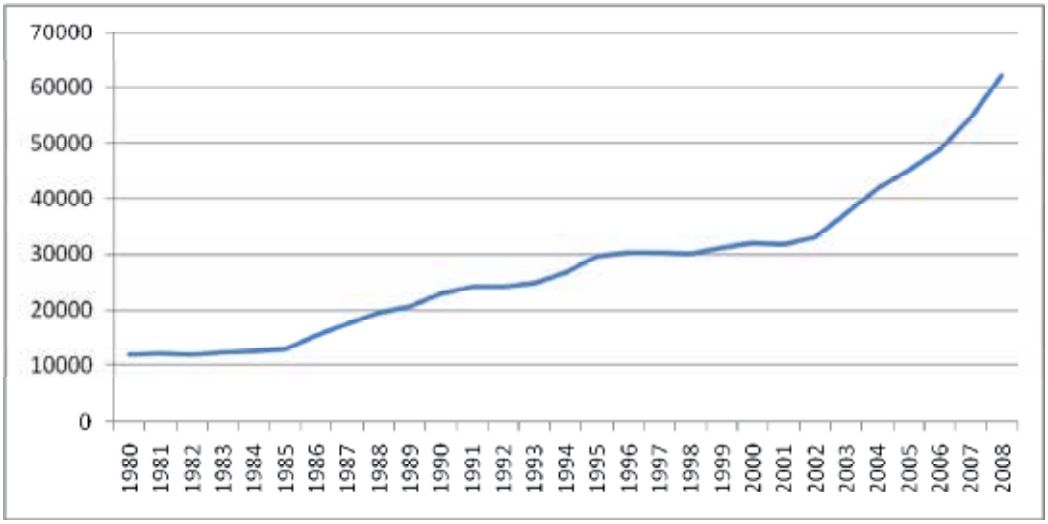


Fig. 9. The Gross Global Production (GGP) in billion US$ and current prices 2008. Source: IMF 2008

As this is total figures and with around 6 billion inhabitants and that Grossman's 10,000US$ were at 1985 prices, we have not reached his estimate for the turning point towards improvements of environmental conditions at a global level, but certainly for a lot of individual countries in the so called developed part of the World, it has happened. But still no nation can be used as a model for how to be in balance with the ecosphere. One of the key ideas in the WCED-report is change and that we have to change now (WCED 1987), that the coming decades will be crucial if we are going to succeed in our crusade against environmental degradation that will be a threat to the Creation's very survival on this Earth.

Over the course of this century, the relationship between the human world and the planet that sustains it has undergone a profound change. /…/ When the century began, neither human numbers nor technology had the power radically to alter planetary systems. As the century closes, not only do vastly increased human numbers and their activities have that power, but major, unintended changes are occurring in the atmosphere, in soils, in waters, among plants and animals and in the relationships among all of these. /…/ The next few decades are crucial. The time has come to break out of old patterns. Attempts to maintain social and ecological stability through old approaches to development and environmental protection will increase instability. /…/ We are unanimous in our conviction that the security, well-being, and very survival of the planet depend on such changes, now. (WCED 1987 p 22)

Below I will present some of the more well known environmental threats that we face. To start with CO_2 that is a major contributor to climate change fig. 10 shows that a "normal" level seems to be around 180 to 280 ppm. The right side is about 2000 years ago and the left side roughly 400.000 years ago. The top peaks are warm periods and the lower occur during ice-times. During the period that we use to call the industrial era we have managed to increase the level by using fossil fuel to nearly 400 ppm (see below, fig 15 p 303) with most likely dramatic changes in the climate. But for the sake of this paper let's compare the emitter or country with their GDP respectively to see how income contributes to the pollution or causes environmental stress. Fig. 11 shows the increase of emissions along with increased GDP. Long-term sustainable levels (by 2100) are 0,2 – 0,7 ton CO_2/capita and year for a 400 ppm and 550 ppm target respectively (Azar 2002 p 20). The chart is made up by data from 148 countries and it is only 39 who manage the lower 'limit' and 35 more if you accept the upper of 0,7 ton. I think it is fair to say that high GDP countries have an 'overproduction' of CO_2 emissions and that there is no Kuznets-correlation.

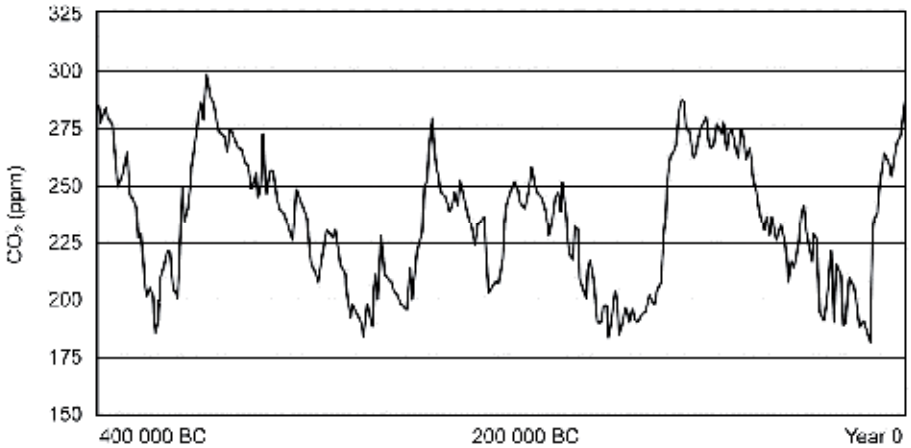


Fig. 10. CO_2 concentration (ppm) during last 400.000 years**.** Source: Petit et al (1999)

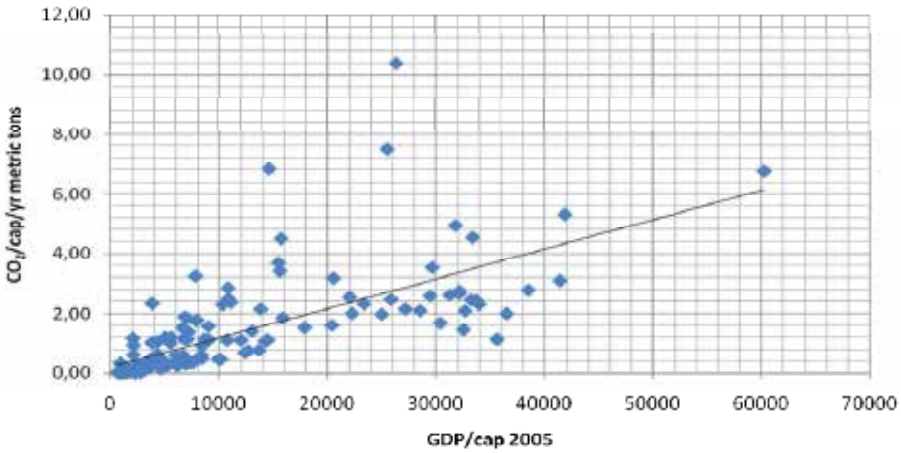


Fig. 11. Correlation between CO_2 emissions/capita and GDP. Source: own chart with data from Explore our planet for CO_2-data and UNEP 2008 for GDP numbers

When it comes to Ozone depletion one can make a curve Kuznets-like if using a spatial parameter (see Fig 12). 'Rich' countries are overrepresented in the tempered zone around the 50th latitude with higher depletion than the low GDP's closer to the equator and where there is very little GDP creation – at the two poles – we have the highest problem and more or less no GDP. So no correlation between ozone depletion and GDP. But the origins of the causative agents were from high consuming countries. But even locking at a temporal x-axis and global values the Dobson Unit-value (an indirect measurement for the amount of ozone) is decreasing despite growing gross global product (GGP). If using the Kuznets analytic frame the curve will actually take the shape of the convex part of the letter D. But then again as NOAA says "All other things being equal, and with adherence to the international agreements, the ozone layer is expected to recover over the next 50 years or so" (NOAA Internet). One can ask if it is due to political agreements or GDPs. Porter says at least that "The ozone-protection regime is considered the most effective of all global environmental regimes to date." (Porter 2000;15)

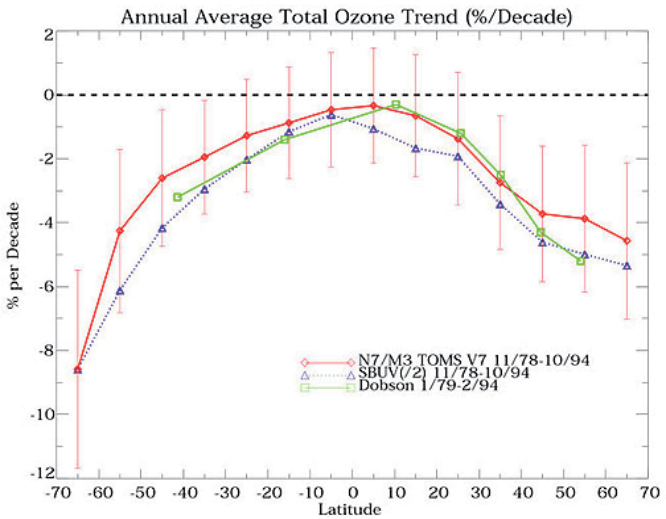


Fig. 12 The Ozone depletion Kuznets curve. Source: CCPO

Another great concern for the WCED was the rate at which species were extinct. WWF has created the Living planet index (see fig 13 p 302) as a measurement for biodiversity. If one wants to be ironic it could also be called the Biodiversity Kuznets curve as it is an inverted U. But in this case it does not mean improvement. The index does not recover with increased GGP, because the temporal scale could also be translated into a GGP. As seen in fig. 9 we have had an increase from 1980 and onwards. A proponent of beneficial economic growth could argue that we haven´t reached the turning point. But then again, before the turning point we should expect a leveling off trend. And that can´t be seen. In the 1970s GGP were 2500 US$, in the 80s 4000 US$ and in the 90s 6000 US$/cap in current prices (2008). So the global biodiversity seems to peak or having its negative turning point around 3-3500 US$/cap. This is in line with the ever increasing demand from us humans on nature to satisfy our needs/wants at the expense of other species. Vitousek estimates that humans now consume something like 40% of Nature's net production and every day the space and resources for other, non-human orders, declines (Wackernagel 1996).

This global trend suggests that we are degrading natural ecosystems at a rate unprecedented in human history. /…/ The recent downturn in the global economy is a stark reminder of the consequences of living beyond our means. But the possibility of financial recession pales in comparison to the looming ecological credit crunch. (WWF 2008 p 1)

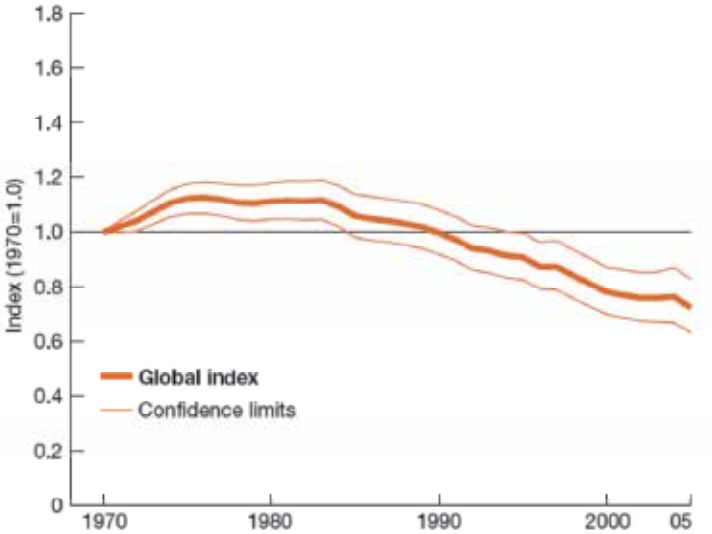


Fig. 13. Global Living Planet Index 1970 – 2005. Source: WWF 2008

In the World Bank report sulphur dioxide (SO_2) was one of the two substances that were empirically tested. The other one was N_2O. When measuring cities there seems to be a drop in SO_2 concentrations but as stated earlier it is due to political will combined with economic reasons. Industries moved out of cities, we built nuclear plants, we taxed sulphur containing oil etc. But looking at larger geographic entities the inverted U-shaped curve is hard to detect (fig 14). Concentration is correlated to emission in a limited atmosphere). An optimist might

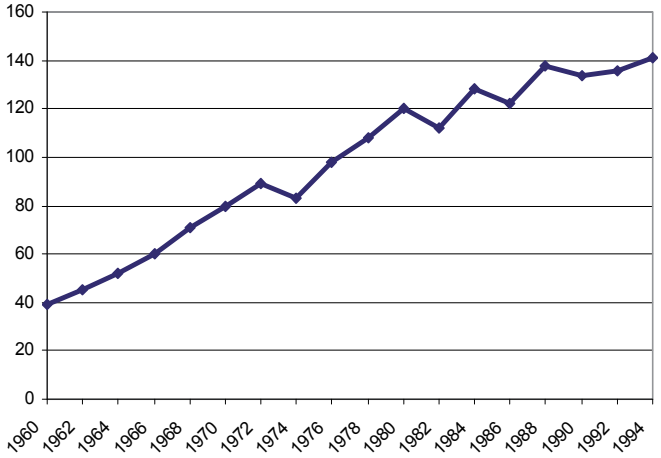


Fig. 14. World SO_2 emission (million metric tons) Source: Downing et al 1997

say that one can see a level off (the beginning of a decline) from the end of the 80s but it could also be explained by the fact that world economic growth also took a break during that period.

The same goes for N_2O, one of the unwanted gases in the atmosphere. Then the proponents of EKC chose to measure *emissions* (not concentration) from *cities* to find the downward slope. It is easy as many producers of N_2O went rural. But again, as this is a gas, it is mixed in the atmosphere quite evenly distributed after what it is produced. N_2O pre-industrial levels were around 260 to 280 ppb. Again one can see a steady increase which is not surprising as the emissions from combustion processes and the use of fertilizers – activities belonging to the industrial era.

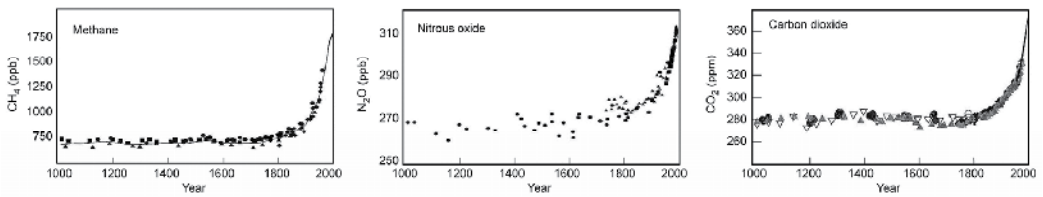


Fig. 15. Global atmospheric concentration of three well-mixed greenhouse gases. Source: Mantua (2007) p 283

When it comes to environmental agreements a great number of states have ratified 14 major global environmental treaties[6] within a timeframe of about 30 years without any correlation to GDP. Poor countries as well as rich countries sign independently of their GDP. As we have around 200 independent nations it is fair to say that a large part of the international community is affected by them. And it is not so that rich countries are first in line to sign. The ones that do not sign seem to have economic reasons not to and this is mostly the rich countries. The Kyoto protocol is perhaps the most notable. (Porter 2000)

As a sum up I will apply the widely well known ecological footprint concept in the EKC analytic framework (fig 16 p 304). As Wackernagel (the founder of the model) says "The Ecological Footprint concept is simple, yet potentially comprehensive: it accounts for the flows of energy and matter to and from any defined economy and converts these into the corresponding land/water area required from nature to support these flows." (Wackernagel 1996:3) That area is a little bit more than 2 ha/cap on a global scale. We have then excluded the needs that all non-human species may have. The conclusion from this chart is that the turning point for an ecological sustainability measured as GDP seems to be around 8000 US$/cap. But in reality less as there are non-human biotic orders on Earth. It is drawn from 143 countries' value of Ecological Footprint.

One explanation of the failure to improve the environment could be what Stern put forward when he says that there is a risk due to the global nature of the externality gives as a result

[6] Like Basel, Cartagena, CBD, CITES, CMS, Kyoto, Montreal, Stockholm, UNCCD, UNCLOS, UNFCCC & World Heritage. Source GEO 4 (2007 p. 9)

that individuals find very little incentives to act (Stern 2007). It is a similar approach that Harding (Harding 1968) presents in his widely cited article *The tragedy of the commons.*

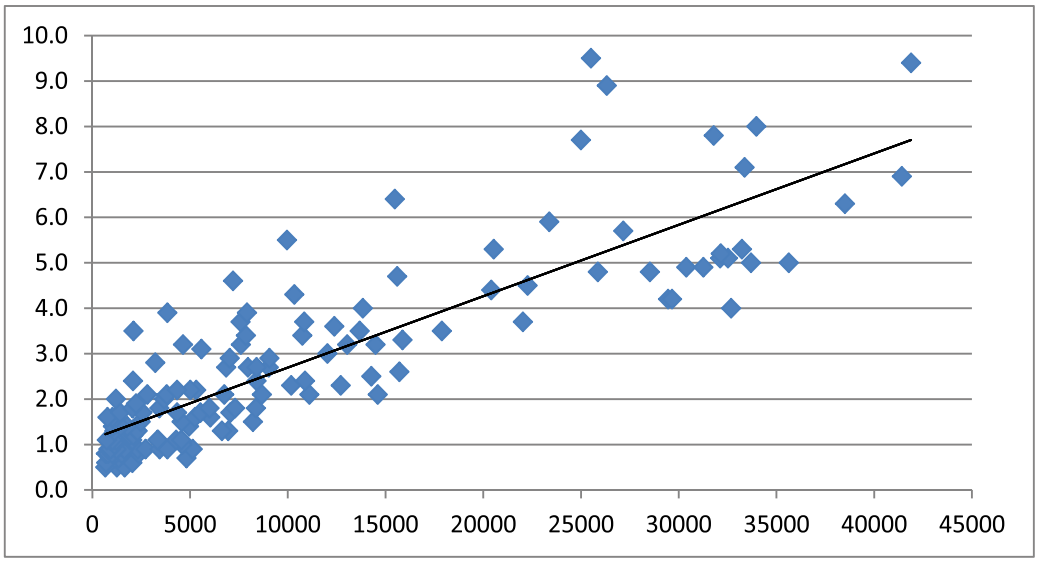


Fig. 16. Ecological Footprint for different countries vs their GDP. Source: own drawing by data from WWF 2008:32-4 and UNDP 2008

4. The problems with the GDP-parameter

Adam Smith's renowned book *Wealth of Nations* (Smith 1776) starts with this paragraph

The annual labour of every nation is the fund which originally supplies it with all the necessaries and conveniences of life which it annually consumes, and which consist always either in the immediate produce of that labour, or in what is purchased with that produce from other nations.

This is the foundation for the idea of GDP, to measure the value of the work the inhabitants of a nation is producing during a year. To know how much they could spend. The x-axis in this survey has mostly been GDP (if not it could be translated to GDP) but that is a very dynamic parameter. It could be measured in 3 different ways,

1. GDP as value added of goods and services (or the value of production at the consumer level)
2. GDP as the sum of profits and salaries
3. GDP as supply balance or expenditures (GNP = (private) consumption + investments/ savings + government spending + (exports – imports)

But it is only transactions that are registered that counts. We do not know the proportions of expenditures or as in the case of China's production and internal consumption as they lend part of the result for someone else to consume (USA). We do not know the Gini-coefficient or division between profit and salary and at what time the money is consumed. We have both a temporal and spatial displacement of GDP and environmental consequences. A paradox is also that ecological disasters create GDP. As an example, the Exxon Valdez tanker disaster,

which spewed 11 million gallons of crude oil over the pristine shores of Alaska in 1989, also led to a short GDP increase due to the costs of the massive clean-up operation.

We use PPP (a cost-of-living adjustment between different countries) or McDonald index to make GDP figures more comparable. Inflation is also excluded to make figures from different years analogous. But shouldn't we also implement a quality factor? Before the time of mass consumption I think we can agree that dairies were more 'natural'. Industrial efficiency had not at that time influenced the quality with artificial additives to speed up production or allow for longer transportation and/or shelf-life in the store. Is a small farm chicken from 1920 in quality comparable to an industrial chemically stuffed chicken from the 21th century? GDP is supposed to measure the production, how much we can consume. The work we have to put in to get a chicken is much less today – so we are richer. But GDP will not be adjusted for the quality change. A friend of order might say that we are paying more for the 'bio-chicken'. Yes that is true, but should we then compare the 1920s chicken with the bio-chicken to see how much richer we really have become?

The reason for doing the GDP/Environmental stress relation curve is that GDP is considered a measure of standard of living. But is it? The Human Development Index, which also includes life span expectation, literacy and provisions of schools and the Genuine Progress Index aggregate something like 15 different parameters to measure human well-being, suggest otherwise. Other scholars like Maslow, Max-Neff and Dodds (Dodds 1997) argue that the quality of life is much more intricate to measure than to reduce it to the pecuniary value of the industrial production.

In the case of environmental curves it could be argued that what has been measured to create the inverted U-shape curve is *urban* concentrations/emission of pollutants. These have been compared to a parameter that measures the performance for a whole country. So by moving out production sites from cities to rural areas one can decrease urban pollution and at the same time keep the high GDP. This movement was quite profound in the 1960s and 70s due to very high prices for real estates in central city areas of high income countries.

The numbers in GDP are *sales-figures*. When the producer sells a liter of gasoline for say 1,5 € that will be added to the GDP. But at the same time when we consume the gas we lose the resource (the capital valued 1,5) and that is not counted for. When it is used it will also add to the CO2-concentration in the atmosphere (environmental costs) and that is not either reduced from the GDP. When looking at corporations' key performance indicators, the normal thing is to read the balance-sheet to find the value of different assets and debts. The most common markers are liquidity and solidity. Only sales figures are not the primary source of information when we want to know the status of a company's economic situation. At least we need a consolidated statement of income with both sales *and* costs. We want to see if we have made a profit. It is the balance-sheet that gives us the information about the amount of resources (capital) we have and over time tells us if these are growing or decreasing. On the debt side we have the value of how much we owe the suppliers. To make a comparison with the global world, an environmentalist could argue that this is the same as the value humans have taking out of the environment without "paying" back. And if we don't pay our suppliers the will stop to deliver. In this world it is the Nature that delivers the needed resources to society. Companies without suppliers are impossible to run and it is

quite obvious that society without the Nature as provider of de natural resources we cannot continue to run Mother Earth.

Could it be that institutional stability both enhance growth and environmental benefits and that the GDP itself is not the mainspring to environmental improvements? So when there is growth we can sometimes see local improvements not because of the growth *per se,* but due to responsible politicians who both creates stability (for growth) and take sustainability a little bit more seriously than in countries with less developed institutions? As said in Brunetti's work *Politics and economic growth* at least "that a political system that include transparent, orderly, incremental law-making process" and a broad citizens participation via a strong party system, is needed to be growth enhancing. (Brunetti 1997) The World Bank itself in the report from 1992 states that it is politics, not the GDP-level, that determines the environmental outcome.

5. Discussion

Can we afford every country to develop economically and pass the "turning point"? What will happen to the environment on the journey up to the top of the curve? It seems that the environmental negative trespassing point – when we consume more than we have – lays around 8.000 US$ (see fig. 17, footprint/GDP-diagram) with current global population. If everybody is going to have that income and keep present consumption patterns we need 4 to 5 planets Earth ???? If the Earth we have has a limited capacity and sustainable development is about satisfying everyone's needs and if we want to lift the low GDP countries towards a decent standard of living it has to be at the expense of the 'Rich'.

Another way to do it, is to slowly and in an orderly way take low income countries, one by one in a pace that the ecosphere can stand, over the 'hill' to the 'blessed' high income, low environmental impact countries. But that could only be good policy if you believe in the Kuznets curve. The empiric evidence has shown that this is not the case, at least not for global problems. It seems that they get worse with increased GDP. So we have a paradox. What could be the guideline if locally perceived problems are solved with increased GDP but global real, but unperceived, stresses get worse by the same economic growth?

And another matter of concern is the question, what will happen to the credibility of the academic world if we with our scientific methods (that are legitimizing us) can deliver answers or theories to totally different world views, that logically cannot co-exist?

An additional unease is the issue of finding a mutual or joint solution to begin the journey on the path towards sustainable development if different paradigms like business as usual that believe in the free market, the eco-modernist who believes in indefinite human creativity to solve problems and the doomsday prophets who are totally convinced about the ecosphere's absolute limits, can get answers from the scientific society that make them feel confident that they are themselves right respectively and the others are wrong.

Due to lack of space it is not possible to expand this perspective of different actorgroups (including scientists) trying to influence the interpretation of research results. I have read Coase's. *The Problem of Social Cost* (Coase 1960), which was the background paper for what was later created as the so called Coaese theorem, which states that there are possibilities to find a free-market solution to environmental stress (Coase himself has the opposite opinion).

Meadows' *Limits to Growth* (Meadows et al 1972) where the conclusion is that we *might* run out of vital resources if humanity continues to exploit the nature at current exponential pace and finally the reports about Ozone depletion (Molina, M. 1974, Rowland, F 1994) and part of the argumentations that followed their publications.

If we scrutinize the debate within the scientific community regarding these three examples, I am convinced we will find that that the academic world is invested with values and that an ideology orientation is a partial compass when we do research. Scholars are guided by what Söderbaum (2008) calls a mental map and Schumpeter (1954) a preanalytic cognitive act. Daly puts it this way; "One might say that vision is the pattern or shape of the reality in question that the right hemisphere of the brain abstracts from experience. Whatever is omitted from the preanalytic vision cannot be recaptured by subsequent analysis"(Daly 2004 p 23). In my opinion we should start to more openly discuss if it is time to include the writer's values in the scientific method to make it credible.

6. Conclusion

When it comes to opinions about environmental curves it is easiest to find pro and contra arguments for the EKC as this is the one where establishment and environmentalists clash. When we look the other way around, towards the EDC it seems that industrialists and producers use the tactic of silence. One has to go back to the beginning of the 1970s after the publication of *Limits to Growth* to find any substantial attack on the environmentalists idea of limits to growth. The Brundtland world-view on environmental curves is not as controversial as 'she' has a solution for the high income countries – eco modernization. Although the moral dilemma with transnational displacement of 'dirty' production to developing countries and keeping the high GDP generating high-tech 'clean' production in the West is a question of fair distribution. But then who is going to produce the commodities we in the west want for a low price is a question that is not answered.

The EKC seems to be a time limited success in a local jurisdiction. And the reason for its appearance does not seem to be environmental consciousness but economic consequences. The losses for forest owners in Northern Europe due to the so called 'acid rain' triggered the political community to action. After Rachel Carsons book *Silent Spring* and that her qualms were verified in Minamata, and Itai-itai, (chemical poisoning) the Club of Rome's *Limits to Growth* and other environmental publications forced the politicians to act with more legislation to satisfy local opinion. This was amplified by the first so called oil crisis in the beginning of the 1970s.

It is hard to find environmental stock/GDP-curves of 'catches' from Nature (i.e. mines, forests or fisheries) that shows a long run sustainability. Instead 'The Newfoundland Cod fishing environmental Curve' could be a good example. For over five centuries the Grand Banks off the coast of the Canadian island of Newfoundland were the richest fishing grounds in the world. The moral of the Newfoundland cod collapse is simple: over-exploiting natural resources such as fisheries, forests or raw materials is good for short term GDP growth but disastrous for ecosystems, economies and communities in the long term.

When it comes to EBC there has been no debate as it is my own invention. One can albeit say that it gets support from UNEP, but the arguments again is deforestation, desertification. And for these arguments Brundtland is very inconsistent, to say the least,

and UNEP doesn't show any empirical evidence. It is just an opinion. When it comes to deforestation there are a lot of other factors influencing the outcome. And as deforestation also is a cause for desertification, it follows that neither WCED nor UNEP can state that low income countries are the cause. The arguments for the poor to be a major cause of environmental deterioration are very 'poor'.

The critique against the environmentalist is that they forget to include technical innovations and human creativity. They are normally doomsday prophets. Another argument is that the Business as usual group can show improvements in richer countries – they can afford to clean up. What they forget is displacement or the rucksack.

One must keep in mind that EKC deals with waste, (emission or concentration), EBC deals with production as an agent for environmental degradation at least in poor countries whereas EDC and ecological footprints look at consumption as the parameter to measure. But as Marx already said, production is at the same time consumption – consumption of natural resources.

If one concentrates the global environmental problems to the ones defined by WCED and tries to find empiric evidence, it is quite obvious that there is no decoupling between GDP and environmental problems. Instead it seems that there is a positive monotonic relationship between economic growth and environmental problems.

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I wish to thank the editorial board of InTech for finding interest in my studies and that they publish my thoughts. Because writing, without readers has very limited value.

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16

Temporal-Spatial Changes of the Oasis in the Heihe River Basin over the Past 25 Years

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1. Introduction

In China, the arid area occupies a quarter of the total area of the land. It mainly distributes in five provinces: Gansu, Ningxia, Qinghai, Xinjiang and Inner Mongolia. In the arid area, oasis is the special landscape on the background of deserts. It is not only the most centralized area of human activities but also the largest area where human disturbances happen at the regional scale. Oasis covers only 4%–5% of the area of the arid region, whereas they load over 90% of the population and 95% of the social wealth in this area (Li et al., 2007). Therefore, oasis plays very important roles in the economic and social development. In recent 60 years, the artificial oasis of this region kept expanding, as a result, living space of human beings became larger, and the overall productivity and capability were improved as well, which made great contribution to the development of regional economy. However, the ecological environment of the arid area is fragile due to the dry climate, scarce rainfall and short water resource. Consequently, over exploitation on oasis led to imbalanced and unreasonable reallocation of water resource, which further make the local water cycle process changed and finally results in salinization, desertification and wind erosion in other parts (Wang, 2009). If no effective measures are taken, stability of the oasis and sustainable development of the economy in arid area of China will face serious threats.

Britannica Concise Encyclopedia defines oasis as fertile tract of land on the background of a desert where a perennial supply of fresh water is available. Oases vary in size, ranging from about 2.5 acres (1 hectare) around small springs to vast areas of naturally watered or irrigated land (Britannica Concise Encyclopedia, 2006); Wikipedia considers oasis as an isolated area of vegetation in a desert. In this study the oasis particularly refers to the dominated vegetation coverage growing in oasis area in view of the value of ecosystem services and research conveniences.

Remote sensing images have been used as a source of information for detecting land-use and land-cover changes at local, regional, and global scales in recent decades. Many scientists have investigated oasis ecosystem of western China using satellite data and some valuable results have been obtained. Luo (2003) constructed the process of land use/land cover change in the oasis of the arid region using remote sensing imagery data of 1979, 1987 and 1998; Tian (2011) studied the spatial-temporal processes of oasis development in the middle reaches of the Heihe River based on a time series of the normalized difference vegetation index (NDVI) derived from the 16-day composite MOD13A2 data with a spatial

resolution of 1km. These studies used either a few phases' imageries or low spatial resolution data to detect changes of the oasis, but few of them reflected the detailed process of dynamic changes in complete time series.

This chapter selected 8 phases of Landsat TM/ETM images that cover a period of 23 years from 1986 to 2009 to reconstruct the process of temporal and spatial changes of the Heihe oasis in northwest China. In order to separate and extract study object directly and accurately, an improved threshold method was proposed for vegetation extraction, and the characteristics and development laws of oasis were further analyzed and discussed.

2. Study area

The Heihe River is the second largest continental river in China .The Heihe River Basin is the representative in the arid area of northwestern China. It is located between 96°42′-102°00′ E and 37°41′-42°42′ N, with an area of 128,000 km^2 approximately. It is one of the areas with the earliest development of irrigating agriculture in the arid area of China, and supports a population more than 1.9×10^6 nowadays. The main stream, with a length of 821 km, originates from the Qilian Mountains of Qinghai Province, flowing through the middle basin called the Hexi Corridor of Gansu Province, and ends in the Juyan Lake, a terminal lake in the desert in the Inner Mongolia Autonomous Region. The runoff from thousands of glaciers, snow and permafrost in the mountainous catchment basically constructs the water resources of the Heihe river basin. Because of its relatively abundant water resource (mean annual runoff is 37.3×10^8 m^3), the Heihe River Basin was developed as the important commodity grain base in north-west China. Additionally, it has experienced rapid socioeconomic development and an increase in population density. 95 percent people of the basin are living in agricultural area of the oasis, and approximately 80 percent of them are engaged in husbandry production. However, the extensive exploitation of the water and land resources in the upper and middle parts of the basin has led to a sharp decrease in the water resource in the lower reaches.

Due to the influence of the water resource distribution and human activities, the oasis of Hehei River Basin distributes mainly on the piedmont lower alluvial fan and fluvial plain in the middle reaches of the river. Administratively, this study area includes Zhangye Prefecture-level City (governs six counties named Ganzhou, Shandan, Minle, Gaotai, Linze, and Sunan Yugur Autonomous County), part of Jiuquan Prefecture-level City (governs Suzhou and Jinta County), Jia Yuguan Prefecture-level City and part of Alxa League (governs Ejin Banner) of the Inner Mongolia Autonomous Region. The location of the Heihe River Basin and the approximate range of its oasis are illustrated in Figure 1.

3. Data and methodology

3.1 Data acquisition and processing

Data selection is very important in a spatial-temporal change analysis: the imagery must completely cover the whole study area; the time period should be suitable to capture the change; the images should be obtained during vigorous growing seasons of the vegetation given oases' phenological differences. Therefore, Landsat TM/ETM dataset was selected to detect the oases change, considering its advantages of multi-bands, high spatial resolution, high temporal resolution especially the continuity over years and free availability. 40 cloud-

free images covering the whole basin acquired every 3 or 4 years from 1986 to 2009 were selected and analyzed (Table 1).

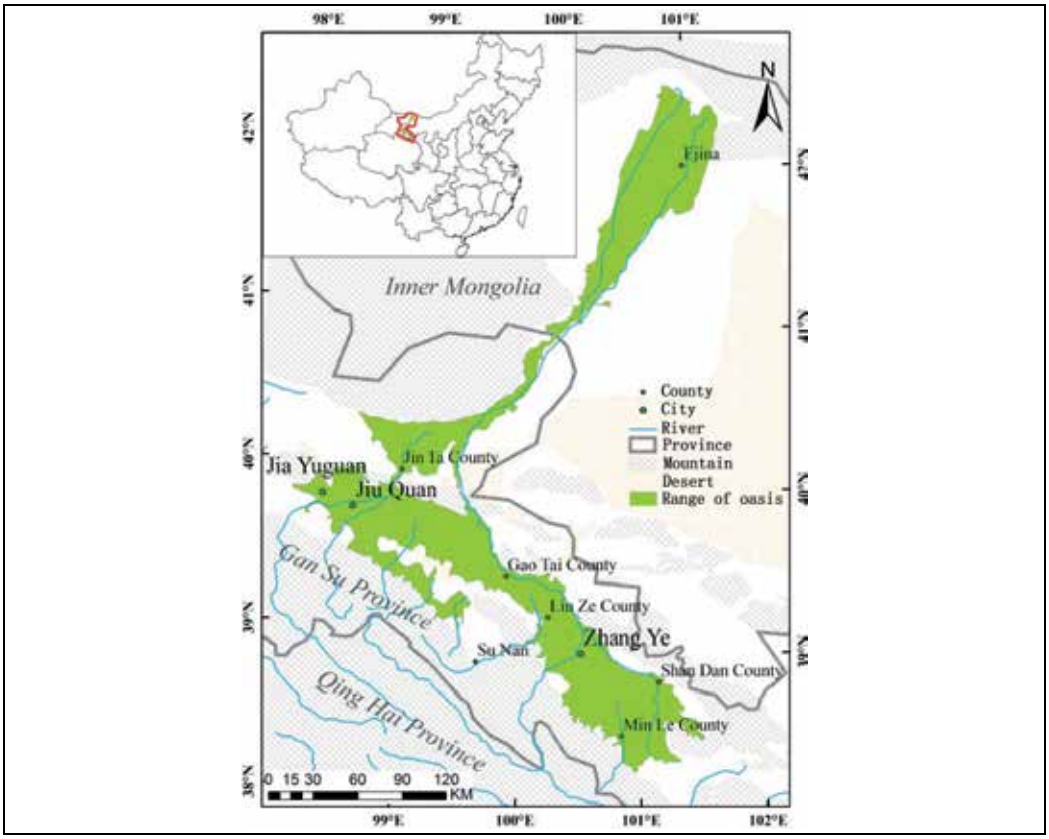


Fig. 1. The location of the Heihe River Basin and the approximate range of its oasis

	133/033	134/031	134/032	134/033	135/032
Landsat TM	09/06/1986	03/08/1986	03/08/1986	18/07/1986	25/07/1986
	23/06/1991	15/09/1990	27/06/1990	27/06/1990	18/06/1990
	12/06/1993	08/06/1993	08/06/1993	08/06/1993	25/07/1992
	23/06/1997	15/09/1996	15/09/1996	15/09/1996	22/09/1996
	23/07/2006	11/09/2006	23/06/2006	23/06/2006	17/08/2006
	24/06/2009	19/09/2009	17/07/2009	17/07/2009	09/08/2009
Landsat ETM	07/07/1999	14/06/2000	30/07/1999	30/07/1999	21/07/1999
	13/06/2002	24/09/2002	23/08/2002	23/08/2002	14/08/2002

Table 1. A list of Selected TM/ETM images

Atmospheric correction of multiple-date remote sensor data is required when the individual data images used in the change analysis algorithm are based on linear transformations of the data. A set of normalized difference vegetation index images were produced for each date in this study, atmospheric correction of multiple-date imageries was performed before image-to-image rigorous registration being conducted. According to the differences on

biophysical and phenological characteristic of the vegetation among the upper, middle and lower reaches of the Heihe River Basin, the images were divided into three parts. 133/033 and 134/033 were combined into a single composite image, 134032 and 135032 were combined into another single composite image.

3.2 Vegetation Index calculation

Since 1960s, scientists have extracted and modeled various biophysical variables of vegetation to provide vegetation information using remotely sensed data. Much of this effort has involved the use of vegetation indices that indicate relative abundance and activity of green vegetation. NDVI (Normalized Difference Vegetation Index) is the most popular vegetation index used to evaluate the variation of surface vegetation at regional and global scales across a range of temporal scales. It is calculated as: NDVI = (infrared - red) / (infrared + red). The ratio reduces many forms of multiplicative noise presenting in multiple bands of multiple-data imagery, such as sun illumination differences, cloud shadows, some atmosphere attenuation and topographic distortions. Seasonal and inter-annual changes in vegetation growth and activity can be monitored using NDVI (John, 2005). The standard MODIS land products include the global 16-day composite NDVI products with a spatial resolution of 500m and 1km respectively (Huete et al., 2002a). Many applications and studies have proven the value of NDVI for vegetation information analysis. Therefore, in this study, NDVI database based on the selected images was constructed for further monitoring vegetation status and dynamic change.

3.3 Threshold method for vegetation extraction

Threshold method is a simple and important form of image segmentation to be widely used in the field of pattern recognition by computer and image processing for gray-level image. It is particularly suitable for specific information and parts of interest extraction. This method takes the difference of gray value between the target objects and the background into account, and determines one or several thresholds of the image on basis of certain principle functions, which each pixel is assigned to one class if its gray value is greater than the determined threshold and otherwise to the other class (Chen & Li, 2006). For remotely sensed images, determining the optimal threshold is a critical task for a large amount of information of the data. At the meantime, this method not only compresses a great amount of data, but also greatly simplifies the analysis and processing steps of the images (Du et al., 2002a).

A great variety of threshold algorithms have been developed in the last few decades (Kittler et al., 2009; Lee & Chung, 1990; Sahoo et al., 1988; Sezgin & Sankur, 2004; Weszka, 1978; Waston, 1987; Yin, 1999). These algorithms can be classified into two types: edge-based algorithms and area-based algorithms (John, 2005), but selecting an appropriate one is difficult. The problem is that independent criteria definition in different algorithms typically produces different results with distinct precision for these algorithms since they make different assumptions about the image. For instance, the famous Otsu's method (Otsu, 1979) is based on a linear discriminant analysis and the recent Kwon's threshold selection method is another technique based on a clustering criterion (Kwon, 2004). These aforementioned typical, simple and relatively effective methods based on criteria pay attention to both the foreground object(s) and the background, and they are affected greatly by proportion of the foreground account in the entire image. At the same time, these methods fail to partially remove noise existing in the background (Chen & Li, 2006).

A new method - the edge weighting method is developed in this study. Normally, the image threshold is supposed to exist in the transition region from the target object to the background. If the gray value in the edge area is obtained, it would become easy to find a suitable threshold according to these gray values. As the edge detective operators are based on differential, they are easily affected by noise or point features (such as outlier). Sometimes the result contains pseudo edges (Li et al., 2006; Yi & Du, 2005), which have a further influence on binarization processing. The fundamental ideas of edge weighting method are as follows: the optimal threshold is supposed to subjectively exist. The average of all gray values obtained by edge detection is set as the critical threshold. Pixels with distinct gray values in the image make different contribution to the optimal threshold: the greater the value of $|\theta - \theta_i|$, the smaller its weight. Therefore, we took the inverse of $|\theta - \theta_i|$ as the coefficient of weight to obtain the binarization threshold of the entire image. The steps can be described as following:

First, edge detection is implemented by using different non-directional operators to obtain the intermediate image. The selected operator is not only helpful for obtaining the position of the edge with easy and good accuracy, but also can largely avoid the loss of interior feature of the objects. Tracking the intermediate image, the position of edge pixels were obtained, and all gray values in the original image of these edge pixels could be found out based on which the mean value marked as θ was calculated. The normalization coefficient can be expressed as:

$$S = \sum_{i=0}^{m} \frac{1}{|\theta_i - \theta|} \tag{1}$$

Where θ_i denotes the gray value on the edge; m represents the number of the different gray values. The weighting coefficient of each pixel is defined as:

$$W_i = \frac{1}{S|\theta_i - \theta|} \tag{2}$$

Finally, add up each different gray value of edge pixels with weighting coefficient and the optimal threshold will be obtained based on statistical characteristic of the image.

4. Oasis reconstruction

4.1 Distribution status of oasis

Using the edge weighting method described above, the oases of sample years were reconstructed. The current oases distribution of the Heihe River Basin is showed in Figure 2. The oases consist of two main parts: the middle reach oases and the low reach oases .They are located in the midst of Hexi Corridor and in Ejin Banner in Inner Mongolia respectively. The oases are distributed in zones along the two sides of the main stream of the Heihe River. According to the administration boundary, the spatial distribution of oases in the Heihe River Basin can be divided into 3 parts: ① Zhangye oasis. The oases are located in the middle of the Heihe River. From the south to the north, the oases include three topographic regions: Qilian Mountain, the central corridor plain and north mountain. The Minle and

Shandan oasis are in the alluvial and pluvial fan and the natural conditions is relative suitable, hence the oasis is widely distributed with relative large area. The Linze and Gaotai oasis are mainly distributed along the two sides of the Heihe River. ② Jiuquan and Jiayuguan oasis. The oases are located in flat open area in north of Qinlian Mountain, which belong to higher position oasis (Zhang, 2002). ③ Ejin oasis in the low reaches. The oases are located in the west part of Inner Mongolia. It has a transitional zone with desert areas, as a result the distribution of the oasis is scattered. More importantly, it is an important line of ecological defense in the leading edge of West China.

The oases distribution of different years can be seen from Figure3, and it shows the main location of oases changed little since 1986.

4.2 Validation on reconstruction of oasis

The results of oasis reconstruction need to be validated after the work have been finished. According to related studies, different methods were used to verify the accuracy of the interpretation of remote sensing. In this study, field validation was used to verify the oasis reconstruction. The specific process is as following: 1) based on the extracted oasis in 2009, the uncertainty regions of 10%-20% were chosen to validate in the fields; 2) according to the results of the validation, the results of reconstruction were further modified. The points of verification in the Heihe River Basin are shown as Figure 2.

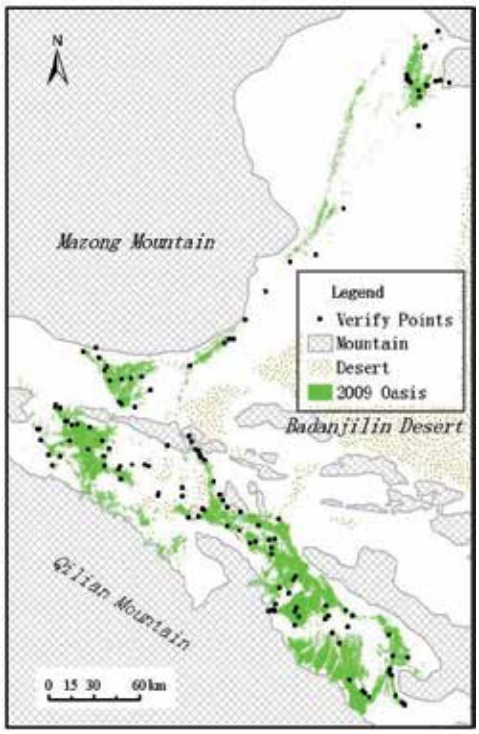
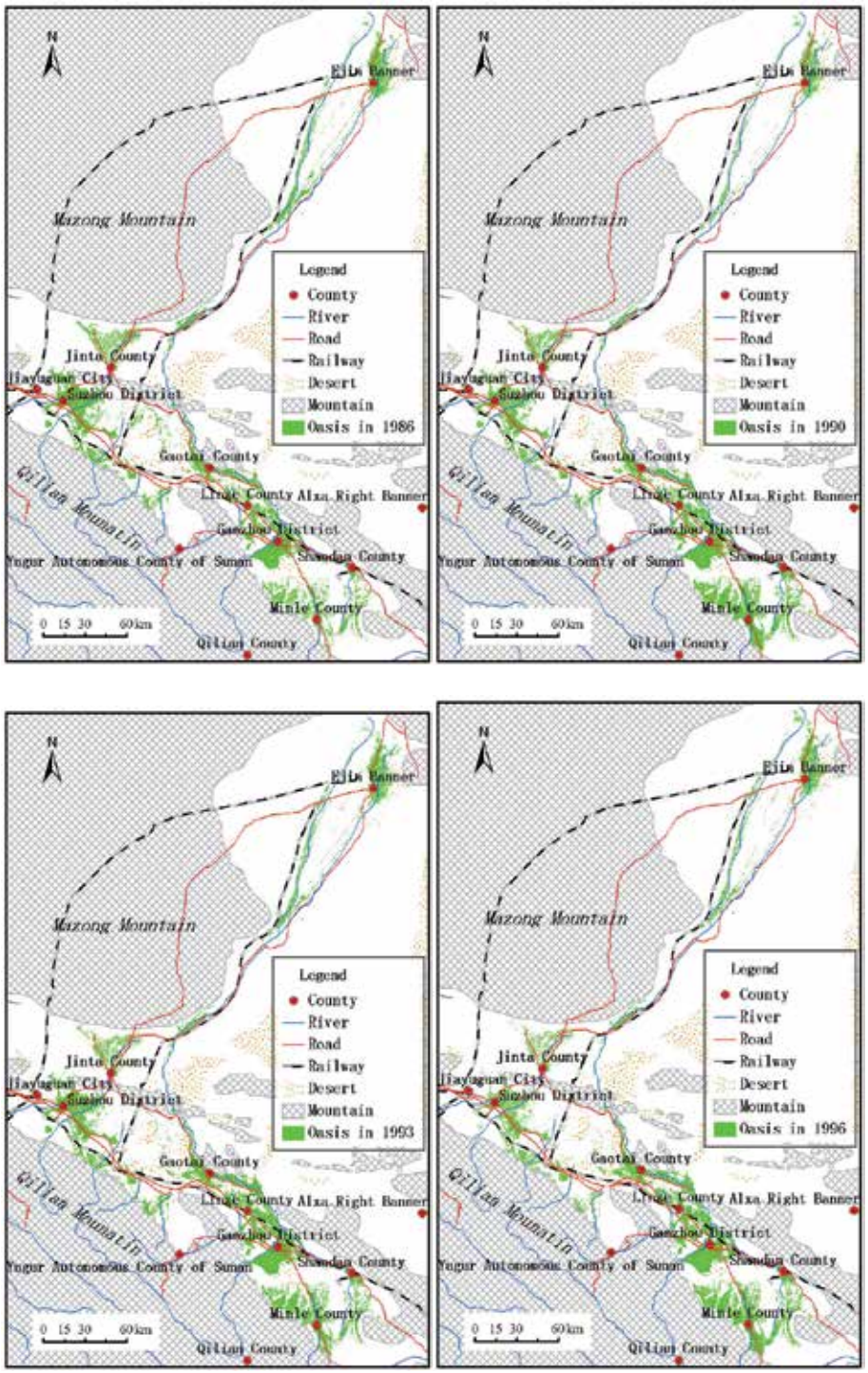


Fig. 2. The validation points in the Heihe River Basin


N
Ejin Banner
Mazong Mountain
Legend
County
River
Road
Railway
Desert
Mountain
Oasis in 1986
Oasis in 1990
Oasis in 1993
Oasis in 1996
Jinta County
Jiayuguan City
Suzhou District
Gaotai County
Qilian Mountain
Linze County
Alxa Right Banner
Ganzhou District
Yugur Autonomous County of Sunan
Shandan County
Minle County
Qilian County
0 15 30 60km

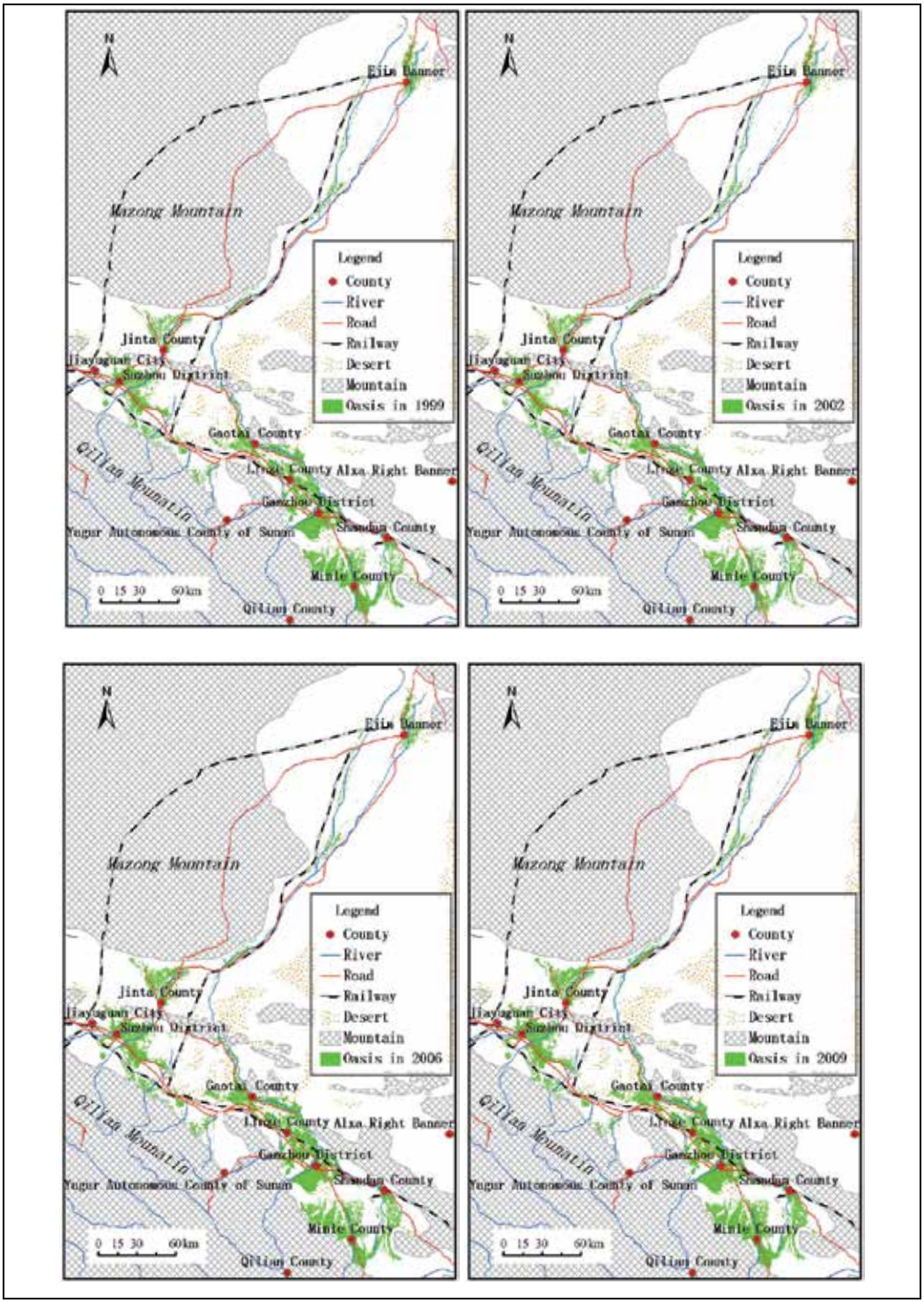


Fig. 3. The oases distribution in the Heihe River Basin from 1986 to 2009

5. Analysis of the oasis changes in the Heihe River Basin

5.1 Analysis of the area changes

Based on the results of oasis reconstruction, oasis areas of the total watershed and each county or district were counted using GIS in each period as shown in Table2, and the change curve of area was drawn according to data in Table2 as shown in figure4. As illustrated in Table 2 and Figure 4, oasis expansion is the main trend from 1986 to 2009 in this area, except 1996 and 2002 that had two periods of short-term oasis atrophy. The smallest oasis area was 4526.16 km^2 in 2002, while the oasis area reached the maximum value of 5581.44 km^2 in 2009. The change trend of area presented slow decline from 1986 to 2002 in this area, during which a decrease was followed by a trend of increase. The oasis area increased rapidly since 2002, reaching a maximum in 2009.

According to Table 2 and Figure 4, the oasis areas are large in Ganzhou district and Suzhou district, but small in Minle County, Jiayuguan City and Sunan County, and the oasis areas of the rest counties is at an intermediate level. The changes trend is not exactly the same between oasis area in each county / district and total area. The changes of area are acute in Ejin oasis. Overall, the trend of decreasing, shrinking and expansion of oases run concurrently. There is slight change of oasis area in Minle County, Jiayuguan city and Sunan County. The oasis areas in other counties have some fluctuations in some years, but generally the trend of change is consistent with the overall trends.

In order to understand the rate of regional oasis changes and their characteristic differences, the dynamic degree is calculated for each county and district. The dynamic degree model could be mathematically expressed as the following function (Liu, 2000b):

$$k = \frac{U_b - U_a}{U_a} * \frac{1}{T} * 100\% \tag{3}$$

City	County/ District	1986	1990	1993	1996	1999	2002	2006	2009
Zhangye	Shandan	243.87	339.78	289.64	341.90	380.67	359.86	383.92	444.76
	Minle	410.57	784.06	636.41	771.92	836.87	734.02	783.09	899.14
	Ganzhou District	890.74	996.12	1019.75	1004.38	1052.66	997.25	1079.18	1113.93
	Linze	325.96	386.27	457.36	411.01	453.93	407.68	486.25	467.21
	Gaotai	402.31	375.58	451.92	405.60	390.52	415.41	487.18	454.08
	Sunan	67.29	17.33	28.77	24.07	19.61	25.38	45.35	52.74
Jiuquan	Suzhou District	973.27	876.18	920.48	717.37	814.45	760.90	926.12	970.01
	Jinta	480.23	408.09	402.40	309.67	368.94	410.06	506.67	586.28
Jiayuguan	Jiayuguan	101.03	80.43	91.17	35.40	70.51	65.60	87.58	102.78
Inner Mongolia	Ejin Banner	770.59	538.67	714.33	689.47	383.67	339.97	342.04	480.37
Total Area		4665.85	4802.50	5012.23	4710.78	4771.82	4516.15	5127.39	5571.28

Table 2. The oasis area in the Heihe River Basin (unit: km^2)

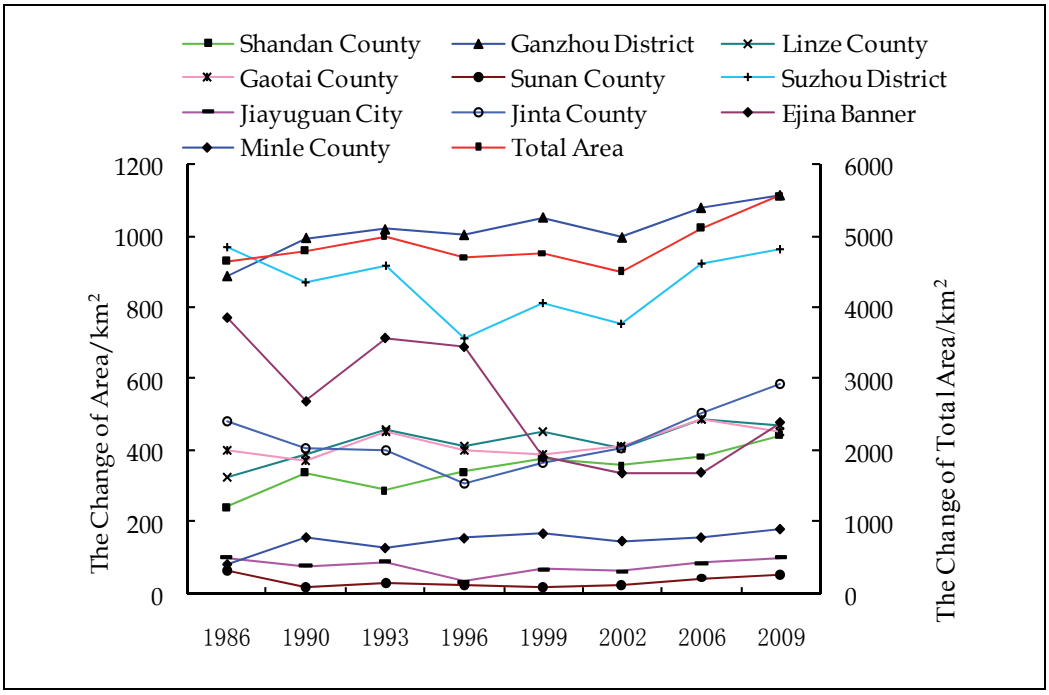


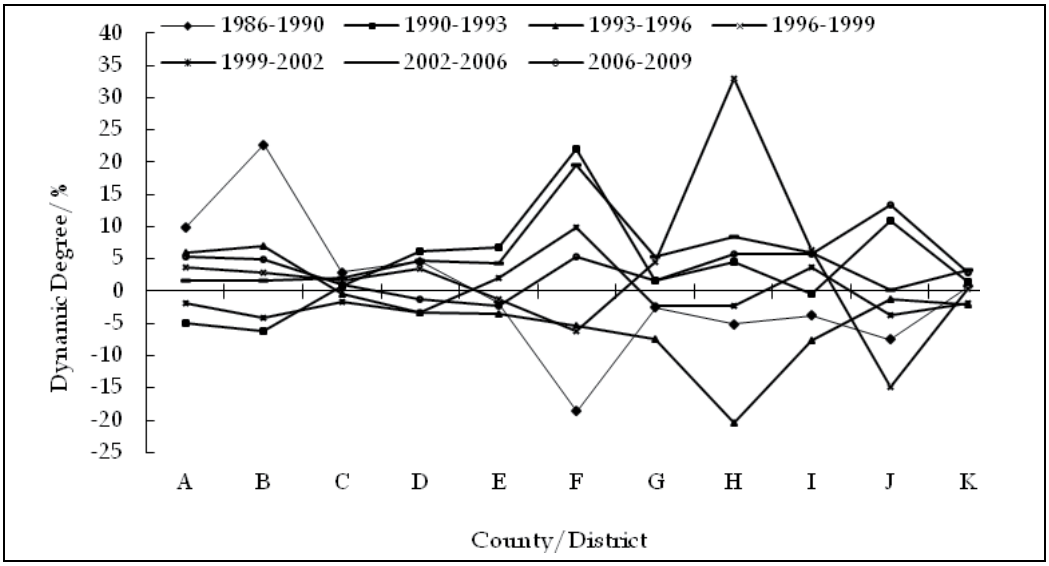
Fig. 4. The oasis area in the Heihe River Basin from 1986 to 2009

Where K is the oasis change rate over time T, U_a is the oasis area at the beginning of the monitoring period, and U_b is the oasis area at the end of the monitoring period .The dynamic degree is thus defined as the time rate of the oasis change that oasis is converted into the desert and that part of the oasis area at the beginning of the monitoring period subjects to change. The dynamic degree represents, in a comprehensive manner, the change of oasis in a given region. The oasis dynamic degree is shown in Table3 and Figure5.

Table 3 and Figure5 indicate that the oasis dynamic degrees are greatly different in different periods. The oasis dynamic degree of Jiayuguan City was the largest compared with that of other counties or districts, which had been increased from -20.39 in 1993-1996 to 33.06 in 1996-1999, indicating that the oasis had severely decreased and increased in these periods respectively. In addition, the oasis dynamic degree was larger in Sunan County, which was -18.56 in 1986-1990 with severe decreasing, and 22.02 in 1990-1993 with severe increase. On the whole, the oasis dynamic degree kept at an intermediate level in other counties, but larger in individual periods. For the whole basin, the oasis dynamic degree maintained a less difference in the Heihe River Basin in all periods, with a gently increase or decrease. Taking the oasis as a complete system, not only the whole oasis system but also part of the oasis should be concerned, because the individual changes which constitute oasis system, could be researched to understand exactly the inner factors of the oasis change. On the other hand, the oasis dynamic degree in the same period remained great difference in all counties. The oasis dynamic degree was up to 22.74 with an extreme increase in Minle County, and -18.56 in Sunan County with an extreme decrease in 1986-1990. The oasis dynamic degree reached the maximum of 22.02 with extreme increase in Sunan County in 1993-1996. The oasis dynamic degree in Jiayuguan city was the largest among all counties in 1996-1999. In

City	County/ District	1986-1990	1990-1993	1993-1996	1996-1999	1999-2002	2002-2006	2006-2009
Zhangye	Shandan	9.83	-4.92	6.01	3.78	-1.82	1.67	5.28
	Minle	22.74	-6.28	7.10	2.80	-4.10	1.67	4.94
	Ganzhou District	2.96	0.79	-0.50	1.60	-1.75	2.05	1.07
	Linze	4.63	6.13	-3.38	3.48	-3.4	4.82	-1.31
	Gaotai	-1.66	6.77	-3.42	-1.24	2.12	4.32	-2.26
	Sunan	-18.56	22.02	-5.45	-6.17	9.81	19.67	5.43
Jiuquan	Suzhou Districr	-2.49	1.69	-7.36	4.51	-2.19	5.43	1.58
	Jinta	-3.76	-0.46	-7.68	6.38	3.72	5.89	5.24
Jiayuguan	Jiayuguan	-5.10	4.45	-20.39	33.06	-2.32	8.37	5.79
Inner Mongolia	Ejin Banner	-7.52	10.87	-1.16	-14.78	-3.80	0.15	13.48
Total Dynamic Degree		0.73	1.45	-2.00	0.43	-1.78	3.38	2.88

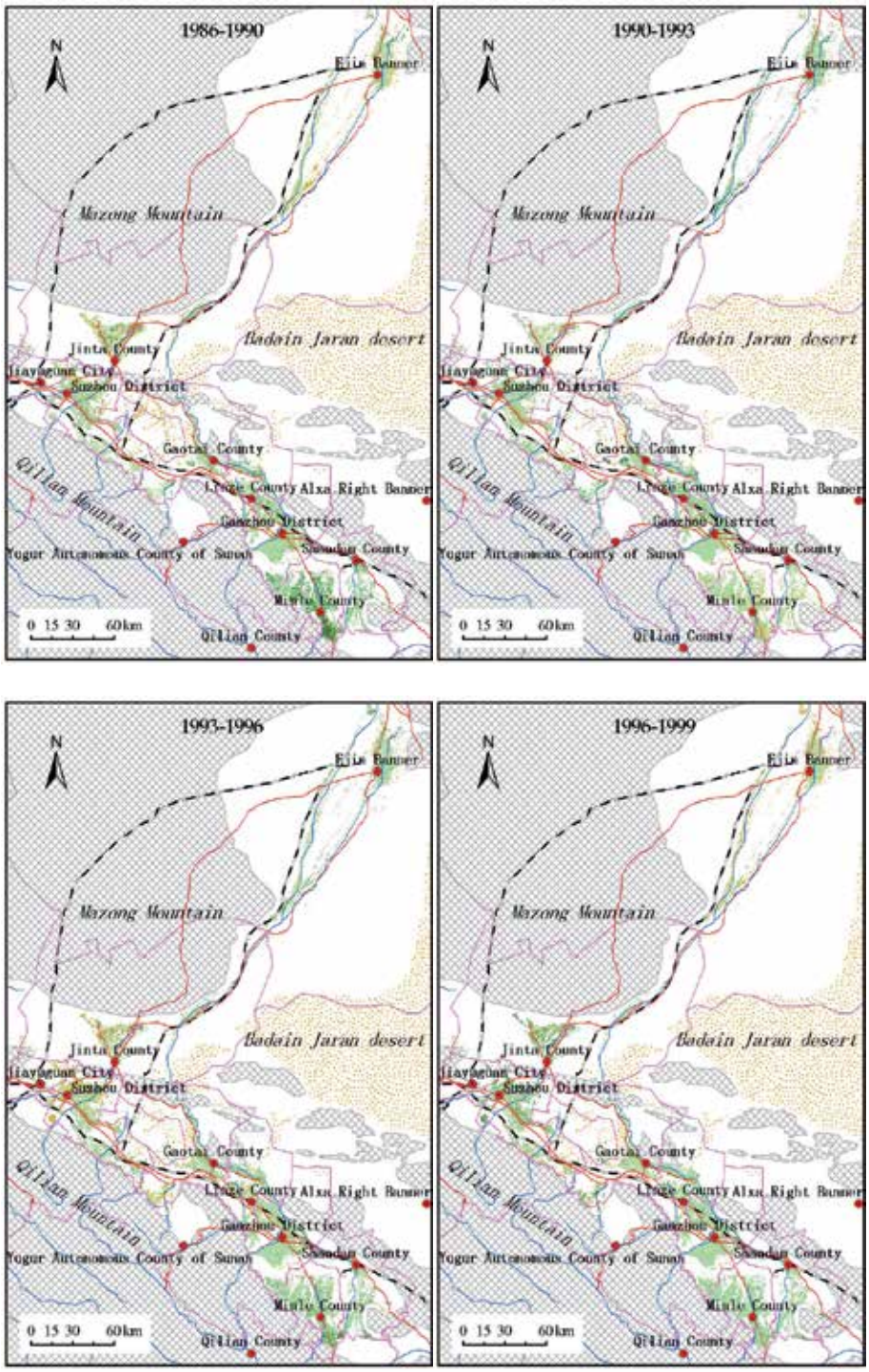
Table 3. The dynamic degree of the oasis change in the Heihe River Basin from 1986 to 2009 (unit:%)



A: Shandan County; B: Minle County; C: Ganzhou District; D: Linze County; E: Gaotai County; F: Sunan County; G: Suzhou District; H: Jiayuguan City; I: Jinta County; J: Ejin Banner; K: Total Dynamic Degree

Fig. 5. The net changes of oasis in the Heihe River Basin from 1986 to 2009

1999-2002, the oasis dynamic degree kept at lower level in all counties, which indicates that the degree of increase or decrease was more gently, and the oasis remained a steady state in a short period. The oasis dynamic degree also kept at lower level in the counties except Sunan County in 2002-2006. From 2006 to 2009, the oasis dynamic degree reached 13.48 with abrupt increase in Ejin oases, while it remained at lower level in other counties or districts.


1986-1990
1990-1993
1993-1996
1996-1999
N
Mazong Mountain
Badain Jaran desert
Qilian Mountain
Jinta County
Jiayuguan City
Suzhou District
Gaotai County
Linze County
Alxa Right Banner
Ganzhou District
Yugur Autonomous County of Sunan
Shandan County
Minle County
Qilian County
0 15 30 60km

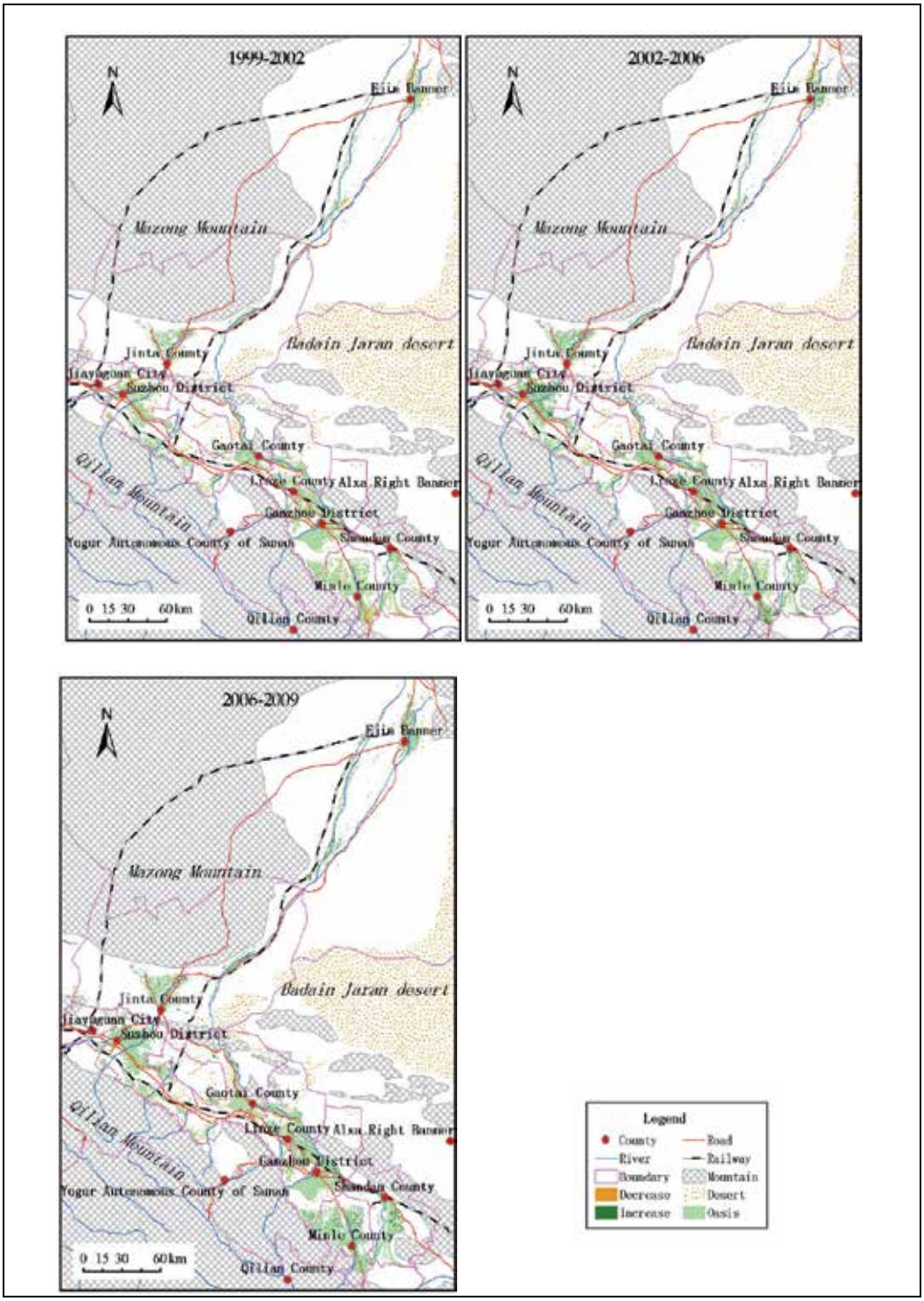


Fig. 6. The maps of oasis change in the Heihe River Basin from 1986 to 2009

5.2 Analysis of spatial pattern change of the Heihe oasis

Eight maps of oasis distribution between 1986 and 2009 were made using change detection in ArcMap (Figure 6). The areas of changed part were calculated as shown in Table 4 and Figure 7. Table 4 shows that the most outstanding increase of area occurred in 1986-1990 as much as 968.84 km^2. The most outstanding decreasing area of 935.96 km^2 occurred in 1993-1996. From 1999 to 2002, the increased area is the smallest (389.38 km^2), and between 2002 and 2006 the decreased area is the smallest (313.99 km^2). From the point of change trends of the oasis area in the study period, the increase and decrease of area are alternately present as undulate. The decreased area is much larger than the increased oasis area between 1993-1996 and 1999-2002, indicating that the oasis shrunk in both periods. It is clear that the shrinking regions are far more than the expanding regions from the change maps of oasis. The increased areas are greater than the decreased area in other periods, indicating that the oasis expanded in these periods.

	1986-1990	1990-1993	1993-1996	1996-1999	1999-2002	2002-2006	2006-2009
Increase of Area	968.84	735.41	634.52	757.65	389.38	925.23	772.45
Decrease of Area	832.20	525.68	935.96	696.62	645.05	313.99	328.54

Table 4. The change of oasis area in each periods in the Heihe River Basin (unit:km^2)

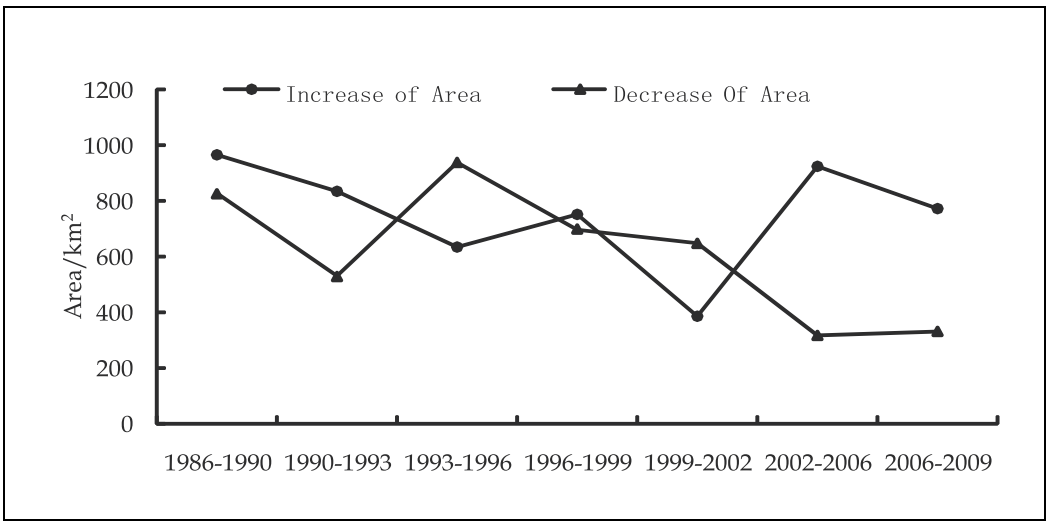


Fig. 7. The change of oasis area in each period in the Heihe River Basin (unit:km^2)

From the point of spatial distribution of oasis changes during the last 25 years, the expansion and shrink of oasis have occurred alternately in all counties in the Heihe River Basin. In addition, the intensity of expansion and shrink varied sharply in different periods. Both of expansion and shrink had a distinct regional distribution between 1986 and 1990. The expanding regions mainly concentrated in Minle County, Shandan County, yet more or less expansion appeared in other counties. The shrunk regions mainly concentrated in Suzhou District, Jinta County and Ejin Banner. From 1990 to 1993, both expansion and shrink of oasis presented scattered, the expanding regions were located in Linze County, northern of Gaotai County and Ejin Banner, while the shrink regions were located in Minle County, Shandan County and Jinta County. From 1993 to 1996, the most serious decline of the oasis occurred in Linze County, south of Gaotai County, Suzhou District and Ejin Banner, while little expanding regions presented in Minle County and south of Shandan County. From 1996-1999, the expansion of oasis was the smallest, and its distribution was scattered. There was a little expansion of oasis distribution in all counties except Ejin Banner. The shrunk regions distributed in Gaotai County, north of Jinta County and Ejin Banner, and the shrinking of oasis was most severe in Ejin Banner. From 1999-2002, the shrinking of oasis widely occurred in the Heihe River Basin, but the expansion of oasis only sporadically took place in Shandan County, Gaotai County and Jinta County. The expanding area of oasis in 2002-2006 was the largest of all periods, and the expanding regions were widely located in the whole basin; correspondingly, there were few atrophied regions. From 2006-2009, the expanding area of oasis was also larger and the expanded oases widely distributed in Minle County, Shandan County, Jinta County and Ejina Banner, while the shrinking of oasis mainly took place in Linze County, Gaotai County and the south of Sunan County.

In the whole study area, the regions that the oasis area changes greater mainly distributed at the border of the oasis. For instance, through artificial cultivation, improvement of irrigation system, a large number of deserts with relatively good natural conditions were converted into farmland, woodland, etc. Meanwhile, grassland degradation and desert formation occurred as a result of water shortage and other undesirable condition. In addition, some areas that have no or are short of surface water began to pump groundwater to irrigate the reclaimed wasteland. Disorder exploitation led to rapid decline of groundwater level and strengthened the drought of soil, yet increased abandoned land. Furthermore, the grassland severely degraded due to over-grazing. The factors mentioned above recurred in different research periods. As a result, oasis changes dynamically between expansions and shrink in the study area.

6. Conclusion

This study discussed the spatial and temporal processes and characteristics of oasis changes in the Heihe River Basin between 1986 and 2009. The following conclusions can be obtained:

First, expansion was the main trend of oasis change in the Heihe River Basin from 1986 to 2009, except the period from 1996 to 2002 in which the oasis shrunk shortly. From 1986 to 2002, the oasis area experienced a process of gentle increasing and then decreasing

process. After 2002, an abrupt increase appeared and reached the top in 2009. The oasis area reached the maximum value as 5581.44 km^2 in 2009 and minimum value as 4526.16 km^2 in 2002.

Second, the changes of oasis dynamic degree were great different in all counties over the past 23 years. The oasis expanding and shrinking occurred in all counties, and both of them alternatively occurred in each county.

Third, the intensity of expansion and shrinking varied in different periods. It indicates that the all oases in the Heihe River Basin are a whole and there is interrelationship existed. However, there are still questions such as the change reasons remaining unclear and further analysis is expected to be made in the future.

Final, the edge weighting method is an efficient way to reconstruct the oasis changes over past decades, which not only makes the reconstruction easier, quick, automatic, but also the results more objective and accurate.

7. Acknowledgment

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17

Saving the World's Most Precious Resource

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1. Introduction

Water is probably the world's most precious natural resource. Without it, there would be no life. It's sad then to think that so many people already live with less than their daily needs and that this situation is predicted to get even worse. In fact, according to an UN assessment, by 2025, around two-thirds of the world's population will have insufficient supply.

The traditional solution to a water shortage problem has been to develop new sources. But as the easily extractable ones have already been exploited, this quest is becoming increasingly difficult. Little wonder then, that even London, the capital city of what is considered to be one of the wettest countries in the world, is turning to desalination as a solution. Not only is this very expensive, but it is has a huge environmental impact. Furthermore, it addresses just the consequence of the problem and not its root cause, which invariably relates to inefficiencies.

So why then, has such a disastrous situation arisen in the first place, particularly when the water utility personnel is amongst the most dedicated of any industry? The answer lies in the traditional approach to water network management, where the objective was not necessarily to improve efficiency, but to ensure that the customers had some supply for a part of the time. Unknowingly, the leakage level was increasing, probably because only a small proportion of leaks ever come to the surface. As the reservoirs ran dry, water was rationed, making things even worse. In some cities water supply is counted in just a few days of the week. The answer appears obvious: reduce the losses. So why is this not done? Probably because the solution is not as easily defined as the problem itself.

2. Water balance

In its simplest definition, water loss is the difference between the total production and total consumption. However, there is a lot more to it than this, as the International Water Association's (IWA) standard water balance, (reproduced below in Figure 1), shows.

The loss is composed of two main components: commercial (or apparent) and physical (or real). The former comprises inaccurate measurement and illegal use, whilst the latter includes leakage from the reservoirs and from the supply and distribution network, including service pipes.

Commercial losses is often thought to be the main cause of water loss, probably because of the impression given by images such as the one in Figure 2, where numerous customer service pipes are illegally tapped into the distribution network.

System input volume (corrected for known errors)	Authorised consumption	Billed authorised consumption	Billed metered consumption (including water exported)	Revenue water
			Billed unmetered consumption	
		Unbilled authorised consumption	Unbilled metered consumption	Non-revenue water (NRW)
			Unbilled unmetered consumption	
	Water losses	Apparent losses	Unauthorised consumption	
			Customer metering inaccuracies	
		Real losses	Leakage on transmission and/or distribution mains	
			Leakage and overflows at utility's storage tanks	
			Leakage on service connections up to point of customer metering	

Fig. 1. IWA Water Balance

Fig. 2. Illegal customer connections

A more detailed study, rather than a subjective observation, has shown otherwise, with leakage representing around 80% of total water loss. This is not surprising when it is considered that a typical leak is between 500 and 1000 times greater than the average consumption of a domestic property. Furthermore, the cost of recovering much of the commercial loss is often uneconomic.

Leakage from reservoirs is usually visible and as the number of such structures in a network is limited, it is considered less problematic and more easily checked and recovered. Leakage from the network on the other hand, is a different proposition, not only because the pipes extend for hundreds and thousands of kilometres and are almost all buried, but mainly because only a small proportion of leaks are visible. This is due to many factors, including the ground conditions and the location of other services such as sewers, in the vicinity. So finding leaks in such circumstances is quite literally a needle in a haystack problem and probably explains why leakage is so high all over the world, with values often exceeding 50% of production.

It is clear that to undertake a proper water balance, it is first necessary to collect a lot of detailed information about the flows and consumptions. Unfortunately this is not always available. Even if it were, such an assessment inevitably ends up being a long term one, normally annual, which means that an invisible leak might run for a long time before its consequence is detected. What is needed then, is a more immediate and precise way of quantifying leakage – one that is not subject to measurement errors. This is precisely the reason the minimum night flow approach was developed. It is based on the principle that as the customer consumption is usually very low at night, the flow into a network at that time corresponds almost entirely to the leakage. Not only does this allow a more accurate assessment, but it also enables a daily check to be performed. As headloss and consequently the operating pressures, are directly related to the flow, it follows that at night, the pressures will tend to be higher, causing leakage to increase. Care is therefore needed when extrapolating the night time value to an average one.

Having derived the leakage level from the water balance, it is necessary to interpret the result. Traditionally, leakage is expressed as a percentage of the inflow. However this gives no indication of the quantity being lost, the area it covers nor how difficult it will be to recover. To overcome this, it has been suggested that leakage is expressed either in terms of the customer connections (l/connection/day) or in proportion to the extension of the network (l/km/hour). The former is better suited to urban areas, whereas the latter is more universally applicable and has the advantage of being directly related to the effort needed to recover it. The IWA Water Loss Specialist Group also propose the ILI (International Leakage Index) as a performance indicator, which relates the existing leakage to a minimum or unavoidable value, with 1.0 representing the optimum. There are some doubts though over the validity of accepting a minimum level for leakage other than zero, and how this is value is defined.

The real answer though, lies in considering leakage not as a technical parameter, but as an economic loss, caused by treating and pumping water that never reaches the final customer. To recover it requires an economic investment, which increases significantly if very low leakage levels are to be attained. If follows therefore that there will be an optimum balance between investment on the one hand and savings on the other, which will vary from

network to network. Finding this point is the objective of the EU-funded PALM project which is currently being developed in Perugia, central Italy.

3. Optimum leakage level

A water network typically evolves in response to the growing needs of the population that it serves. Surface sources are often the first to be exploited. Then as the demand exceeds supply, a new and more expensive resource has to be developed, usually by tapping underground aquifers. As more and more water is extracted, the available resource risks becoming depleted and contaminated, leading to even more costly treatment and pumping. In extreme cases, particularly when the existing sources are unable to satisfy demand, desalination has to be introduced, which is very expensive and environmentally unfriendly due to the huge energy requirements of the process.

Reducing leakage will halt this viscous circle. When leakage is lowered, it is possible to optimise the production, by both extracting less from the most costly sources and exploiting lower electricity tariffs to fill the reservoirs at night. This offsets the initial cost of the intervention. The objective of the PALM (Pump And Leakage Management) project is to find the optimum leakage level for every network.

The project, which is based in Perugia in central Italy, is co-financed by the EU's LIFE Programme and involves experts from three international companies, some of which having a long and distinguished experience in leakage control. The water network of Perugia is currently managed by Umbra Acqua SpA. which is part of the ACEA group in Rome and was chosen for its complexity (2 spring sources, 3 wells, 20 reservoirs and over 100 pumps) and the long experience of controlling leakage which exists there.

The definition of the optimum level of leakage is obtained by the creation of the "Efficiency Calculator". This will be a freely available web-based software, where the main characteristics of the network will be inserted and an assessment made of the scope for reducing leakage. The key data required include the following:

- Current production volume;
- Customer consumption volume;
- Characteristics of the sources;
- Characteristics of the pumps;
- Capacity of the reservoirs;
- Length of mains;
- Energy costs;
- Treatment costs;
- Intervention costs;
- Cost / m^3 of developing new sources in the case of intermittent supply or insufficient current production.

It is recognised that the records of the water utilities are often incomplete and rarely up to date. One example of this, is with the pumps. Even if the characteristic curve is available, it invariably refers to the operation of the pump when it was new and not to its current performance which deteriorates over time. Consequently a typical wear factor will be applied which will be derived from the testing in Perugia. In addition, the flow resulting

from a combination of pumps is lower than the sum of the single units. Again, a typical factor will be derived. Few water utilities have detailed information about the cost of creating a permanent leakage control system and locating and eliminating the leaks. The Perugia network will be used to collect this information, supplemented by data derived from other projects undertaken by the partners.

The Efficiency Calculator is a DSS which compares the cost of reducing leakage with the economic benefit obtained from improving the efficiency of production. It works by integrating the network's cost / recovery curve for reducing leakage with the system cost / production curve to determine the quickest return on the investment.

Although the input data will be kept to a minimum, it will still be sufficient to provide a realistic evaluation of the situation, particularly with the application of the factors derived from Perugia and elsewhere.

The Efficiency Calculator is a tool for Water Utilities and Regulators alike, which aims to set realistic targets for improving the efficiency of a water network, as opposed to the often arbitrary percentage values which are used today. Once the target has been set, it is then necessary to achieve it, by locating the leaks. This is by no means as straight forward as it might seem, particularly as it involves finding breakages a few millimetres wide in underground networks hundreds of kilometres long.

4. Leakage control

A leak in a pressurised system generates a noise. This is the operating principles of acoustic instruments, developed specifically to locate invisible leaks. They comprise correlators, noise loggers and ground microphones which can "listen" to the noise of the leak. They have been successfully applied all over the world to accurately detect hidden leaks, provided that the knowledge of the network is good, the leak generates sufficient noise and that the pipe has good noise propagation qualities. This means that a pinhole leak in a metallic pipe subjected to high pressures is more easily detected than a split in a plastic pipe operating under low pressures. Special sensors have been developed which can be inserted through hydrants or other fittings, which improves the distance over which the noise can be detected, particularly for non-metallic pipes. However, locating leaks on such pipes is still a severe limitation of the acoustic methodology in much the same way as denying fuel is to a thoroughbred engine.

The unfortunate reality is that very few water utilities have accurate and up-to-date maps showing the characteristics of the network. Even when the knowledge is complete, to blanket survey the network is highly inefficient and not always an entirely successful exercise either, as a new leak can easily appear following the repair of a previous one. What is needed then is to be able to quantify the extent of the leak and target more precisely the detection activity with the acoustic instruments, to just the leaky pipes. This is the motivation behind the development of the District Meter Areas (DMA) methodology.

The chances of finding a lost personal item is much greater if the search is directed to just one room of a house rather than the whole town. The same principle applies to locating leaks. The key is to divide the network into a number of sectors called DMAs, in which the inflow is permanently monitored so as to immediately identify the presence of a new leak

and allow its rapid location. This is achieved by permanently closing the boundary valves and preferably supplying the DMA from a single pipe on which is installed a flow meter. An example of the division of a network into DMAs is shown in Figure 3 where the different colours refer to the degree of leakage.

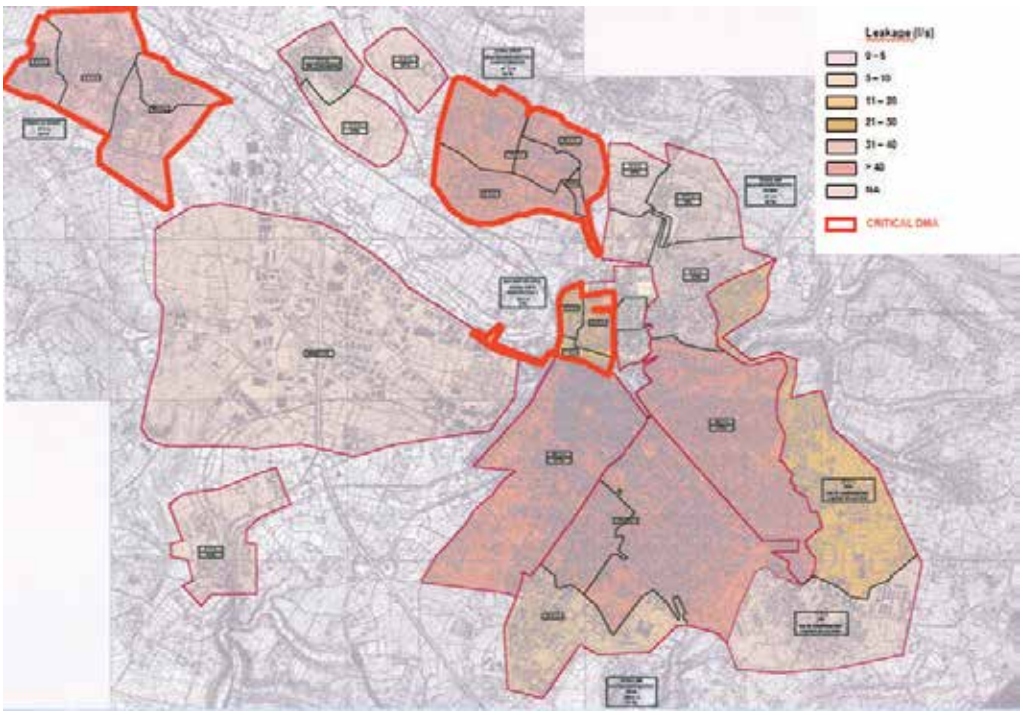

Fig. 3. Division of a network into DMAs with the critical one highlighted with a red boundary

To simplify the detection activity even further, a night step test can be performed which involves progressively isolating the DMA network. The reduction in flow following the closure of each area or step, corresponds almost directly to the leakage in the isolated pipes. This approach is also useful to verify the accuracy of the maps and identify previously unknown connections. To be effective, the test does require efficient line valves.

One significant advantage of a single supply pipe to the DMAs is that it allows a more accurate measurement of the flow than would otherwise be possible with multiple feeds, particularly cascading ones. In some situations, such as for fire fighting requirements, it might be necessary to have a reserve supply, preferably controlled by a hydraulic valve, which would open only in case of an emergency. An added benefit is that a pressure control system can be created by installing a pressure reducing valve (PRV) downstream of the flow meter, without risk of generating undesirable oscillations that might otherwise occur with multiple inlets. In this way, it is possible to maintain the optimum pressure in the DMA at all times.

Leakage is directly dependent on pressure. The higher the pressure, the higher the leakage. Experience has shown that unlike the theoretical exponential relationship derived from assessing a round orifice in a metallic pipe, in a real network it is almost linear. This

difference is thought to be due to non-homogenous pipe materials and varying breakage sizes. As the network pressure is dependent on the flow, it follows that higher pressures are likely at night when the consumption is a minimum, leading to increased leakage. This means that there is often considerable scope to lower even further the night-time pressure, to recover some of the leakage. This can be done either by installing a twin-pilot PRV, controlled by a timer, or in more sophisticated installations, to relate the downstream pressure of the PRV to the flow through the DMA meter. In addition to lowering the existing leakage level, it has been shown that a PRV also reduces the burst frequency, allowing a lower leakage level to be maintained for a longer period of time.

There are many successful applications of the permanent leakage and pressure control systems all over the world, and the results have been very positive. The difficult always relates to creating the optimum single inlet configuration without affecting the standard of service to the customers. The answer is found in the application of a fully calibrated hydraulic model.

5. Hydraulic model

A hydraulic model accurately simulates the operation of the real network in all of its key features. It is therefore a very powerful tool, not only to understand the current system operation, but also to design the optimal configuration of a network. As such, it is the key to dividing a complex water system into DMAs. A model is composed essentially of nodes and arcs; the former representing the junctions and the latter the pipes as shown in Figure 4.

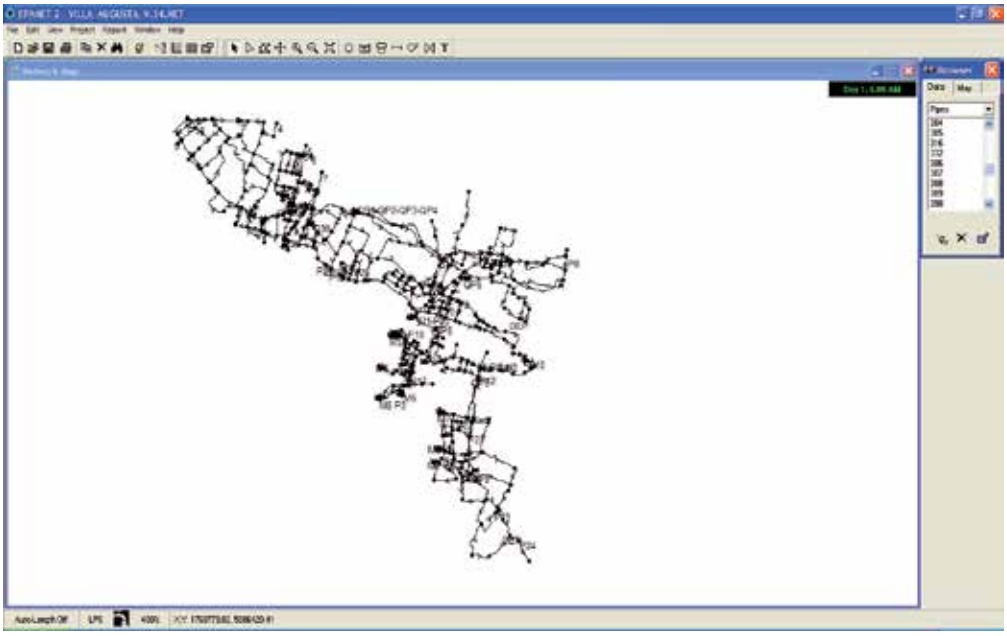

Fig. 4. Typical structure of a hydraulic model

Consumption is assigned to the nodes and ideally should be classified into the key customer categories, to which are associated typical demand profiles representing the daily variation

of consumption. Water loss should also be assigned a separate demand category to allow the assessment of a reduction in leakage on the overall network operation. An essential part of creating a hydraulic model, is to verify its accuracy. This is undertaken by comparing the pressures and flows calculated by the model with those measured in the field. Any differences indicates an error in the historical knowledge and should be investigated and resolved. Anomalies typically relate to an unknown status of line valves, with throttled or fully closed valves being particularly prevalent.

Undertaking a field monitoring exercise can be a costly operation as it requires the contemporary installation of a significant number of data loggers, pressure transducer and portable flow meters. However, to limit or even avoid completely this activity, represents a false economy, particularly when compared with the cost of an erroneous design derived from an incorrect model. Only after the model is confirmed to accurately represent the reality and all the important anomalies have been resolved in the field, can it be applied with confidence to the design of the optimum DMA boundaries. This is particularly important in networks having low operating pressures, which invariably have a high leakage level in the first place and represents a classic chicken and egg situation: leakage causes low pressures; leakage cannot be recovered without first dividing the network into DMAs; dividing the network into DMAs tends to lower the operating pressures. A well calibrated hydraulic model solves this vicious circle. By identifying the pipes having little or no hydraulic importance which can therefore be closed, the current level of the service to the customers can be maintained even with a single supply pipe.

The model can also be used to assess how the DMA design will operate with future consumptions and to define a pressure control system. In fact, it is very useful to determine the critical customer, the optimum position and correct size of the valve so that it doesn't cause operational problems in the future.

The application of hydraulic modelling for the design of DMAs is still not particularly common. This is unfortunate and severely limits the creation of permanent leakage control systems. Part of the reason is the mistaken idea that to build a model, first it is necessary to have perfectly accurate data. This is not the case, as the calibration of the model acts as a check of all of the historical information used to build it. In fact the verification of the model highlights where the historical knowledge is incomplete or incorrect. As such, it is an extremely powerful tool, which can be applied for most if not all of the design, management and maintenance activities regarding a water network.

Once the design has been defined with the model, it is possible to create it with confidence in the field. It is necessary to ensure that all the boundary valves are operational and the inefficient ones are replaced. A check should be carried out to ensure that there are no unknown connections which could falsify the monitoring. The flow meter on the inlet pipes needs to be installed and commissioned, coupled where possible to a PRV.

The creation of DMAs does not in itself reduce leakage, although the reduction of pressure will be beneficial. What it does, is allow the identification of the leakiest parts where a detection activity should be targeted. It follows therefore, that it is essential to manage diligently the DMAs, which when undertaken manually can be a laborious, repetitive and time-consuming activity. For this reason it is preferable to automate the process. This is the object of the EU funded project called Autoleak.

6. Optimum management of DMAs

The division of the network into DMAs allows a constant control to be kept on the situation at all times. In most cases, this involves simply checking the minimum night flows to see if there has been any variation. The flow data can be transmitted daily to the control room thanks to the deployment of simple, low cost GSM data loggers. Despite all of this, leakage levels are still higher than optimal in many of the world's water network. Most surprisingly perhaps, is that this even applies to networks where DMAs have been constructed. The question is why?

The answer can be found in the repetitiveness of the manual process and the lack of priority given to maintaining a low leakage level. The solution is to automate as much as possible, preferably by relating the leakage to the economic loss and environmental impact. This is the objective of the Autoleak project funded by the ECO-INNOVATION programme of the European Union.

As the name implies, Autoleak aims to automate the process of managing leakage by integrating readily available technology. For instance, it combines the flow from the DMA meters transmitted by GSM loggers, with the customer consumption, to determine daily the leakage level. It then introduces the historical information regarding the minimum leakage level, past interventions and the production cost of the water in each DMA to define the typical cost of the intervention and the likely benefit.

Leakage is like hair: if not cut regularly, it just keeps on growing. This process is clearly seen in Figure 5 and is termed the natural rate of rise of leakage and is determined in Autoleak from the historical data for each singular DMA.

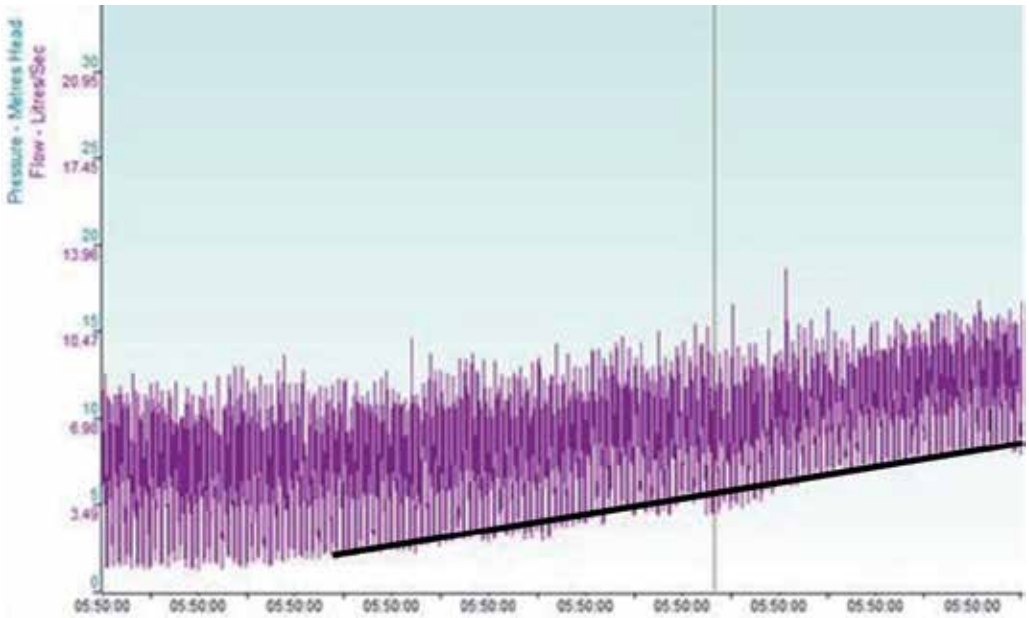

Fig. 5. The natural rate of rise of leakage can be seen from the steady increase in the minimum night flow.

As a result, it is possible to predict the duration of the recovery and hence the total value of the recovered water. This can be compared with the estimate of the cost of intervention which again is based on historical information for the DMA. If the value of the recovered water (V) is greater than the intervention cost (X) then it is worthwhile reducing the leakage. The mechanism is shown graphically in Figure 6.

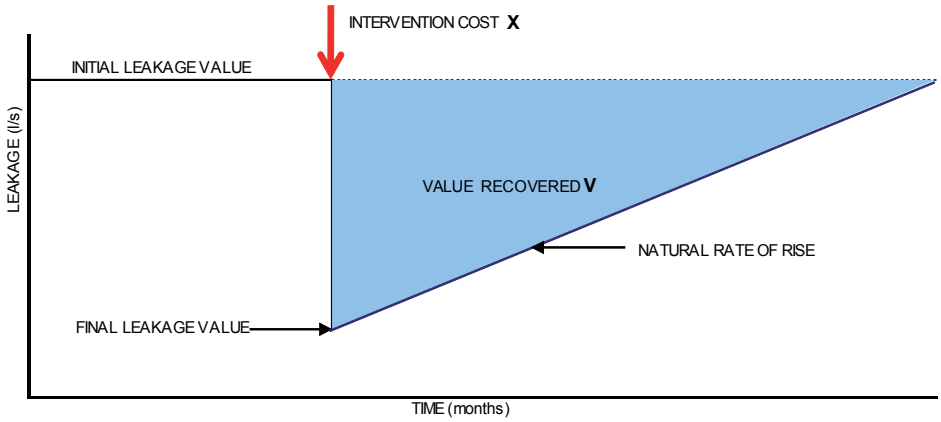

Fig. 6. Operating mechanism of Autoleak where an Intervention (red arrow) will yield a benefit (blue triangle)

Autoleak is notable for its innovative approach to managing DMAs which exploits and integrates existing and readily available technology with a self-teaching mechanism. It can be configured for different degrees of sophistication, ranging from the minimum night flow analysis to full integration with Automatic Meter Reading systems (AMR). This last aspect, which probably represents the maximum expression of today's technology, can be used also to gather information from noise loggers which are permanently positioned in the network and communicate the position of a leak without having even going out on site.

In addition to the economic evaluation, Autoleak will also determine the environmental benefit from recovering the leaks. Water is often considered to be one of the cleanest and purest of the earth's natural resources. This does not take into consideration however the significant environmental impact of pumping and treating water which is then lost. This aspect is likely to become an important issue in the future.

7. Conclusions

The world is already facing an acute water crisis and in the coming years it is predicted to get even worse. One important contributing factor is the losses from water supply and distribution networks which can often exceed 50% of the production. Such a contradiction might be hard to comprehend, particularly when it relates to probably life's most important natural resource. But the number of water networks in the world subjected to intermittent supply is ample testimony to the seriousness of the situation. It begs the question then, why is nothing done about it.

The answer is complex and relates mainly to the 'out of sight out of mind' mentality which is so prevalent in water utilities all over the world. If however a simple water balance was

undertaken, the reality would quickly become apparent. Relating the results to the economic loss, would show a very rapid payback period on the investment needed for the intervention. Thanks to an innovative decision support system, developed as part of the EU-PALM project, such an assessment is now a reality.

But even if it was worthwhile economically to do something about the leakage, what is the solution? The classic answer would be to replace most of the pipes, on the basis that they are old. But this is far from the optimum approach which is to identify and fix what is broken. This is achieved by applying a step by step approach which involves dividing the whole network into sectors, called District Meter Areas (DMAs), supplied by a single pipe on which is installed a flow meter. In this way it is possible not only to identify immediately the presence of a leak, but know in which part of the network it is located.

A broken pressurised pipe generates a noise. By applying specially developed acoustic instruments, it is possible to accurately locate the position of an invisible leak. The area of application of these instruments can be further restricted by isolating at night the DMA network during a step tests to identify the leakiest pipes, allowing an almost instant recovery of the leak.

The key to maintaining a low leakage level in a water network is to reduce the frequency of failure. An important contribution to achieving this goal is provided by the permanent control of pressure through the installation of pressure reducing valves (PRV). The single supply to each DMA not only allows the optimisation of the system by avoiding potentially damaging pressure oscillations which might otherwise occur with multiple feeds, but lowers the night operating pressure to reduce even further the leakage level.

The reality of water networks in many parts of the world is that the information regarding them is often incomplete and out of date. Probably, for this reason, leakage is such a problem in the first place. It does make dividing the network into permanent districts, by the closure of line valves, all but impossible. The solution is found in the application of a fully calibrated hydraulic model which simulates the real network in all of its key features. In this way, by first eliminating the previously unknown anomalies, it is possible to define the optimum DMA boundaries which when constructed will not affect the existing quality of the service to the customers.

The creation of DMAs has in itself little impact on the leakage level, but is the key to resolving the problem. What it does, is to allow the situation to be kept permanently under control, so that when a new leak breaks out, its size and position is easily identified. The difficulty is that if undertaken manually, this constant checking becomes tedious, repetitive and time consuming activity which ends up eventually being neglected. Inevitably the leakage level starts to climb again. The solution is to apply a Decisional Support System which automatically evaluates not only the current leakage level and assesses how much can be recovered, but from historical data, can predict the future trend so as to quantify the total potential saving and compare it with the likely cost of the intervention. The innovative Autoleak system, developed as part of an EU-financed project, represents such a system.

With the application of the latest technology, including hydraulic modelling and Decision Support Systems, it is feasible to not only lower significantly the existing leakage levels in water networks around the world, but just as importantly, maintain a low level in the future

– all for a relatively low investment. This will contribute to alleviating the severe water crisis that the world is already facing, the solution to which must start from a more efficient use of the available resource.

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Securing the future of the human race will require an improved understanding of the environment as well as of technological solutions, mindsets and behaviors in line with modes of development that the ecosphere of our planet can support. Some experts see the only solution in a global deflation of the currently unsustainable exploitation of resources. However, sustainable development offers an approach that would be practical to fuse with the managerial strategies and assessment tools for policy and decision makers at the regional planning level. Environmentalists, architects, engineers, policy makers and economists will have to work together in order to ensure that planning and development can meet our society's present needs without compromising the security of future generations. Better planning methods for urban and rural expansion could prevent environmental destruction and imminent crises. Energy, transport, water, environment and food production systems should aim for self-sufficiency and not the rapid depletion of natural resources. Planning for sustainable development must overcome many complex technical and social issues.

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