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СОЦИАЛЬНО-ЭКОНОМИЧЕСКИЙ ПОТЕНЦИАЛ УСТОЙЧИВОГО РАЗВИТИЯ

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Textbook on

SOCIAL AND ECONOMIC POTENTIAL OF SUSTAINABLE DEVELOPMENT

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Russian version of the textbook is recommended as a textbook by the Ministry of Education and Science of Ukraine. The letter №14/18-Г-418 of 22.02.2007.

Social and Economic Potential of Sustainable Development / Edited by L. Hens and L. Melnyk – Sumy: "University Book", 2008. – 320 p.

ISBN 978-966-680-380-4

This textbook is prepared by scientists from 15 countries. It deals with the theoretical and practical aspects of sustainable development. The textbook focuses on complex relationships between human beings, biosphere and economy. The book represents a unique supplementary reading material in addition to lectures on sustainable development for both bachelor and master's students, and their instructors. It also targets other interested in sustainable development parties such as environmental experts and/or companies, unions, NGOs, government authorities and others.

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Table of contents

Sustainable Development Shapes a New Way of Thinking (Preface)

Having defined an increase in social welfare and security of a human being safety, as well as his strive to live and create in harmony with nature as the main goal of a country's development, equipped with fundamental principles, formulated by the UN Conference on Environment and Development (Rio de Janeiro 1992) currently many countries, including Ukraine, begin their transformation process, which due to its character and resource utilization, investment policy, science, education, technological change, nation security will comply with current and future needs, and will create favourable conditions for transition to sustainable development (SD).

Sustainable development is a viable solution to one of the largest problems of humanity. In fact, it is about the very existence of human civilization compelled to search for an answer, whether or not the global community would be able and willing to mobilize the required mechanisms to allow future generations to meet their needs and to live and develop on their own.

Since the adoption of the SD concept in 1992, the world community has designed and published dozens of fundamental documents and recommendations, held hundreds of symposiums, conferences, and forums associated with the concept. However, as matter of fact currently the achieved results significantly diverge from the earlier formulated goals, and the world socio-economic situation remains disturbing. One of the reasons for this is that despite all the efforts the SD concept has not been broadly accepted by the public. In particular, extremely poor coverage of the SD concept in education remains a very important issue. There are no special disciplines and almost no required literature, and traditional courses are not properly reformatted. Although for a decade and a half the whole world has been living under a new ideological doctrine, nonetheless annually new graduates start their careers with the ad-hoc knowledge of the SD concept. As well there is no targeted retraining of current professionals, even though living, thinking, making decision and acting under new circumstances must also be new.

The timeliness of the textbook is not only in its pioneering effort in the field of SD in Ukraine, but also in its practical application, namely the development of practical instruments for the socio-economic potential of the SD concept. Fortunately the authors pay much attention to the dynamics and inner content of the studied phenomena. The authors interpret components of the SD concept not as static, but as constantly evolving self-developing systems, including non-material managerial systems, models, real economic structures and social systems.

Apparently and without exaggeration, this textbook can be viewed as a new generation of educational literature. Its materials, many of which could be parts of a monograph, are presented to students in an easygoing and acceptable way. Such an approach is beyond any doubt. Closing the gap between scientific ideas and their broad implementation is a reality of time. The importance of this statement is especially magnified with respect to the SD concept which plays a decisive role in the destiny of the whole mankind. It is encouraging that researchers from 15 countries have participated in its design. It is a double pleasure that the textbook's place of birth is Ukraine.

Without any doubt publication of this textbook is a significant scientific and academic event. It is remarkable that despite vast geography of the authors, they appeared as a strong homogeneous team of specialist with similar views able to create solid, rich in content, well systematized and easily acceptable studying material. This is a significant achievement of the editorial board, which is a collaboration of the Ukrainian and Belgian Universities – Sumy State University and Free University of Brussels – both well known for their previous experience in the field.

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Introduction

Leonid Melnyk
Luc Hens

This book contains selected and summarized fragments of the international textbook “Social and Economic Potential of Sustainable Development” (in Russian).

The international textbook intends to familiarize students with the biological, ecological and economic aspects of sustainable development. Each of these aspects has its own homeostasis and metabolism. Sustainability of the homeostasis is a distinguishing feature of the first two systems. Humans can only survive under the physical and chemical conditions that prevail in the ecosystems. In turn, these parameters depend on the physical and chemical properties of the natural environment. Therefore, the main problem of sustainable development can be seen as deviations from a balanced equilibrium in ecosystems as a result of human activity.

Continuous population growth (a quantitative cause) and consumption (a qualitative cause) are the main reasons for the disequilibria. To prevent pressure on the natural environment, economic system must constantly respond to these drivers of destruction. It is most necessary to reduce the pressure per unit of goods and services produced and consumed. Therefore, the goal of social and economic development should be:

- To maintain homeostasis of the “human species” (biological humans). This reflects the human dimension of sustainable development (SD).
- To maintain homeostasis of the supporting natural systems. This reflects the ecological dimension of SD.
- To provide goods and services by the economic system. This reflects the economic dimension of SD.

To achieve these goals, two other systems that do not have their own metabolism and homeostasis, should be included in the approach:

- The social individual, who is part of the biological individual;
- The social system (the community of people), which exists on the basis of economic system.

The Socio-individual determines the economic human. This "homo economicus" is a major factor in production and consumption. The social and economical aspects of a man combine with the biological human in a physical body. Consequently, harmony between these three human aspects is necessary for a proper economic system.

These considerations have driven the structure of this textbook.

This textbook emerged from the need to act urgently on sustainable development. We feel the threats for the environmental, social and economic issues. We have no time to experiment with strategies on sustainable development. This textbook collects different essential aspects of how the international community understands SD today.

To this end the project promoters attracted the leading scientists on SD from 15 countries (Australia, Belarus, Belgium, Ghana, Germany, Italy, Canada, Republic of China, the Netherlands, Moldova, Russia, Ukraine, Czech Republic, Switzerland, and Japan) to contribute to this textbook. The most recent research results on sustainable development are presented in an easy and understandable way. The book targets those who feel responsible for future generations, and for present day students.

This textbook is also on a quest for a common conceptual field, which allows the representatives of different countries to start the study of such a complex phenomenon as *sustainable development*. This is of utmost importance, in view of the common international problems, the international community currently faces and which call for urgent solutions.

The textbook equally aims to remove barriers of misunderstanding (barriers including language), which, unfortunately, still continue to exist between west and east (post Soviet) scientific schools. For a number of English language papers, the key terms in the original language are indicated between brackets. These interlanguage "bridges" facilitate understanding of the concepts, and provide the reader an opportunity to understand deeper the original ideas. We consider this useful in a teaching process.

This textbook results from a project in which Ukrainian and Belgian researchers cooperated (the Department of Economics at Sumy State University, Economic Research Centre (Ukraine) and the Department of Human Ecology at Vrije Universiteit Brussel (Belgium). Publication of the textbooks in Russian and English (Economics, 1998; Environment, 1998), (Basics, 2005), two study guides (Basics, 2005; Basics, 2006), a textbook (Basics of Ecology, 2006) and a monograph (Methods, 2005) preceded the publication of this textbook.

Collaborators of the Sumy State University, and Economic Research Centre (Sumy) prepared the manuscripts for publication.

Knowledge has a unique ability to result in new knowledge. This is a paradoxical multiplication (field broadening) effect. Currently humanity "knows more" about sustainable development. We seem to know even more about it than fifteen years ago, when the concept first appeared. We urgently need to proceed from flat to deep understanding of SD. This textbook aims at contributing to this transition of knowledge. The next step is absolutely new knowledge.

The authors hope that this textbook will add to understanding of the principles, mechanisms and methods of sustainable development. They equally hope it will pave the road to solutions to vital problems based on sustainable development.

The editorial board is grateful to all authors, who participated in the preparation of this textbook; reviewers, who improved the content, and all others, who took an active part in the prepublication activities. State Fund of Fundamental Research, JSC Khimprom, Enterprise «Spetsoborudovanie» are the co-sponsors of English version publication.

Authors' contribution (the country of residence for non-Ukrainians is given in brackets).

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Luc Hens
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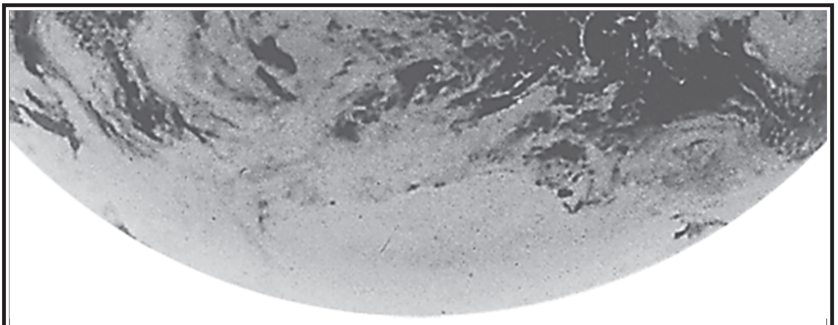
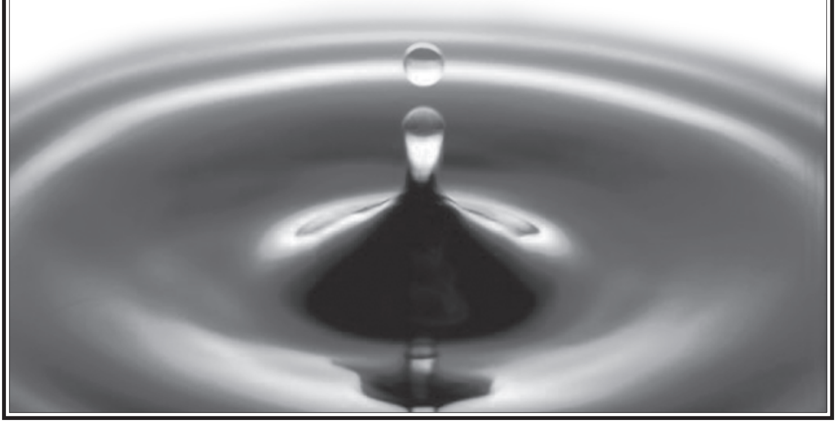


PART I

PREREQUISITES TO SUSTAINABLE DEVELOPMENT



1.1. Fundamentals of systems sustainable development

Deep understanding of sustainable development prerequisites requires researching fundamentals of systems development. Detailed analysis of mechanisms and factors of development allows introducing the diagram of their integral interaction (Figure 1.1.1).

The *system* is a material and information entity (whole) consisting of different components. The system possesses properties that are not present for its components (the entity is greater than the sum of its components). The *development* is irreversible, directed and logical change in the system.

The main postulates of the mentioned mechanisms are the following:

1. Only *open stationary systems* are able to develop.

The *openness* of the system means that it carries out the metabolism, i.e., exchange of material, power and information with the environment. The metabolism serves as a source of free energy entering into the system and removes vital activity wastes from it.

If the system is stationary, it means that it is able to maintain stable (sustainable) dynamic equilibrium – *homeostasis*. The homeostasis is characterised by a dynamic relative constancy of system's composition and properties. It is needed for maintaining the required difference in physical and chemical potentials (temperature potential, chemical potential, electromagnetic potential, etc.) between the system and the environment, as well as between separate components within the system. The system can exist only carrying certain homeostasis values that fall into very narrow intervals of the mentioned potentials.

The deviation of the system's parameters determining the level of homeostasis from the system's optimal values leads to damage in its functionality or to termination of its existence as a self-developing system. To change the homeostasis level it is necessary to reorganize the whole system, i.e. to introduce radical changes to interactions between the system's components.

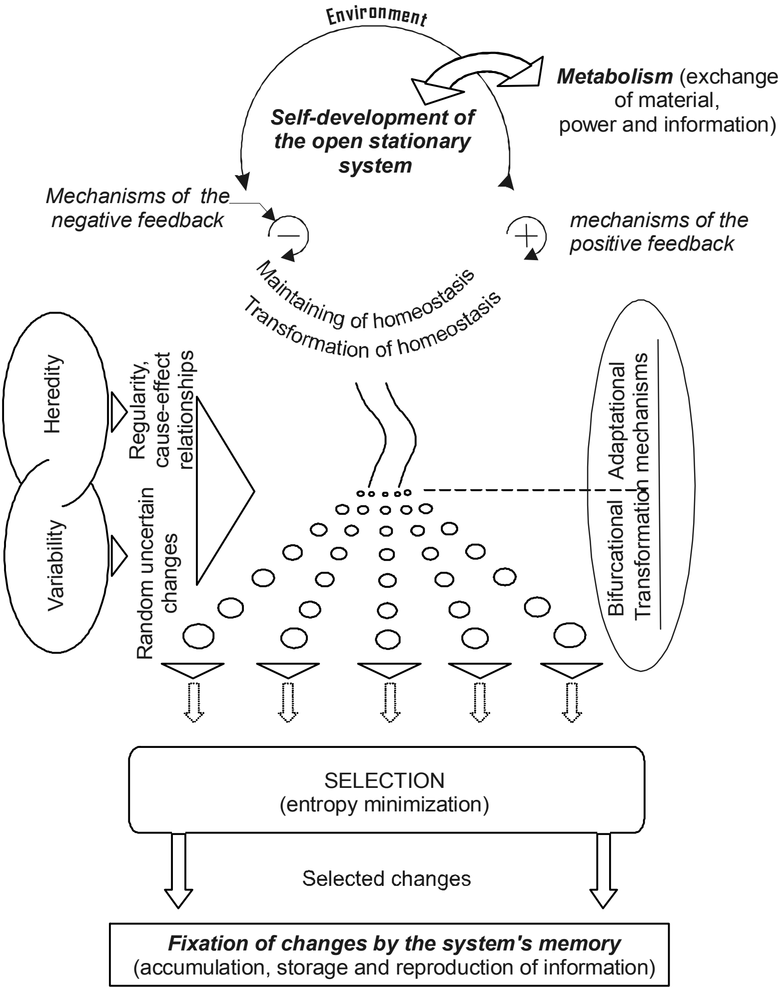


Figure 1.1.1: The integration diagram of development mechanisms and factors

Open stationary systems include inanimate structures exhibiting cooperative behaviour, live organisms, ecosystems, social organizations (firms, associations, markets, microeconomic systems).

2. To *carry (maintain) homeostasis* the system uses the mechanisms of the negative feedback that are aimed at compensating the influence of environmental factors. *Negative feedback* mechanisms act in an opposite direction to the influencing factors. To implement the mechanisms of negative feedback the system has to spend *free energy*.

3. In case the system's energy balance is disrupted and the total energy consumption by the system becomes larger or smaller than the free energy inflow, the system gets reorganised. So, the system changes its homeostasis level increasing or reducing it accordingly (if the system is elastic enough for such a reorganisation). *The change in homeostasis level* and related to it reorganisation of the system's structure is achieved by using *positive feedback mechanisms*. Those mechanisms require free energy as well.

4. The system's development is accomplished due to interaction of three groups of factors: *variability, heredity, selection*.

Variability provides *random uncertain* fluctuations, i.e., deviations from the system's equilibrium state.

Heredity guarantees *regularity* of changes. It is determined by *cause-effect relationships* between the processes. Due to this feature *the future* is *dependent on the past*.

Selection chooses the most effective states of a system, i.e., the changes that the system has experienced. *The selection criterion* is the minimization of the system's entropy. It means that only those states of the system with *the maximum information value* can be selected. Eventually, this leads to *minimization of dissipation* (irreversible dispersion) of energy. Thus, only the most effective states of the system survive.

5. The mentioned factors of development can be implemented by the system via two classes of mechanisms: adaptational and bifurcational.

Adaptational mechanisms implement functions of variability, heredity and selection under the rule of preserving the main characteristics of the existing system, i.e., within the limits of the same biological organism, ecosystems, firm, country.

Bifurcational (branched) mechanisms implement the mentioned functions on the basis of consecutive change in qualitatively new system states that lose the main characteristics of their predecessor, although keeping hereditary links with it. Biological organisms generations change, firms restructuring, radical change of a form of government, etc. are the examples of such processes.

Bifurcational mechanisms allow reaching the most favourable conditions for development. Discontinuity and branching allow the system to "forget" the former, less effective state and to select a new, more effective one (or new ones) using multivariant search. The same mechanisms not only assure irreversibility of the process, but also implement another important property of fixing the occurred changes. Bifurcational mechanisms are much more effective in comparison with adaptational mechanisms as they allow considerably increasing the rates of development.

The origin of the intellect with its ability to form and select *virtual bifurcations* allowed accelerating the processes of development significantly (functions of variability, heredity and selection). It played the role of impulse in avalanche-like rates acceleration in nature evolution. The computer era reinforced these processes.

6. Information fixing of the changes that have happened is the last stage in every cycle of the system's development. The system memory plays the leading role here. *The memory* has the ability to *accumulate*, *store* and *reproduce* information. In fact, new standards of the system's behaviour are fixed there. The system will function according to them until new changes come and get fixed. To function for the system means to duplicate and reproduce the system processes of vital activity repeatedly. Thus, the memory serves as the mean for fixation of the most effective system states. As we see, the memory is the last and very important component of every development cycle.

7. All processes of systems functioning and development happen due to the interaction between three natural origins: *energy potency, information reality,* and *synergetic phenomenon.*

Energy potency stipulates system's ability to fulfill work (change).

Information reality realizes in the system as the system's energy potential, fixed by memory, i.e. its ability to change in space and time in concordance with strictly defined programs (the ability to reproduce definite states of the system). In particular, it means the ability to store or change different parameters of the system: form, colour, scent, vibrancy and other movements etc.

Synergetic phenomenon stipulates the interactions of the separate parts of the system. As a result, they begin to behave as a whole unit. For this to happen two conditions are necessary:

(a) first, separate parts of the system must react to (external) environmental changes;
(b) second, separate parts must show coherent actions, i.e. "interact" as synchronizing their changes. Synergetic phenomenon leads to the so called emergency effect, when components form the system, i.e. the whole, which is greater than the sum of its parts.

Acting so, the triad of the mentioned above phenomena forms the fourth origin of nature – reproduction phenomenon, which reproduces a certain natural essence, being able to reproduce (sustainably renew) in time its characteristic features. In particular: elementary particles, atoms, molecules, cells, biological species, social structures (families, firms, and countries) can be considered as such essences.

Mechanisms and factors mentioned above create necessary and sufficient conditions for realizing evolutionary processes. They create a multilevel system, which constantly reproduces those necessary *irreversible, direct* and *regular* changes of systems in stochastic conditions and indefinite states of the environment. Socio-economic development can be sustainable, if self-organization, self-regulation and self-reproduction mechanisms of natural systems are preserved.

Reproduction processes mean the unites of the three groups of factors: energy, information and synergetic phenomenon. Every natural essence (plant, animal, ecosystem and the biosphere) is a unique system, which constantly reproduces in time and space the unity of three natural origins (material basis, information and synergetic phenomenon). The reproduction of every natural essence, including the biosphere (which guarantees necessary life conditions for human beings) is a very complex task. Human being will never be able to completely understand this reproduction mechanism. Moreover, human being will never be able to totally control these processes. It means a human being must not exceed the level of impact on nature reproduction mechanism and its three key subsystems:

a) *material* (critical margins of material component derivation – plants, animals);
b) *information* (withdrawal, distorting and collecting the new information);
c) *synergetic* (impede communication links between biological species)

Preservation of the reproduction mechanism is not only a necessary condition of life sustainability on the Earth, but also a prerequisite of its development in all forms, including social. Development can happen only due to sufficient development factors: *variability, heredity and selection*.

1.2. Basics of reproduction of systemic human triad and functions of nature

Problems of sustainable socio-economic development deal with management of the three interrelated systems: human biological nature ("bio-person"), the biosphere and socio-economic system. Human factor, which is the leading subject and object of current changes, is the key component in their functioning and development.

The complexity and difficulty of solving the problems of sustainable development relates to the complexity of the human nature itself. Human is a unified system (whole), which includes three interrelated and interconnected systems:

- A man as a biological creature is a part of the natural environment in physiological constitution.
- A man as a social creature (personality) is a part of the society and its social nature.
- A man as a component of the economic system is a workforce, labour resource.

Environmental factors influence a human via the following functions that can be united into four main groups (Figure 1.2.1):

1. Physiological functions support a person's life as a sociological constitution ("bio-person").
2. Social functions support development of a person's personality ("socio-person").
3. Economic functions determine activity of the economic system, including the labour resource reproduction ("labour-person").
4. Environmental functions form, support, and govern the state of ecosystem, where a person lives.

Even though three persons (bio-, socio-, and labour-) exist in one physical body they differ from each other to a great extent in their vital needs, such as:

- "*Bio-person's*" needs are related to satisfaction of the natural necessities in food, water, air that are essential for life and physiological comfort (temperature, pressure, humidity, etc).
- "*Socio-person's*" needs are related to development of personality and fulfilment of social interests.
- "*Labour-person's*" needs are related to achievement of certain economic aims (profit maximisation, cost minimisation, reproduction of skills).

Apparently, everybody can identify the differences between functions and motives of each person's actions. Fear, starvation, and other instincts urge the psychological person. "Socio-person" is guided by duty, aspiration for self-expression, and public recog-

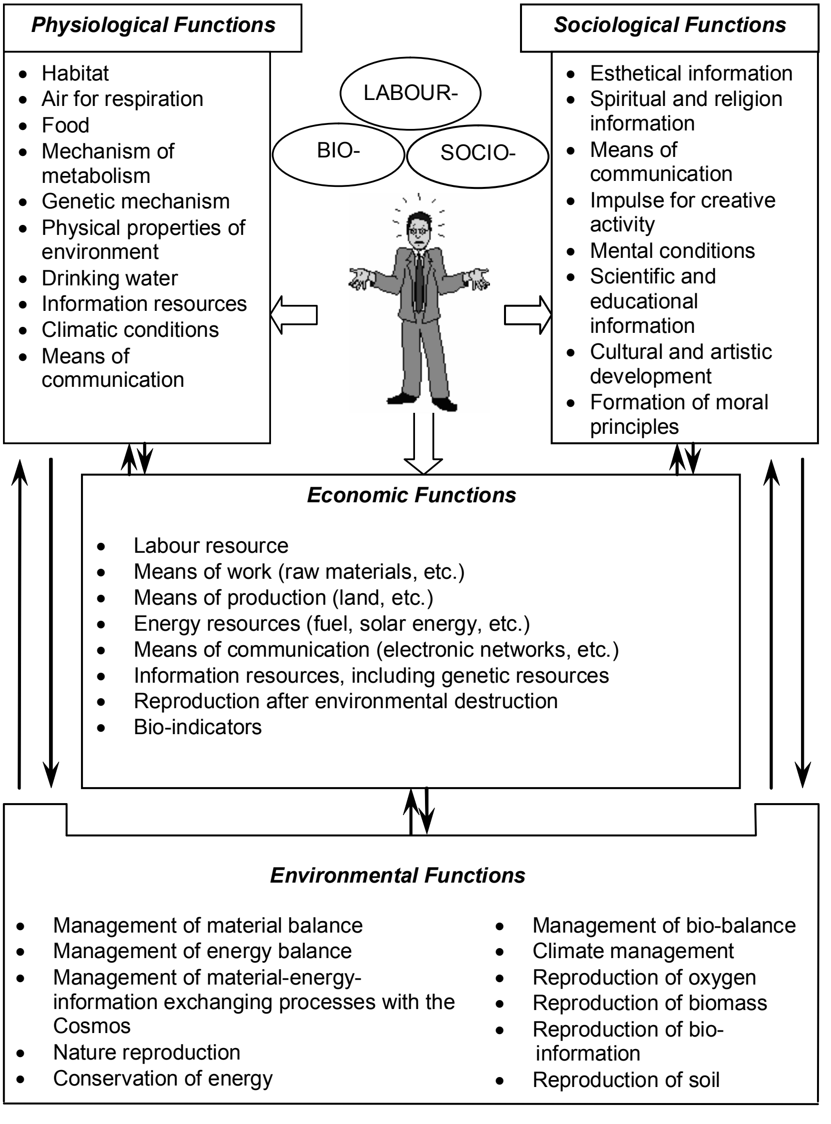


Figure 1.2.1: Environmental functions

nition. The motives of a "labour-person" are the tendency for making profit and career goals among others.

Undoubtedly, it is a very simplified scheme because the given trinity is not a simple sum of its components, it is a very complicated system. It is well known that a person may be called the "microspace". Successes or failures of the "labour-person" in many cases depend upon the "bio-person's" health and "socio-person's" creative abilities. The "bio-person" and "socio-person" are in close connection with the economic functions.

It is necessary to emphasize the environmental and economic conditions as well as the environmental functions that are closely related to the components forming the person's trinity. The prerequisites for solving the given contradictions are, in fact, achieved mainly at the expense of the realization of the person's physiological and social needs which, in their turn, depend upon the successes of the economic system.

Why is it necessary to know the tri-union system of human essence and the corresponding functions of nature for understanding and solving the problems of sustainable development (SD)?

(a) Breaking of the impact margins on the planet's biosphere will be ruinous for the biological nature of a human ("bio-person"). It stipulates one of the objectives of SD, namely preserving and conserving conditions that support human life.
(b) Problems of sustainable development deal not only with the necessity of "bio-person" survival, but also with the provision of conditions for "socio-person" development. This requires preserving the information value of natural systems where a "socio-person" lives and develops. It is also important for solving the problems of sustainable development itself. Only a socially developed person (i.e., the one that has sufficient knowledge, outlook and moral principles) can adequately estimate the problems of SD, make correct decisions and have the will to implement them.
(c) Solving of SD problems depends on a "labour-person's" ability for adequate transformation. Their ability to change themselves and to change economic system (to improve knowledge

and human abilities, to make the demand and supply "green", to increase the efficiency of processes, to decrease the resource-intensity of production and consumption of goods and services) will determine their level of success in achieving SD.

Achieving the sustainable development is a difficult and dynamic task. As the result, the art of SD management means the ability to *preserve* (conserve) some functions of nature that support the needs of "bio-person" and partially "socio-person" and very rapidly change some other functions of nature that satisfy the needs of "labour-person" and partially "socio-person".

1.3. Sustainable development: goals, objectives, problems

At large sustainable development includes the following three elements – each of which belongs to the class of open stationary systems:

- a man as a biological organism and as a social being;
- ecosystem and biosphere in general;
- social-economic system.

Systems analysis can provide us with fundamental differences of the objectives of sustainable development from a concept of a pure economic development. As it stands, the principle goal of sustainable development is associated with predominantly infinite existence of human civilization and its evolutionary development (Figure 1.3.1). This goal is applied at two levels: (i) Necessary level, also known as subsistence level, which basically means physical survival of a biological human being; 2) Sufficient level, which means spiritual development of a social human being. Both levels are extremely important.

Among objective of the sustainable development there are ***providing objectives*** that are aimed at: (i) preservation of biosphere in a very narrow sense when human biological being can exist (i.e., human organism can maintain its homeostasis level); this depends on such parameters as key climate characteristics and physical parameters (temperature, electromagnetic features, cosmic em-

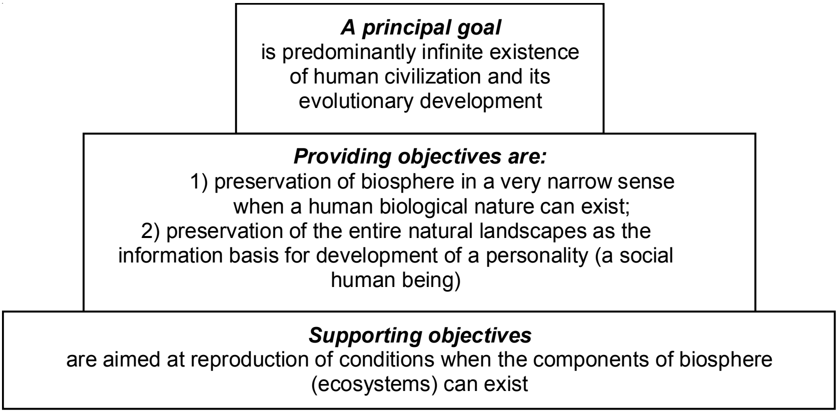


Figure 1.3.1: Objectives of sustainable development

anation), atmosphere and water composition, the composition of soil used for agricultural production; (ii) preservation of the entire landscapes as informational basis for development of a personality (a social human being).

As well there are ***supporting objectives*** that stipulate the creation and maintenance of the conditions when biosphere and its components can exist, which actually provides some vital conditions for a human being as a biological being and as a homo sapience.

Social-economic system also helps to achieve some goals of sustainable development. These goals are: (i) provision of biological metabolism (nutrition and drinking water supply); (ii) provision of optimal physical conditions; (iii) provision of material and informational flows for spiritual development of a human being.

Principle difference amongst three components of sustainable development mentioned above is as follows (Figure 1.3.2). A man as a biological being can live only within a very narrow interval of physical and environmental parameters set for him by nature. Any deviation from these parameters threatens the entire existence of human civilization. To preserve this narrow interval, some negative feedback mechanism is required based on constraints, standards,

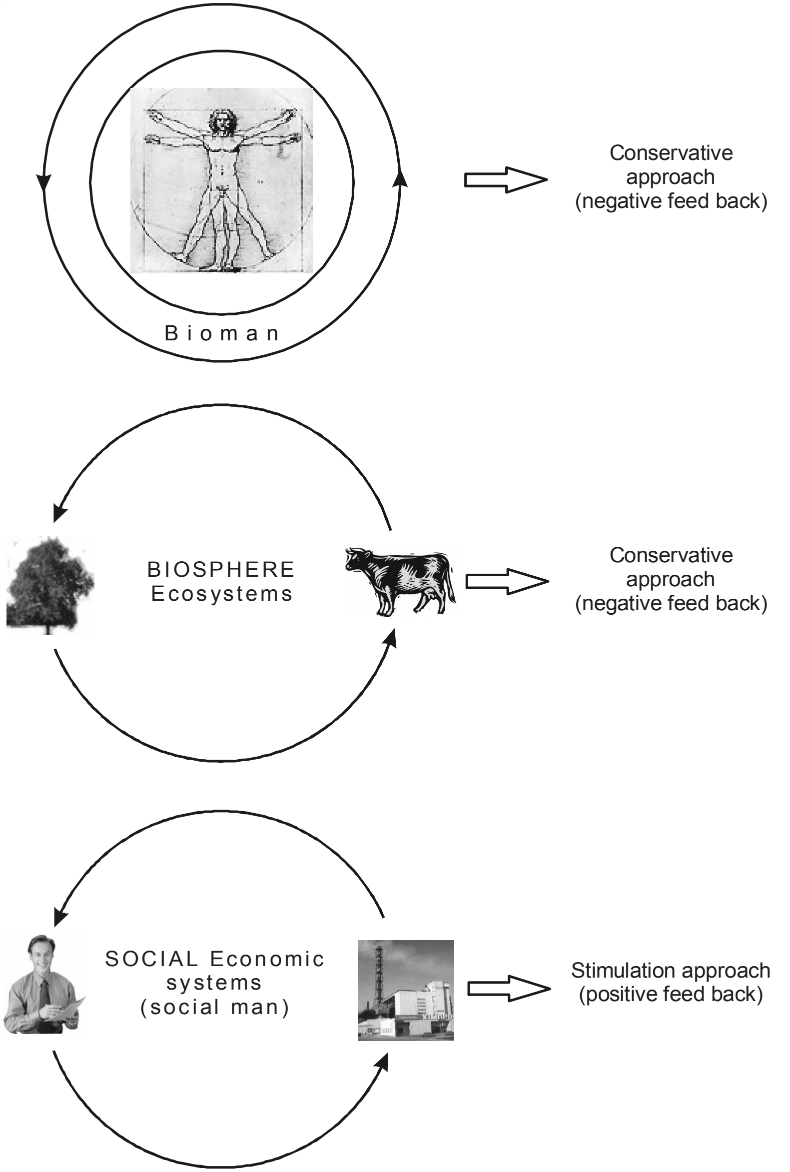


Figure 1.3.2: Approaches to formation of economic instruments of sustainable development

bans, sanctions, etc. This is how ideally economic mechanism should work in order to achieve goals of sustainable development.

In contrast, constraints that are associated with the necessity to preserve *biosphere and ecosystem elements'* homeostasis are relative in nature. Change in the environmental conditions and biosphere's homeostasis as well as preservation of ecosystem's homeostasis are the required conditions for a human being. Negative feedback loops including economic instruments are needed to preserve original power of land (reserves and national parks) as well as to reduce ecological impact on all the components of the natural environment.

Social-economic system is the only element that can and must transform rapidly. It is necessary because of first, satisfaction of social needs of a human being that change very quickly or in other words they progress; second, because of improvement of the social-economic system itself. The latter is based on production that satisfies ever-increasing human needs. In order to be able to accommodate constantly growing population and to stay within the capacity of ecological system, production needs have to become more efficient to achieve resource preservation, particularly in terms of reduction in material and energy consumption. So, contrary to a biological human being and biosphere, management of the social-economic system should be a target of progressive change in homeostasis instead of just its preservation. In this regard, positive feedback mechanisms should be developed.

Two approaches, *conservative* and that of *positive changes* constitute a methodological basis of a modern economic mechanism to achieve sustainable development.

Conservative approach is based on the use of negative feedback mechanisms. With their help mankind resists any changes (this is where the name comes from) that can threaten ecosystem's sustainability. Currently, in environmental sciences this approach is realized in the following forms (Figure 1.3.3):

- *preservation methods:* creation of reserves, national parks – territories, where the impact on nature is reduced; bans on endangered biological species;

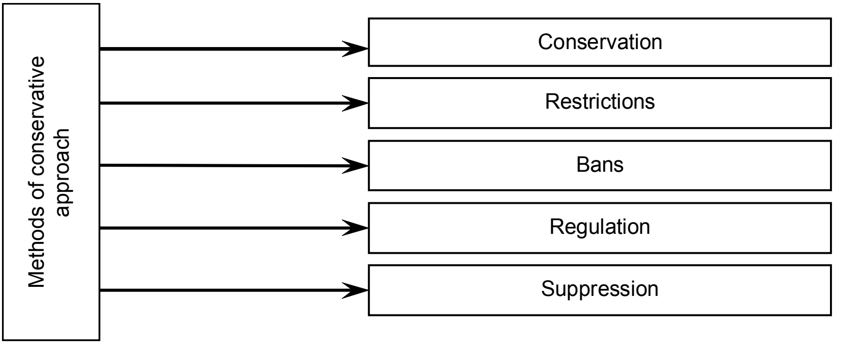


Figure 1.3.3: Forms of conservative methods

- *restricting methods:* licenses for the use of natural resources; quotas for wild animals trade; environmental standards; regulation of hunting; birthrate regulation;
- *prohibitive methods:* bans on hunting of certain animals; bans on cloning, bans *on* production and use *of* some substances (pesticides, ozone harmful substances);
- *regulating methods:* soil cultivation (kinds of crops and kinds of cultivation to be used on hills with different angle tilt); transportation and storage of ecologically dangerous substances; use and transportation of biological species and biologically toxic substances;
- *suppressive methods:* economic sanctions, fines, increased prices, taxes.

Positive changes approach is associated with incentives to stimulate changes on condition that they help reduce destructive pressure on the environment. Such approach is based on the use of positive feedback mechanisms. In particular, the approach is based on the use of different favorable terms, materials and moral incentives for innovations (Figure 1.3.4).

The principle goal of this approach is to provide constant re-production of four basic components of social-economic system: (1) demand; (2) supply; (3) people; (4) motifs of human activities.

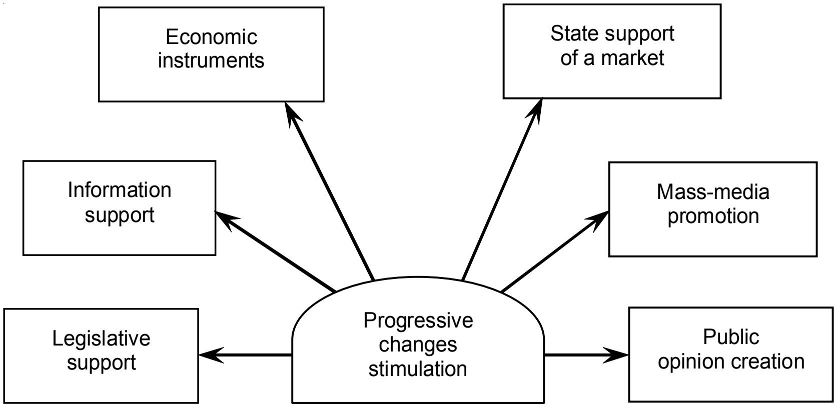


Figure 1.3.4: Forms of positive changes methods

In countries with a market economy economic mechanism is the basis for sustainable development. Economic mechanism includes the whole complex of economic structures, institutions, forms and methods of management with the help of which current laws are implemented in accordance with social and private interests. Basic components of such a mechanism are: 1) legislative basis of economic activity (rights, duties, licenses, restrictions, procedures); 2) property rights; 3) formal institutions; 4) informal institutions (traditions, moral, religion, spiritual values); 5) economic instruments.

Conditionally economic instruments can be subdivided into three interdependent and interconnected groups: prices of resources; economic benefits/costs, and transfer payments.

Depending on implementation, systems of ecological and economic instruments can be divided into 4 basic groups:

1) *Administrative redistribution of funds* (mostly fines and subsidies). This group of economic instruments is a system of well defined and well addressed cash flows (for instance, from a guilty party to victims) which is used in cases of environmental emergency when the consequences of environmental impact are not conventional and specific evaluation is needed.

2) *Financial transfers*. This is a well-regulated and controlled system of redistributive mechanisms (taxes, payments, credits).
3) *Free market mechanisms of funds redistribution*. A good example of this instrument would be the so-called tradable emission permits that have become widely spread in some USA states.
4) *Promotion in the market*. This instrument is related to the use of non-monetary forms of economic promotion (rewarding with special incentives; free of charge advertising), which gives additional competitive advantage.

Different ecological and economic instruments are used in different countries. However, the most popular ones are taxes, subsidies, grants, bonuses, payments, fines, promotions, price control, insurance, and amortization instruments.

1.4. Evolution of the concept of sustainable development and current state of the art

From eco-development to sustainability. In the seventies of last century, 'sustainable development' was known in the literature as 'eco-development'. At that time, the term 'eco' was politically and philosophically too loaded to reach a consensus. Mainly from a political and industrial perspective, the more neutral term 'sustainable development' was more accepted.

In 1972, the first International United Nations Conference on the Human Environment was held in Stockholm (Sweden). It focused international attention on environmental issues, especially those relating to environmental degradation and transboundary pollution (UN, 2002a).

The term 'sustainable development' first came to prominence in the World Conservation Strategy (WCS) published by the World Conservation Union (IUCN) and the World Wildlife Fund (WWF) in 1980 (Reid, 1995).

Ten years after the United Nations Conference on the Human Environment of Stockholm, the measures taken to implement the Declaration and Action Plan adopted at that conference were reviewed in the Nairobi Declaration (1982).

In Resolution A/38/161 –"Process of preparation of the Environmental Perspective to the year 2000 and beyond" of the United Nations General Assembly the need to establish of a special commission focussing on environmental strategies was expressed (United Nations General Assembly, 1983).

The special commission mentioned in Resolution A/38/161 is the UN World Commission on Environment and Development (WCED). This commission would become a milestone for the concept 'sustainable development'. As a result of their report, "Our Common Future", the concept 'sustainable development' achieved a new status and became known on a global scale. The more popular name for "Our Common Future" is the "Brundtland Report" in recognition of Gro Harlem Brundtland's role as chair of the World Commission on Environment and Development (Brundtland Commission).

The Brundtland Report and the work of the Brundtland Commission laid the groundwork for the United Nations Conference on Environment and Development (UNCED), often wrongfully named the Earth Summit, held in Rio de Janeiro (Brazil) in 1992. The UMCED resulted in the Rio Declaration on Environment and Development, Agenda 21, the Convention on Biological Diversity, the Forest Principles and the Framework Convention on Climate Change. A half-year after the UNCED, the UN Commission on Sustainable Development (CSD) was established to ensure an effective follow-up of United Nations Conference on Environment and Development.

A Special Session of the General Assembly to review and appraise the implementation of Agenda 21 was held in 1997 in New York. Earth Summit+5, as the special General Assembly session is called, reviewed and appraised implementation of Agenda 21 and other commitments adopted by the Earth Summit.

In September 2000, the United Nations General Assembly agreed on the Millennium Development Goals. These are eight goals which the UN member states have agreed to try to achieve by the year 2015.

The World Summit on Sustainable Development (WSSD), informally known as Earth Summit 2002, took place in Johannesburg (South Africa) in 2002. It builds on the early declarations made in

Stockholm in 1972 and Rio in 1992. The result of this summit was the Johannesburg Declaration. Apart from the attention given to sustainable development, special notice was given to multilateralism as the path forward.

Nowadays, ‘sustainable development’ has become a common used catchphrase in everyday language. Sustainable development is part of the mission of countless international organisations, national institutes, cities, companies, NGO’s and others (Parris and Kates, 2003). In a search engine, such as Google, ‘sustainable development’ results in more than 62 million hits. However, this has lead to the fact that the term ‘sustainable (development)’ is often used in a context that is unrelated to the original definition as stated in the Brundtland Report.

United Nations Conference on the Human Environment (1972). The Stockholm Conference was the first conference to have laid the foundations of environmental action at an international level. Following this conference, the United Nations Environmental Program (UNEP) was launched to encourage United Nations agencies to integrate environmental measures into their programmes. (UNESCO, 2005)

According to the Declaration of this United Nations Conference, the solution for environmental problems could be found in scientific-technological solutions.

The Action Plan that was the result of this conference, lists 109 that recommendations were subdivided into three categories:

- Framework for environmental action,
- Recommendations for action at the international level (Pollution Generally & Marine Pollution),
- Educational, informational, social and cultural aspects of environmental issues.

The World Conservation Strategy: Living Resource Conservation for Sustainable Development. The World Conservation Strategy (WCS) was commissioned by the United Nations Environment Programme (UNEP), which together with the World Wildlife Fund

(WWF) provided the financial support for its preparation and contributed to the evolution of its basic themes and structure.

The Nairobi Declaration (1982). The United Nations, assembled in Nairobi form May 10th to May 18th 1982 to commemorate the tenth anniversary of the United Nations Conference on the Human Environment, held in Stockholm. The starting point in Nairobi was the review of the measures recommended by the Declaration and Action Plan adopted at the Stockholm Conference.

In the Nairobi declaration, environmental problems are regarded in their social-economical perspective:

- "Threats to the environment are aggravated by poverty as well as by wasteful consumption patterns: both can lead people to over-exploit their environment." (UNEP, 1982).
- "The human environment would greatly benefit form an international atmosphere of peace and security, free from the threats of any war, especially nuclear war, and the waste of intellectual and natural resources on armaments, as well as from apartheid, racial segregation and all forms of discrimination, colonial and other forms of oppression and foreign domination." (UNEP, 1982).

Resolution A/38/161 – "Process of preparation of the Environmental Perspective to the year 2000 and beyond". On December 19th 1983, the United Nations General Assembly agreed on Resolution A/38/161.

The General Assembly suggests in Resolution A/38/161 that the special commission, when established, should focus mainly on long-term environmental strategies.

United Nations World Commission on Environment and Development (1987). As the result of Resolution A/38/161, the United Nations' World Commission on Environment and Development was established. The more popular name of this commission is the Brundtland Commission, named after the commission's chair Gro Harlem Brundtland. At that time, she was Norway's Prime Minister.

The Brundtland Commission's report, "Our Common Future", was published in 1987 after three years of public hearings and over five hundred written submissions. Commissioners from twenty one countries analysed this material, with the final report being submitted to the United Nations General Assembly in 1987 (WCED, 1987; UNESCO, 2002). The report popularised the notion of sustainable development and is still one of the most important documents concerning sustainable development.

United Nations Conference on Environment and Development. The formal intergovernmental UNCED process yielded five documents signed by heads of state:

- The Rio Declaration on Environment and Development: a statement of broad principles to guide national conduct on environmental protection and development.
- Framework Convention on Climate Change.
- Convention on Biodiversity.
- A Statement of Forest Principles (official name: Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests).
- Agenda 21: a massive document presenting detailed work plans for sustainable development, including goals, responsibilities, and estimates for funding (Parson *et al.*, 1992).

United Nations Commission on Sustainable Development. The United Nations Commission on Sustainable Development (CSD) was established by the United Nations General Assembly in December 22nd 1992 (Resolution A/RES/47/191) to ensure effective follow-up of UNCED (UN, 1992e). The Commission is responsible for reviewing progress in the implementation of Agenda 21 and the Rio Declaration on Environment and Development, as well as providing policy guidance to follow up the Johannesburg Plan of Implementation (JPOI) at the local, national, regional and international levels.

Earth Summit+5 (1997). The official name of Earth Summit+5 is the "Special Session of the General Assembly to Review and Appraise the Implementation of Agenda 21". The meeting took place in New York from June 23rd to June 27th 1997. (UN, 1997)

The Commission on Sustainable Development (CSD) is there to monitor and report on implementation of the Earth Summit agreements. It was agreed that a five-year review of Earth Summit progress would be made in 1997 by the United Nations General Assembly meeting in special session. This special session of the UN General Assembly took stock of how well countries, international organizations and sectors of civil society responded to the challenge of the Earth Summit (UN, 1997).

Millennium Development Goals (2000). The eight Millennium Development Goals were established at the beginning of the new millennium. They provide an action program for the 21st century. They list the absolute policy priorities to make this world a better place to live. They equally form a blueprint agreed to by the world's countries and all the world's leading development institutions. They have galvanized unprecedented efforts to meet the needs of the world's poorest (UN, 2005a).

World Summit on Sustainable Development (2002) (Hens and Nath, 2005). In late 1999, the United Nations General Assembly called in Resolution A/Res/55/199 for a 2002 World Summit on Sustainable Development (WSSD), where country delegations and other stakeholders would review and follow up on the initiatives, many collected in Agenda 2l, that were agreed upon 10 years earlier at the UN Conference on Environment and Development in Rio de Janeiro. (Gutman, 2003).

The main outcomes of the Summit are:

a) The Johannesburg Political Declaration
b) Johannesburg Plan of Implementation
c) The Partnership Agreements

Conclusion

Over a period of twenty years, policy makers contributed to specify the policy dimensions of sustainable development. From a vague idea in the Brundtland report, sustainable development was specified as policy principles (Rio Declaration) and programmes (Agenda 21, JPOI).

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1.5. Economic issues of sustainable development management

Natural, including ecological, systems perform at least three major functions: existence of humans as biological organisms, satisfaction of their material needs, and social and humane development. Economics views these systems as a kind of capital and deals largely with the optimal pecuniary performance of the second – material resource – function with due regard to the first and third ones.

Sustainable development refers to the societal change in which resource use, investment trends, scientific advances and institutional development are in accord and further present and future capacity to meet human needs and aspirations. It aims at non-declining temporary and spatial quality of life and natural capital. It initially does not opposes economic growth as such but rather advocates the wanton use of environmental resources and generation of waste. The transition towards knowledge society leads to de-materialisation of economic activity as well as, for example, the de-coupling of economic growth and per capita energy production and consumption.

The concept of sustainable development emerged as a concordance of economic, ecological, and social views on the development process.

The economic basis of the sustainable development concept can be related to the 'true' (Hicks/Lindahl) income which is defined by the maximum amount which may be spent on consumption in one period without reducing real consumption expenditure in future periods. Since productive assets include the resources of the natural environment, it follows that a necessary condition for the protection of the consumption possibilities open to future generations is that the value of the produced or man-made capital stock plus the value of the resources of the natural environment should be non-declining.

Such an approach implies that human capital which is an integral part of national wealth is also non-declining. However, for adequate interpretation and assessment of this concept it is necessary to determine which capital (human-made, natural or human capital) should be kept non-declining and to what extent these kinds of capital are substitutable and how to value them, especially it concerns natural capital. Two kinds of sustainability are considered. 'Weak sustainability' refers to a non-declining sum of natural and human-made capital (thus admitting the substitutability of the two) while 'strong sustainability' refers to the necessity of keeping natural capital as non-declining (to achieve this it is suggested that part of income from sales of nonrenewable resources be transferred to raise the overall value of natural capital) (Table 1.5.1).

Table 1.5.1: The basic characteristics of strong and weak sustainability

Weak sustainability	Strong sustainability
Overall (natural, human-made, and natural) capital stocks should be non-declining over time	Some (called 'critical') amount of natural capital should be conserved to keep the total capital non-declining
Broad spectrum of substitutability of different kinds of capital is allowed (e.g., fossil resources can be replaced by solar energy sources)	Limited possibilities of sustainability between natural and human-made (physical) kinds of capital are admitted
There is a firm belief in technological innovations that would adequately solve the problems of natural resource depletion and environmental pollution	Less reliance on the capability of technological innovations to successfully solve increasing environmental problems
Fundamentals of neo-classical economics prevail	Ecological economics prevails

An intermediate view of sustainability retains the focus of the weak sustainability definition on preserving the value (rather than a physical condition of the environment), but emphasises preserving the value of natural (instead of total) assets, thus not permitting substitution between natural and human-made capital.

Dozens of sustainable development definitions have been offered since the publication of the Brundtland Commission report 'Our Common Future: in 1987. Many of these definitions single out one of the following three aspects of sustainable development.

Some underline sustainability of economic benefits from the use of natural wealth since these benefits should be non-declining for and shared between present and future generations. They admit a substitution of natural and human-made assets and argue that not all revenues from trade in natural resources should be viewed as current income to be used for consumption only.

The second aspect emphasizes the maintenance of the physical property of the environment. This view puts an absolute value on the preservation of the ecological function of the environment, and the level of the preservation is given in terms of scientific knowledge on ecological property of natural assets.

The third aspect emphasises non-declining utility, which includes quality of life in the widest sense, and man-made assets in the narrowest sense. This may come on top of sustained economic benefit or sustained physical environment. This is where different values of different people come in, and this sometimes leads to the inclusion of interregional equity, reduction of poverty, human capital or historical monuments in the definition of sustainable development.

In the early 1990s sustainable development came to be viewed as a set of three components, such as ecological integrity, eco-efficiency, and equity. This triad is placed at the base of national sustainable development strategies (for example, in the USA) or transition to it (for example, in Russia). Security could be considered the fourth component, being part and parcel of quality of life people, communities, nations and the world community as a whole.

Sustainable development scenarios are expected to meet the following four criteria:

1. Economic growth (gross national product per capita) sustains throughout all period.
2. Social and economic inequality between and among regions will be considerably narrowed in the 21st century. It is expected that per capita GDP among all world regions will have been leveled off by 2100, with the inter-country difference being similar to that existing now among OECD nations (inter-regional equality).
3. The reserves-to-output ratio of exhaustible primary energy sources will not essentially decrease in comparison with the present day value (inter-generational equity).
4. It is possible to reduce long-term stress on the environment. In particular, CO_2 emissions by the end of the 21st century will be approximately at the current level or is lower. Emissions of other greenhouse gases can increase, but the total radioactive forcing (from all direct or indirect GHG) should be rather stable in a long-term perspective (about 100 years). Short-term and medium term environmental pressures (e.g., acidification) will decrease to achieve the critical level.

The major thrust of different schools advocating sustainable development is that approaches to sustainable economic development, conservation of environmental resources, poverty and inequity alleviation are largely consistent and complimentary. Neoclassical economists stress the use of the “right” prices. The school of ecological economics refers to the anthropocentric and biocemtric optimums for the size of the economic system thus underlining the ecological niche of the humankind.

Property rights play an important role in economic systems and human behaviour. Present legislation in many countries views environmental resources and ecosystem goods as things and reduces them to the relevant property of natural and physical persons. Damage to migratory birds and ecosystem services are mainly calculated as damage to someone’s property or not taken into account at all. Heavily exploited biological species often are not owned by a specific person. The same is valid for the use atmospheric air. Air pollution as environmental damage is computed via the damage to human health which damage to ecosystem health is ignored. These are the cases of not only market failure but also of the legislation failure that severely undermines the transition to sustainable development.

Sustainable development envisages two major changes in economic development. The transition to nature saving economies aimed at reducing or levelling-off natural resource consumption, pollution loads, on the one hand, and economic growth based on clean, low waste, recycling technologies, including alternative energy sources, on the other. A third direction is gaining momentum, namely the increasing interest in natural, especially living capital and emphasis on ecosystem goods and services with their inclusion in the world market system and improvements in property rights.

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1.6. The world population and its regulation

Population is totality of people capable for self-reproduction and self-development, and occupying certain territory namely country, region, continent or any other part of the planet. Population accompanied by natural environment, mode of production, and system of social relations composes background of human society. Level of development of the society depends on the population’s capability to utilize and reproduce natural resources. On other hand, this capability influences on structure and dynamic of population itself.

Number and other indices are been in use to characterize population. The term natality, or birth rate was given to the integral indicator reflecting social, economic and environmental conditions of human life. Birth rate is annual difference between total births and deaths per 1000 people. Fertility coefficient (annual ratio of born children to total females’ number) is another important characteristic of population. Average lifetime depends on quality of life and indirectly describes the development level of community of society.

Number of structural indicators is used to describe population. Gender structure, i.e. quantitative ratio of males and females, characterize reproduction capability of population. Age-specific structure, i.e. distribution of population by age, is important indicator representing part of population able to work and perspectives of reproduction. Ratio of rural and urban population, distribution by nationalities, education level, income, literacy, languages are very important characteristics for understanding and forecasting of population's dynamic.

The key issue of demography is reproduction of population, i.e. process of generations' shift. Reproduction is positive in the case if the coefficient of natural increase is more zero. In this case the fertility coefficient should be more than 2.

Demographical processes of variation in structure and numbers have country and regional specific. Therefore both general characteristics and regional features have to be taken into account while forecasting the tendencies in human society development.

Lack of statistic data was the reason of domination of estimation methodology in population evaluation and forecast. According to such estimation the Earth population has reached one billion by 20th century. In 125 years the population has been increased as much as two times. Population has been increased by one more billion people during 35 years only; it's happened in 1960 (Table 1.6.1).

Analysis of dynamic and tendencies of human society development resulted in conclusion that 10 billion people will be living on the planet by 2025. However, it is expected that population growth rate is going to decrease so that "the only" 14 billion people will share Earth resources by the end of 21 century. Most optimistic forecasts indicate that Earth population will be stabilized at the level of 10–11 billion.

Progress in science and technologies, medicine and sanitation are key factors of significant decrease of human mortality. Since the end of 19 century, most regions of the planet demonstrate stabile tendencies in mortality decrease. Implementation of newest achievements of medicine in second part of 20th century significantly improved this indicator in developing countries. At the same time birth rate in developing countries remains at the same high level. Since 1960th some countries have demonstrated tendencies of slight decrease in birth rate. It does not relate to

Table 1.6.1: World population, total quantity and annual increase, 1950–2000 (US Bureau, 2001)

Year	Total number in the middle of the year, billion	Annual increase, million	Year	Total number in the middle of the year, billion	Annual increase, million
1950	2,555	38	1984	4,774	81
1955	2,780	53	1985	4,855	83
1960	3,039	41	1986	4,938	86
1965	3,346	70	1987	5,024	87
1970	3,708	78	1988	5,110	86
1971	3,785	77	1989	5,196	87
1972	3,862	77	1990	5,284	83
1973	3,973	76	1991	5,367	83
1974	4,015	74	1992	5,450	81
1975	4,088	72	1993	5,531	80
1976	4,160	73	1994	5,611	80
1977	4,233	72	1995	5,691	78
1978	4,305	75	1996	5,769	78
1979	4,381	76	1997	5,847	78
1980	4,457	76	1998	5,925	78
1981	4,533	80	1999	6,003	79
1982	4,613	81	2000	6,080	77
1983	4,694	80			

the developing countries of equatorial and southern Africa and Middle East.

Rapid growth of population in some regions causes lot of negative consequences and problems, which is burdensome to world community. Sustenance of human life and society development require enormous amount and variety of natural resources. Regretfully, many developing countries are not capable to support citizens by necessary means – food, water, dwellings, education and job. Ironically, these countries have highest birth rate therefore the problems of life support are worsening. Population growth results in increasing pressure on environment, unsustainable consumption of natural resources and deterioration of life support capacity. Exhaustion of natural resources undermines abilities of both present and future generations.

According to the laws of classic ecology, development of the population of any species depends on resources availability and competitive species consuming the same resources. In spite of social character of *Homo sapiens*, development of human society and population increase depends as well on resources availability. Therefore we may assert that maximum of population is restricted by resource capacity of Earth and human capability to reproduce resources needed to support life and development.

1.7. The world population growth and resource consumption: the greatest challenges in management of our future

Humanity is at the perhaps most critical turning point during its entire history: It is becoming increasingly evident that the *Limits to Growth,* as predicted by Dennis Meadows in 1972, have been reached (Meadows, et al., 2004). Every year, over 80 million people are added to the human population. This growth essentially takes place in the lesser developed countries. At the same time, the disparities between the rich countries of the North and the poor countries of the South are rising. Fighting poverty has become a major political objective. The United Nations, in their *Millennium Development Goal,* have pledged to halve poverty in the world by the year 2015 (Sachs, 2005). It is argued in the succeeding pages that poverty is only the tip of the iceberg of today's problems. Increasing aid for the poor countries will be essential, but alone will be insufficient to solve the most pressing problems of our time.

The ecological Footprint. A convenient measure of human resource consumption is the Ecological Footprint. It can be defined as *the land and water area that is required to support indefinitely the material standard of living of a given human population, using prevailing technology* (Wackernagel & Rees, 1995). The consumption of land area includes usage for habitation (dwellings), transport (roads, rails, and waterways), agricultural production, mining, industry, and waste disposal. An important feature of the concept of the *Ecological Footprint* is that it is based on sustainable use of resources[1], and by taking into consideration the uptake capacity of the environment for waste products[2] (Figure 1.7.1). The overall ecological footprint is a function of the magnitude of a population and the intensity of land use. On a global average, the *per capita* ecological footprint at present is 2.1 hectares. In developing countries only 1.0 hectare is available per person. In the wealthy industrial nations, almost ten times as much land is used per person (the value for the U.S.A. is 9.6 hectares, Wilson; 2002).

When the ecological footprint of one person is multiplied by the number of people on Earth, striking results emerge that make abundantly clear the present state and future prospects of the global environment: Based on the current world average ecological footprint, the overall area that at present can be put to sustainable use for a human population of 6.5 billions is $137 * 10^6$ km^2, or 90% of the total land area of the Earth. If it is assumed that the entire world population would consume global resources at the level of the average U.S.-citizen, a total area *four times the total combined land area on Earth* would be required to meet these demands. Actually, much less land is available to human use because about 15% of the total land area is permanently covered by glacier ice and therefore cannot be utilized at all. Moreover, as much as 30% of the land area is either desert or extremely dry land that can produce only

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[1] The term "sustainability" was adopted for environmentally sound economic and social development, as spelled out by the *Brundtland Report* (1987) and during the UN *Conference on Environment and Development (UNCED)* of 1992 which set the foundations for a number of international agreements such as the *Kyoto Protocol* to protect the Earth's climate in 1997. The *Convention on Biological Diversity* (1992) was negotiated at Rio and went into effect in 1993 under the auspices of the *United Nations Environmental Programme* (UNEP). However, the effectiveness of most of these political instruments, however, has been limited.

[2] In this context also the release of chemical constituents to the atmosphere such as greenhouse gases and CFCs is to be considered as waste disposal.

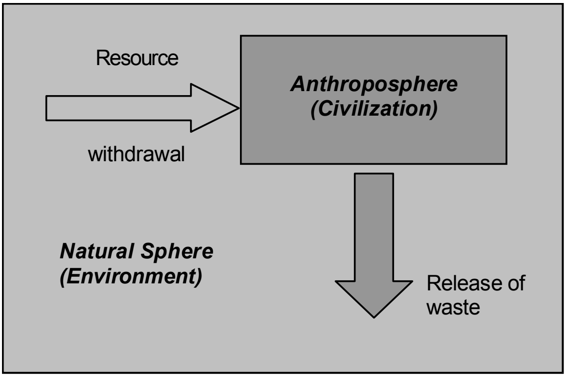

Figure 1.7.1: Interactions between the *Anthroposphere* (human civilization) and the *Natural Sphere* (environment): Unlike natural ecosystems, the flow of matter within the Anthroposphere as a rule is not cyclic, as is the case in ecosystems. As a consequence, resources are withdrawn from and waste is released to the environment. Sustainability is possible (1) if only renewable resources are withdrawn at rates smaller than the renewal rate, or by the withdrawal of non-renewable resources that are far in excess of human demand, and (2) if waste is released at rates below the critical thresholds of the natural environment. The ecological footprint is defined by the area that can be used per person in a sustainable fashion thus defined. The overall carrying capacity of any system is defined by the upper limits of its sustainable use. *Original*

after irrigation. Since most resources are not used in a sustainable fashion, smaller land areas suffice to meet our demands. Based on these figures, it is estimated that already by 1978, human population had exceeded Earth's sustainable capacity. If, as required by the *Brundtland Report*, 12% of all land were set aside for the protection of the natural environment, the global carrying capacity of Earth was already exceeded in 1972 (Wilson; 2002).

The growth of the human population. Human population densities were low until the end of the ice age. The first acceleration of population growth occurred after the onset of the Neolithic, which is defined by the establishment of permanent settlements, breeding of animals and plants, and cultivation of land with the aim of increasing crops. The second major turning point in the development of human civilization was the *Industrial Revolution* which was triggered by the invention of the steam engine in 1767. By 1800, the human population had risen to 1 billion. The development of technology, made possible by the usage of external energy sources, allowed an unprecedented change in the structure of society that was characterized by urbanization and industrialization.

The improvement of living conditions was leading to a drop in infant mortality and an increase in the average life expectancy However, birth rates remained high. This combination led to a dramatic acceleration of population growth. Due to increased affluence, urbanization, and improved education, birth rates and hence growth rates of the European population dropped sharply at the beginning of the 20th century. However, to the present day, population growth remained rapid in lesser developed countries, where mortality began to decrease, but birth rates have continued to be high. In the autumn of 1999, the world population surpassed 6 billions (Figure 1.7.2).

Columns: absolute annual rates of growth (in millions), solid line: relative growth (in percent). Note that the relative population growth peaked in 1963/64, and the absolute growth did in 1989/89. Both have slowed since then. Redrawn from *US-Population Reference Bureau.*

The Core Problems of Global Change. The increase in the adverse effects of the human civilization on both, the natural environment and human society during the 20th century, have been mainly due to non-sustainable development caused by the combination of growing population numbers and rising *per-capita* resource consumption. As a consequence, the following *core-problems of global change* have emerged. Most of these problems are closely interrelated: (1) Anthropogenic climate change, (2) ecosystem degradation and loss of biological species, (3) deforestation, (4) soil degradation, (5) shortage of freshwater supply, (6) shortage of food supply, and (7) shortage of energy supply. The observed slowing of annual population growth rates, both in terms of absolute numbers and relative rates of increase (Figure 1.7.2, lower panel), by no means are the result of successful measures with the aim of curbing population growth. In fact, they are an indication that the growth of the human popula-

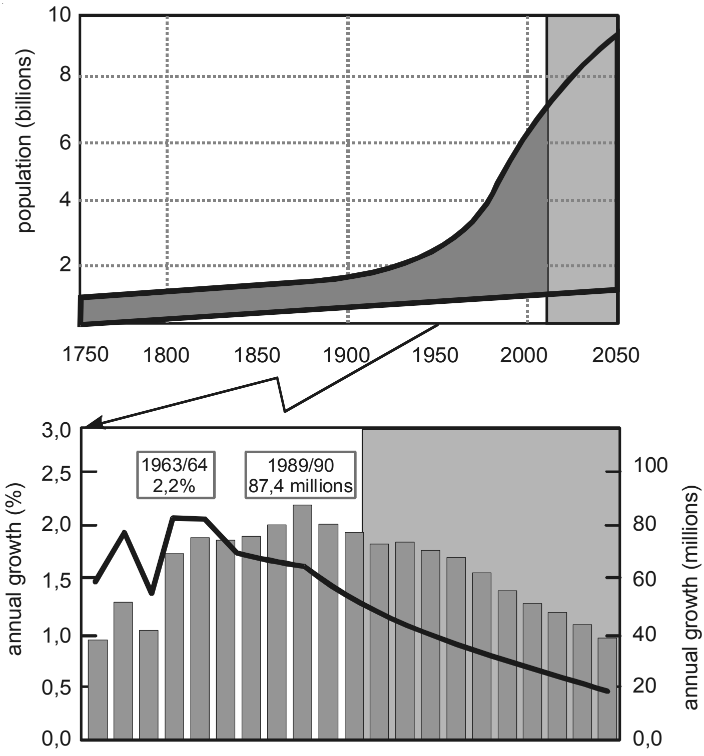

Figure 1.7.2: The growth of the human population. *Upper panel:* World population since 1750 (prior to the onset of industrialization), and projections until the years 2050 (light shading). The lower curve shows the population rise in developed countries, the dark shading represents the population in lesser developed countries. *Lower panel:* Annual rates of population growth since 1950, and projections until the years 2050 (light shading)

tion is approaching its limits, as is typical for any growing population of organisms (Figure 1.7.3).

The shaded area shows the discrepancy between the unlimited maximum growth potential of a population and the actual growth due to the progressive depletion of resources and/or the degree to which the critical loading threshold of a system for waste is approached. *Original.*

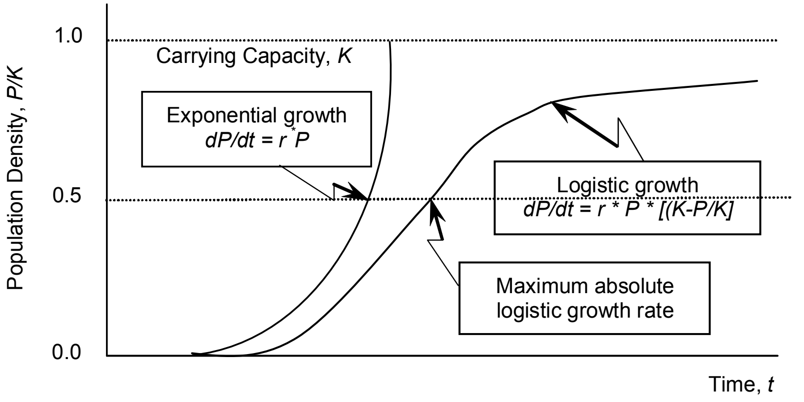

Figure 1.7.3: Time-course of the density of populations of organisms (*P*), ranging from bacteria to humans. In higher organisms, apparent growth is the net result of birth rates *(reproduction)*, and death rates *(mortality)*. *Exponential growth* is only possible if resources are far in excess of demand, thus defining the upper growth potential of a population. *Logistic growth* is characterized by a sigmoid growth curve which reflects decreasing relative growth rates with increasing population size, until a saturation plateau (the *carrying capacity K)* is reached

As a rule, saturation plateaus of populations are not sustained for long, but are followed by a collapse of the population(s) involved. Population collapse usually has two causes: Decreasing fertility due to the exhaustion of vital resources, and increasing mortality due to the deterioration of living conditions. In the case of the human population, deterioration of living conditions is defined by the above-mentioned Core Problems of Global Change. *From this we can draw the conclusion that the living conditions on Earth to be expected in the future strongly depend on the magnitude of the world population.* The consequences of approaching the carrying capacity of the Earth system already now can be seen in some of the poorest regions of the Earth, mainly in sub-Saharan Africa and in Southeast Asia. These include water shortage, famine, the spread of infectious diseases, and economic collapse. Mainly due to the HIV/AIDS pandemic, life expectancy in these countries has decreased dramatically. In the 31 countries at the bottom of the list of wealth, 28 of which are in sub-Saharan Africa, mean life expectancies have dropped by 20-25 years to an average of 46 years, or 32 years less than the mean life expectancy in countries of advanced human development (UN News Centre, 9 November 2006). It is also by no coincidence that political unrest and civil strife are most common in countries with high population growth rates. Probably also the occurrence of genocide, at least in some cases, can also be attributed to resource depletion and poverty as a consequence of overpopulation (Table 1.7.1).

The political Challenge of the future. A convenient measure of the future living conditions on Earth to be expected in case of continuing rapid population growth is the expected average global ecological footprint as a function of the total world population. An ecological footprint of 3.0 hectares could sustain a world population of 4.3–6.0 billion people. At a world population of 9.0 billion, only 1 hectare would be available per person for sustainable use (Richard, 2003). In other words, if the world population would reach nine billions, the average standard of living would fall to the value currently valid for the poorest countries of the world. The most recent projections suggest a world population of 9.242 billions by 2050 *(Population Reference Bureau,* August 2006).

Table 1.7.1: Countries with the highest relative population growth rates. Values as of mid-2006 (Population, 2006)

Country	Relative growth (% per year)	Doubling time (years)	Children per woman	Infant mortality (per 1.000)
Palestine (Gaza, 2005)	3.4 (371)	20 (19.25)	5.6 (5.78)	21 (22,4)
Liberia	2.9	24	6.8	142
Saudi Arabia	2.7	25	4.5	23
Afghanistan	2.6	27	6.8	172
Nigeria	2.4	29	5.9	100
Sierra Leone	2.3	21	65	165
Global average	*1.24*	*56.2*	*2.7*	*55*

The top and foremost priority for the immediate future, therefore, must be to halt population growth before *the carrying capacity of the Earth system for humans is reached*. Unless this is achieved, the future of humanity will be miserable. The following political measures should have highest priority:

1) to curb resource consumption in the wealthy countries,
2) to drastically slow population growth in the poor countries,
3) to re-distribute wealth and resource consumption between the rich and the poor countries with the aim of diminishing the existing disparities, however, by still reducing the overall resource exploitation,
4) to fight corruption in all countries,
5) to minimize pollution in *all* areas, both on land and in the sea,
6) to secure the survival of biological species by setting aside sufficient areas as natural habitats in order to preserve life on land and in coastal areas, and by protecting the high seas from over-exploitation.

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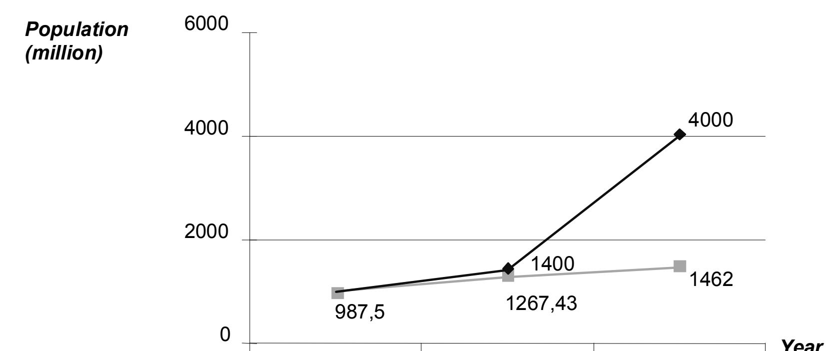
1.8. Control of population growth in China

In 1980 the telegraph agency of XinHua published the «Demographic prognosis for China on one hundred years». The communication showed that if the birth-rates remain at the 2000 level (1.4 billion of Chinese in 2000 there will be 4 billion of Chinese citizens in 2050 (Figure 1.8.1). No doubt stricter population control is necessary after this policy prognosis. The result was the policy "one child in a family".

This means that a family in city can have only one child. Families who live in villages are allowed to have a second child, when the first child is a girl. The policy is more flexible for minority groups. They can have two children (regardless the gender of the first born child). Over all, the government sticks merely to the prohibition to have a second child and the methods to realize this. A fine has to be



	1980	2000	2050
Prognosis without population growth control (Chinese forecast)	987,5	1400	4000
Population growth and prognosis made by UN about the population growth control policy	987,5	1267,43	1462

Figure 1.8.1: Population growth in China

paid by the family that violates the prohibition (the sum of a fine varies by province). The family is also deprived from social security, following a proposal of the birth-rate planning department. For example, a family can lose the right on an apartment or can be allocated a dwelling of low quality. Workers in industry may lose bonuses. Civil officers may attract an administrative penalty.

More recently, the focus shifted from punishment to encouragement of a small family.

Results. During the 1990ies the birth-rate did not exceed 1.464%, in spite of the number of women in the fertile age range attained a peak. Figure 1 provides information on the efficiency of the demography policy in China. In the absence of the one child policy, China was expected to have 1.6 billion citizens 2005th. In reality the number approaches only 1.3 billion.

Experience. Experience with the demographic policy in China allows to conclude that it is impossible to reach success with birth control without a persistent governmental policy. An important element is the strict measures to maintain the policy. In particular the Birth-rate Planning Commission is a public institution with the status of a ministry. Nearly a million of civil servants are engaged in this policy all over the country. Education and information on family planning (effective contraception, knowledge and skills on managing young family, etc.) is essential. Legal support is equally necessary. Since 2002 the basic aspects of the demographic policy are laid down in «The law of population and birth-rate planning in China».

The role of a demography policy. Population control allows to deal with social, economic and environmental problems. In particular the tension between the number of people and the limited amount of natural resources was alleviated. It equally addresses social problems as the food deficit. As a whole, the policy is seen as a precondition to sustainable development. There is a statistical correlation between the decrease in birth-rate and economic growth. During the last 10 years, the average annual GDP growth was about 13%. The per capita GDP grows even quicker with 26 to 34% per year. This shows how economic growth proceeds faster than population growth. The annual increase in the real level of the population's welfare is estimated at 25 to 40% . All these successes were realized in China during the last 25 years. It is assumed that the role of the demography policy will increase in the future.

1.9. System of environmental standards

Environmental standards are instruments to regulate the quality of environmental systems. They aim to maintain the quality of the environment in such a way that human health, social development or the environment (services of nature) are not harmed.

Environmental standards relates to 3 functions: human health, the quality of the biosphere (i.e. objects and natural processes) and the technosphere (i.e. the objects produced by man and the underlying processes).

Types of environmental standards.

Standards to protect organisms. Parameters that describe the condition of humans and organisms of other biological species are *environmental or health standards*. Although important, these values do not describe in full the environmental systems.

Standards to protect ecosystems. Any organisms can survive only under environmentally acceptable conditions, i.e. a defined temperature range, humidity, light, electromagnetic parameters, speed of metabolism and predators in its environment. These environmental standards characterize the physical and biological parameters of the environment. They include the composition of the atmosphere, the quality of food, and for marine organisms the quality of the water they live in.

Standards for conditions of labour. Human activity can be characterized by acceptable conditions of labour (stress, occupational health) that are important to safeguard the quality of life.

Social standards related to personal characteristics. A human being is not only a biological organism, but also someone who arts

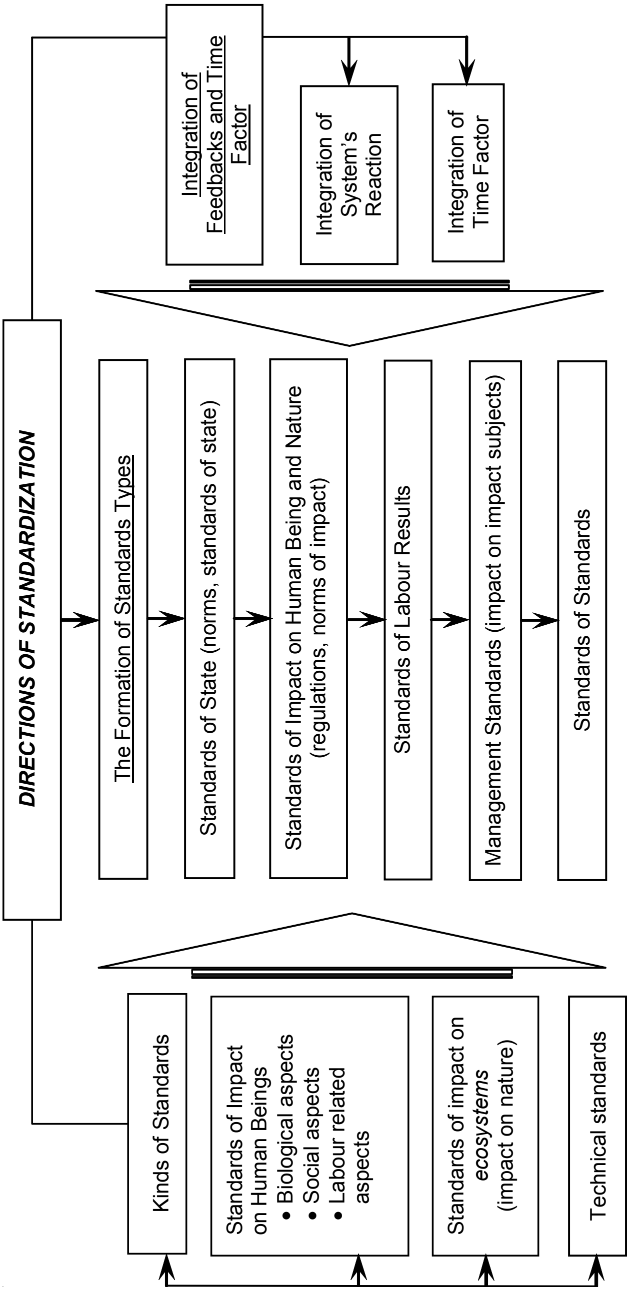


Figure 1.9.1: Framework of standardization processes realization

in a social context. Humans are shaped by their personal qualities. Part of people's formation is their relationship with nature. Therefore the natural environment offers elements that are necessary for a balanced spiritual development. Currently these aspects are insufficiently described in a quantitative way. Nevertheless attempts to describe these aspects as standards exist. Social indices of life quality also relate to this type of standards.

Technical standards. Technical standards have to assure the safety of technical operations and products. They have equally to avoid technical catastrophes (e.g. Chornobyl catastrophe). An absence of this type of standards may cause additional (economic) costs, a decrease of effectivity, and environmental damage.

Environmental standards affecting labour conditions. Human activities are closely related to environmental quality. Therefore we need standards that regulate the compliance of the output of labour with the carrying capacity of nature. These standards entail: those related to waste discharged into the environment; ways in which agricultural land is used (for example, respect flood areas); and food quality standards (for example, on dyes and conservation products).

Environmental standards for products. Production is often a long chain of technological processes. Each of them can have a harmful impact on human or natural systems. Therefore they are subject to environmental standards. These standards may relate to: e.g. construction of goods, used construction materials, composition of fuels, etc. The rationale behind these standards is that the use of some materials can cause damage to nature. In proper use of raw materials and defects in the construction of products affects waste production. The problem can partially be managed by bans (e.g. on ivory) but also by standards that specify (the recyclability of) products.

Standards of consumption. Products should not only be produced, but also used in an environmentally safe way. Consumption goods can entail risk factors (high speeds, toxic substances – pesticides, home chemicals, dyes, etc.). To regulate this product standards can be used. They entail an aspect of environmental quality. *These standards can or cannot be certified by procedures and labels that* prove their (relative) environmental safety.

Management standards. Also management is subject to quality and to quality standards. ISO 9000 and ISO 14007 are the best known examples of such management standards worldwide. EMAS is the environmental management quality standard for the European Union.

Metrology standards. The development of standards as such is subject of quality control. Development of standards requires its own standards. This is investigated by metrology.

1.10. Measuring sustainable development

Approaches to measuring sustainable development. Sustainable development is characterized by a complex set of interrelated factors such as *poverty, health, environment, welfare, food, education, human rights, social stability, etc.* It's impossible to measure such a complex concept in a narrow mathematical way, certainly because the value for each factor differs from individual to individual, from issue to issue and from place to place.

Quantifymy sustainable development can be alone by behaving the most important factors as indicator and calculating a 'sustainable development'-index.

Indicators fit in models there latter to help to understand the complexity of reality. Therefore models are always a simplification of reality, combining the essential elements and showing the relationships between them.

From an operational point of view, sustainable development should be:

1. Economically viable: paying for itself, with costs not exceeding income.
2. Ecologically sustainable: maintaining the long-term viability of ecosystems.
3. Socially desirable: fulfilling people's cultural, material and spiritual needs in equitable ways.

Sustainable development can only be achieved by fulfilling the economic, environmental and social objectives. Figure 1.10.1 provides a simple representation of the basic components of sustainable development. It shows that its ultimate aims are to maximise the (black) area where economic, social and environmental agendas and targets coincide with each other.

Indicators for sustainable development. An indicator quantifies and simplifies phenomena and helps to understand complex realities. An indicator provides information about the changes in a system. Whether an indicator is useful, depends on the particular context in which the indicator is used.

According to Chapter 40 of Agenda 21, "indicators of sustainable development need to be developed to provide a solid basis for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems".

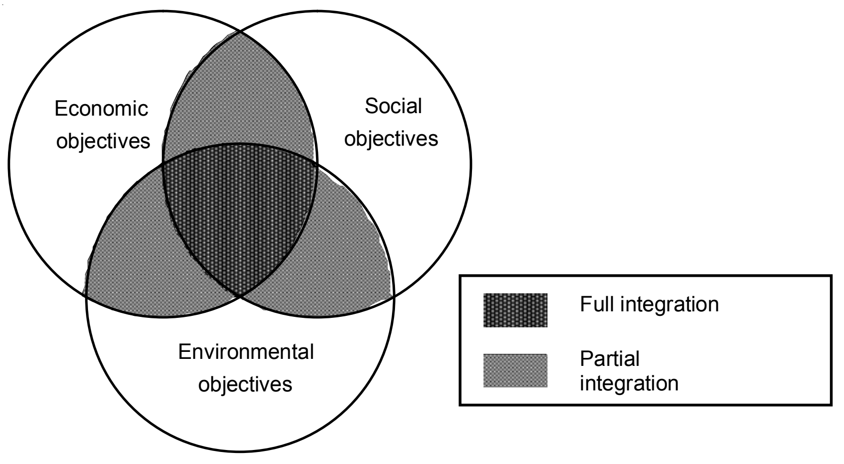


Figure 1.10.1: Sustainable development is the zone where social, economic and environmental objectives are fully integrated

The following are essential features of indicators:

- Indicators must be relevant, serving their purpose, capturing and measuring the essence of the issue.
- They must be understandable for all members of the target group. Complex indicators developed by academics to measure complex processes or situations lose their relevance unless simplified to be understandable for a whole audience of stakeholders.
- Their conception must be well founded and easy to interpret.
- They should be easily adaptable to new developments, thus responsive.
- They need to show the link between economical, social, environmental and institutional aspects of society.
- They should embrace a long- and wide-range view and show trends over time.
- Indicators should be global.
- They must be reliable (based on reliable data) although not necessarily precise.
- Data should be available at a reasonable cost-benefit ratio, adequately documented, of known quality, and regularly updated. They must provide information in a timely fashion, so as to be able to prevent or solve problems in due time.

According to the OECD, indicators can be divided into six different categories:

1. Social indicators.
2. Environmental (health) indicators.
3. Economical indicators.
4. Energy indicators.
5. Housing indicators.
6. Sustainability indicators (OECD, 1997).

In a wider sense, these steps form part of an environmental policy cycle that includes problem perception, policy formulation, and monitoring and policy evaluation (Guven, 2001).

The PSR-framework divides the indicators into 14 different issues or themes (Guven, 2001):

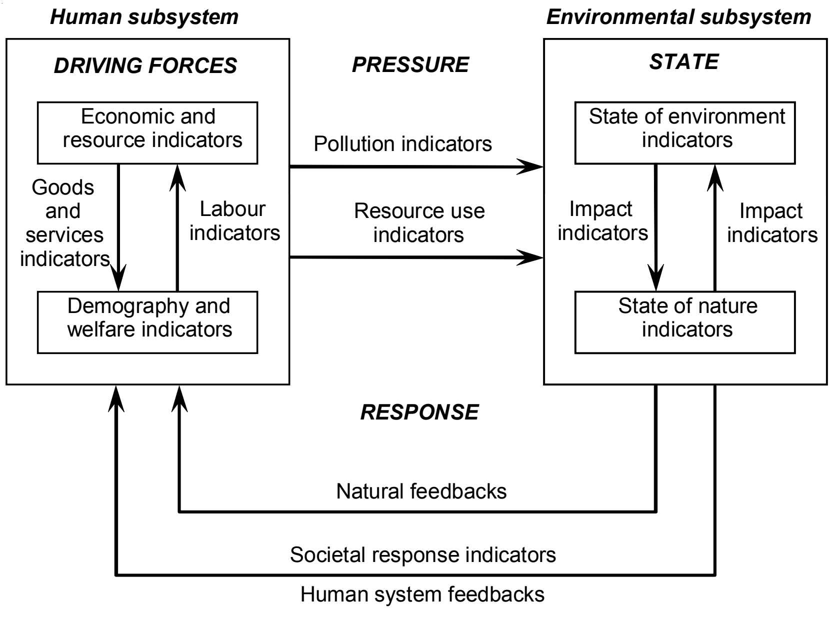


Figure 1.10.2: The conceptual framework of the PSR-model (after UNEP and DPCSD, 1995)

1. Climate changes;
2. Ozone layer depletion;
3. Eutrophication;
4. Acidification;
5. Toxic contamination;
6. Urban environmental quality;
7. Biodiversity;
8. Landscapes;
9. Waste;
10. Water resources;
11. Forest resources;
12. Fish resources;
13. Soil degradation (desertification and erosion);
14. General indicators

The CSD published a list of 98 indicators that serve as reference for countries to develop national indicators for sustainable development. These indicators are revised every five years and the most recent set of indicators date from 2006. The indicators fulfil three criteria:

They cover issues that are relevant for sustainable development in most countries.
They provide critical information not available from other core indicators.
They can be calculated by most countries with data that is readily available or could be made available within reasonable time and costs.

The chosen indicators are in the most recent version of the 'CSD-indicators of Sustainable Development'-document placed in a framework of 14 themes (United, 2007):

Poverty	Health	Freshwater
Natural hazards	Land	Biodiversity
Economic development	Oceans, seas and coasts	Global economic partnerships
Governance	Education	Consumption and production patterns
Atmosphere	Demographics	

Models for SD.

1. *Driving forces-State-Response-model.* In April 1995, during its third session, the Commission on Sustainable Development (CSD) approved a work programme on indicators of sustainable development. The work programme included a list of 134 indicators organized according to the Driving forces-State-Response-model (DSR-model). In this model, Driving Force indicators represent human activities, processes and patterns that impact on sustainable development; State indicators indicate the "state" of sustainable development, and response indicators indicate policy options and other responses to changes in the state of the environment. The DSR-framework allowed to develop indicators belonging to the four different categories of Agenda 21: the social category, the economical category, the environmental category and the institutional category (Guven, 2001).

2. *Driving forces-Pressure-State-Impact-Response-model.* The European Environmental Agency (EEA) developed a conceptual framework known as the Driving forces-Pressure-State-

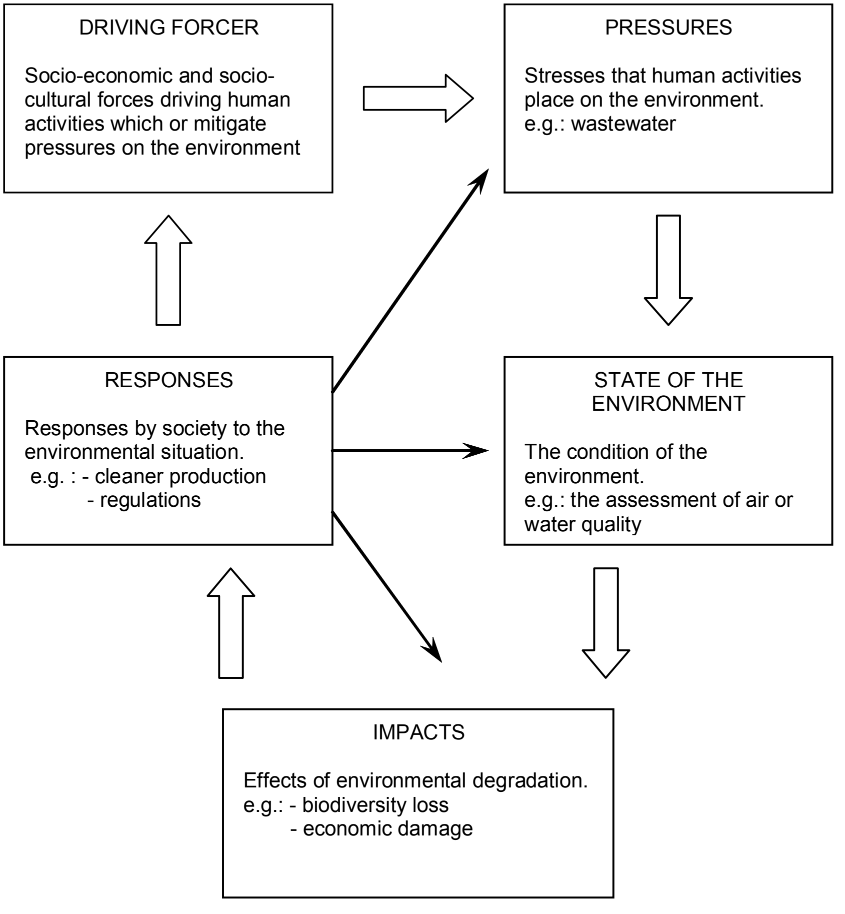


Figure **1.10.3:** The conceptual framework of the DPSIR-model

Impact-Response assessment framework. Particularly useful for policy-makers, this DPSIR-model builds on the existing PSR-model and offers a basis for analysing the inter-related factors that impact on the environment (EEA, 1999).

3. *The Driving forces-Pressure-State-Exposure-Effect-Action-model*. The Driving forces-Pressures-State-Exposure-Effects-

Actions-model (DPSEEA-model) builds further on the DPSIR-model. It has been developed to deal with the specific elements of environment-health problems in a decision-making context.

The conceptual framework of the DPSEEA-model is represented in figure 1.10.4.

Indices for sustainable development. Indices differ from indicators. An indicator provides information on a "simple" event in a

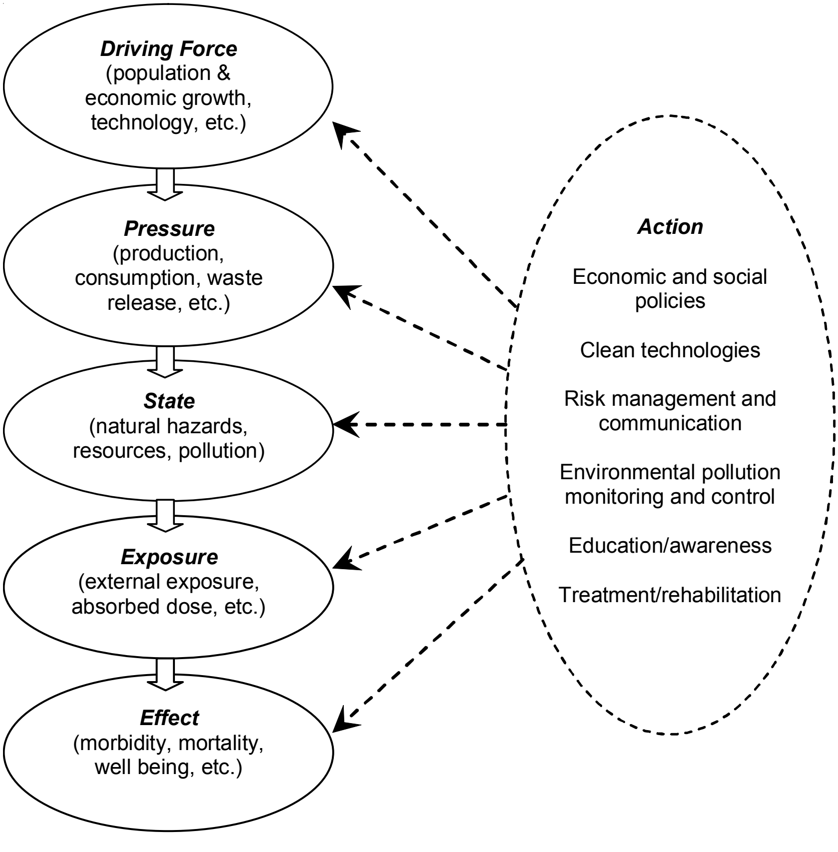


Figure 1.10.4: The conceptual framework of the DPSEEA-model

SD context an molex relates motivators to each other and thru quantifies more complex phenomena. An advantage of an index is that these complex phenomena (e.g. sustainability) of different variables (e.g. countries of the world) can be compared to each other (motivators also allow comparison on the countries).

There are a massive amount of different types of indices. In this chapter, only the most relevant ones for sustainable development are discussed.

The Ecological Footprint. The term ‘Ecological Footprint’ was first coined in 1992 by Canadian ecologist William Rees and his Ph.D.-student Mathis Wackernagel. The concept is nowadays the most widely spread index of environmental sustainability.

The Ecological Footprint measures people’s natural resource consumption. The footprint can be compared with nature’s ability to renew these resources. A country’s footprint is the total area required to produce the food and fiber that it consumes, to absorb the waste from its energy consumption and to provide space for its infrastructure. People consume resources and ecological services all over the world. Their footprint is the sum of these areas, wherever they are on the planet (Living Planet Report, 2004).

The Ecological Footprint is the summation of six components:

1. The Cropland Footprint,
2. The Grazing Land Footprint,
3. The Forest Footprint,
4. The Fishing Ground Footprint,
5. The Energy Footprint,
6. The Built-up Area Footprint.

The global Ecological Footprint was 14,1 billion global hectares in 2003 (Figure 1.10.5), or 2,2 global hectares per person. Based on its biologically productive area, the earth’s biocapacity was in 2003 approximately 11,2 billion global hectares, which is a quarter of the Earth’s surface. The productive area of the biosphere translates into an average of 1,8 global hectares per person in 2003. This means the creation of an ecological debt (unsustainable situ-

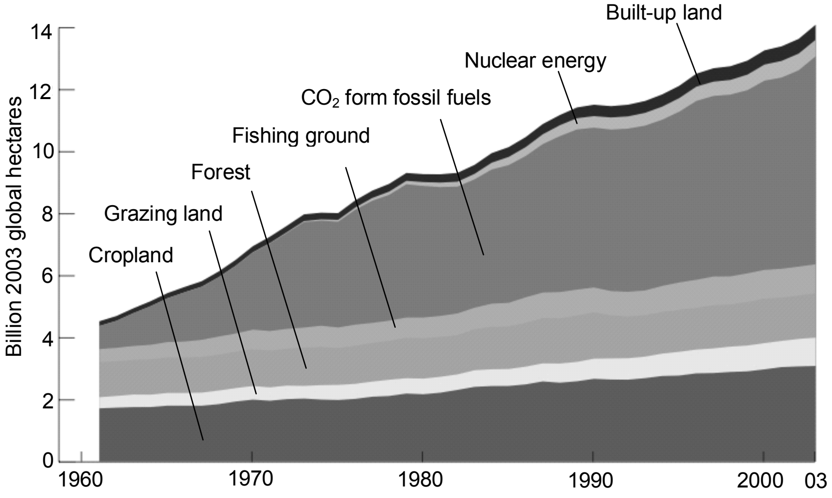


Figure 1.10.5: Evolution of the world's Ecological Footprint from 1961 to 2003 (Living, 2006)

ation) and that humanity's Ecological Footprint exceeded the global biocapacity by 0,4 global hectares per person or 21%. This global overshoot began in the 1980s and has been growing ever since (see Figure 1.10.5). Overshoot means spending nature's capital faster than it is being regenerated (Living, 2006).

The Human Development Index. The Human Development Index (HDI) was developed in 1990 by the Pakistani economist Mahbub Ul Haq, and has been used since 1993 by the United Nations Development Programme in its annual Human Development Report. It is allows to classify countries as developed, developing or least developed.

The HDI relaters the average of the Education Index (EI), the Life Expectancy Index (LEI) and the Gross Domestic Product Index (GDPI). These three sub-indexes are calculated in the following way:

$$EI = \frac{2}{3} \times ALI + \frac{1}{3} \times GEI \;; \qquad GDPI = \frac{\log(GDP_{pc}) - \log(100)}{\log(40000) - \log(100)} \;;$$

$$ALI = \frac{ALR}{100};$$

$$LEI = \frac{LE - 25}{85 - 25};$$

$$GEI = \frac{CGER}{100};$$

$$HDI = \frac{EI + LEI + GDPI}{3}.$$

In which:

EI: Education Index.

ALI: Adult Literacy Index.

GEI: Gross Enrollment Index.

ALR: Adult Literacy Ratio.

$CGER$: Combined Gross Enrollment Ratio (the CGER gives a rough indication of the level of primary, secondary and tertiary education amongst residents in a given jurisdiction).

$GDPI$: Gross Domestic Product Index.

GDP_{PC}: Gross National Product per capita at Purchasing Power Parity in U.S. dollars.

LEI: Life Expectancy Index.

LE: Life Expectancy at birth.

HDI: Human Development Index (Human, 2005b).

The Environmental Utilization Space. The Environmental Utilization Space (EUS) has been introduced in the literature of sustainable development by Dutch scientists in the beginning of the nineties of last century. The Environmental Utilization Space (EUS) is a quantitative estimate of acceptable pressures exerted by material flows on the environment. Acceptable means consistent with the principles of sustainable development and these pressures are the extraction of scarce materials and the emission of waste, which can damage the quality of the environment. The calculations are kept relatively simple and are based on a selection of assumptions concerning the pressures nature can stand and some targets considering the equity of resource-distribution (Doom, 2001a).

Basically one can stick to a simple model to focus on the environmental pressure exerted by material flows, as well as on the distribution of these flows among economic sectors and/or populations. This model is known as the formula:

Impact = Consumption x Production x Population

Measuring sustainable development is important for science and policy. Science for sustainable development necessitates quantification. Policy for sustainable development necessitates trend analysis. These trends can be expressed using indicators and in dices.

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1.11. Criteria of sustainability

Over the years, economic, social and environmental impacts have traditionally been treated as separate issues. This is reflected in the criteria commonly used to assess these impacts. For example, some traditional indicators include atmospheric concentrations of certain gases for the environment, employment rates for society and Gross Domestic Product (GDP) for the economy. The main problem with these indicators is that they are measured separately as if they were independent of others. In reality the economy, society and environment are linked in many ways, which must be reflected in sustainability criteria. At large there are two groups of sustainability criteria:

(i) Sustainability Performance Indicators (SPI);
(ii) Aggregate Sustainability Measures (ASM).

Below analysis of both groups is presented.

Sustainability Performance indicators (SPI). SPI is a set of indicators, which measure the isolated impacts of human activity on economy, environment and society. It turns out that the number of sustainability indicators within a given set may be highly variable creating difficulties in collecting data and interpreting the results. A set of SPI can be selected from a pre-defined list or it can be tailor-made. For example, there are the so-called "Bellagio

Principles" developed during the international Bellagio Conference in Italy in 1996 that define "*...the whole of the assessment process includes the choice and design of indicators, their interpretation and communication of the result*" (International Institute for Sustainable Development, 2000).

The Global Urban Indicators Database developed by the United Nations Centre for Human Settlements (UNCHS, 2000) is an example of such a pre-defined list. This database consists of around 40 indicators which are measured by all participating cities and countries (currently around 110 countries and 237 cities), as well as a list of supplementary indicators from which participants may choose those which are particularly relevant to their local situation.

This approach has some obvious disadvantages. First, selection of a set of "good" indicators is a difficult task, both in terms of ensuring the number is manageable and that each indicator conforms to as many of the characteristics as possible. Second, some sets of indicators may send conflicting messages when different indicators point in different directions making it difficult to understand and interpret the overall result. Therefore, we do not know, in general, whether the development is on a sustainable path or not and at what speed. Third, it is very difficult to use a set of indicators in modeling a sustainable system since mathematically it becomes a problem of multiple criteria.

Aggregate Sustainability Measures (ASM). There are two popular ASC:

(i) The Index of Sustainable Economic Welfare (ISEW),
(ii) The Genuine Progress Indicator (GPI).

Both are economic measures because they are expressed in monetary terms, and both are associated with adjustments of GDP to take into account social and ecological dimensions of the sustainable development.

The ISEW was developed by the Friends of Earth (United Kingdom) in association with the Centre for Environmental Strategy

(CES) and the New Economics Foundation (NEF). It recognizes that *GDP takes no account of increasing inequality, pollution or damage to people's health and the environment* (Friends of the Earth, 2002). It is assumed in GDP that any economic activity is good regardless of whether this activity improves or directly damages our quality of life. In this regard, the ISEW corrects GDP over a range of issues such as income inequality, environmental damage and depletion of environmental assets. It has been already calculated for nine countries, European Union and Chile.

In 1995, Redefining Progress – a nonprofit public policy and research organization in USA – created an alternative measure of economic progress called the Genuine Progress Indicator (GPI). The GPI takes into account more than twenty aspects of our economic lives that GDP ignores. It includes estimates of the economic contribution of numerous social and environmental factors which GDP dismisses with an implicit and arbitrary value of zero. It also differentiates between economic transactions that add to well-being and those which diminish it. The GPI then integrates these factors into a composite measure so that the benefits of economic activity can be weighed against the costs. Specifically, the GPI starts with the same personal consumption data GDP is based on, but then makes some crucial distinctions. It adjusts for certain factors such as income distribution, adds certain others such as the value of household work and volunteer work, and subtracts yet others such as the costs of crime and pollution. The GPI is designed to extract significant long-term trends from short-term accounting fluctuations. The GPI for the United States and Australia has been calculated by the experts of Redefining Progress since 1950.

In general, ASM can be used to present a general picture as a summary avoiding the details of various indicators, included in a set of SPI. Since there is no consensus in the literature on a standard set of indicators, an ASM could make it easier to interpret the results and compare with other standards. The drawback of the ASM, however, is that the general picture may provide misleading information when one dimension significantly over-weighs the other.

1.12. Indicators of sustainable development as the basis for socio-economic management

Design of a system of indexes and indicators for qualitative and quantitative evaluation of sustainable development (SD) is an important issue. The main requirement for such a system is its informational completeness and adequate representation of the interrelated sustainable development elements. Currently various international organization and numerous research groups are dealing with this issue. However, uniform representation of such a system has not been achieved yet.

Let us analyze the system of sustainable development measures proposed by the Institute of Applied Systemic Analysis NAS of Ukraine and MSE of Ukraine (Zhurovskiy, 2006; Zhurovskiy (a), 2006).

In this system, it is suggested to measure the level of SD with the help of a composite index I_{SD} (Sustainable Development Index) which is calculated as the sum of three-dimensional indexes: economic, (I_{ECD} – Economic Dimension Index), environmental (I_{ED} – Ecological Dimension Index) and social (I_{SOCD} – Social Dimension Index) with appropriate weight coefficients assigned (Figure 1.12.1).

Each index I_{ECD}, I_{ED} and I_{SOCD} is calculated on the basis of six global indexes widely used in international practice (Table 1.12.1).

As seen from table 1.12.1, each global index is calculated using a large number of indicators as well as qualitative and quantitative data sets. Of course, all indicators and data sets that influence components of the indexes mentioned above as well as indexes themselves are measured in different units and have different interpretations. That is why they were normalized to be in the interval between 0 and 1. In such a case, the worst values of the above mentioned indicators will be close to 0, while the best values will be close to 1. Such design allows us to calculate each index I_{ECD}, I_{ED}, I_{SOCD} and I_{SD} as a mean of its components with appropriate weight coefficients.

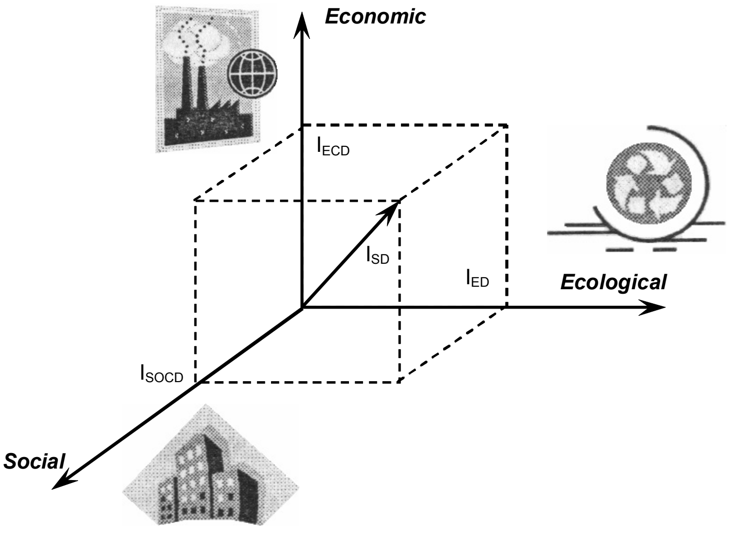


Figure 1.12.1: The Development of SD Index

Table 1.12.1: The List for Aggregated Sustainability Index Measure

Measure of Sustainable Development	Global Index	Components	Source
Economic (I_{EC})	CI – Competitiveness Index	3 indicators, 47 data sets	World Economic Forum // www.weforum.org
	IEF – Index of Economic Freedom	10 indicators, 50 data sets	Heritage Foundation // www.heritage.org
Environmental (I_E)	ESI – Environmental Sustainability Index	21 indicators, 76 data sets	Yale University USA [www.yale.edu/esi]
Social (I_{SOC})	LQI – Life Quality Index	9 indicators	Economist Intelligence Unit // www.en.wikipedia.org
	HDI – Human Development Index	3 indicators	United Nation Development program // www.hdr.undp.org
	IDC – Information Society Index	3 indicators, 15 data sets	UNDESA // UN Publication. 1, 2005

Table 1.12.2: The most economically efficient world economies, 2005

Rating	Country	GNP per capita purchasing power parity (USA thousand dollars)	Economic Dimension Index (I_{ECD})	Competitiveness Index (CI)	Index of Economic Freedom (IEF)
1	Hong Kong (China)	31,660	0,632	0,483	0,781
2	Singapore	32,530	0,594	0,548	0,641
3	Finland	29,650	0,567	0,594	0,540
4	Denmark	32,490	0,563	0,565	0,561
5	USA	41,529	0,562	0,581	0,543
6	Iceland	33,560	0,561	0,548	0,574
7	Ireland	36,790	0,550	0,486	0,632
8	Luxemburg	54,690	0,557	0,490	0,625
9	Great Britain	31,150	0,542	0,511	0,574
10	Sweden	30,590	0,537	0,565	0,510

Details

With regard to the post socialist countries, rating on the basis of the Economic Measure Index is as follows: Estonia – 12 (I_{ECD} = 0,533), Czech republic – 26 (I_{ECD} = 0,459), Slovakia – 36 (I_{ECD} = 0,428), Hungary – 37 (I_{ECD} = 0,424), Latvia – 38 (I_{ECD} = 0,420), Poland – 45 (I_{ECD} = 0,401), Bulgaria – 57 (I_{ECD} = 0,365), Moldova – 79 (I_{ECD} = 0,33), Ukraine – 89 (I_{ECD} = 0,319).

Table 1.12.3 shows ranking of world economies according to the Environmental Measure Index.

Rating of the post-socialist countries according to the Environmental Measure Index is as follows: Latvia – 16 (ESI = 0,604), Estonia – 28 (0,582), Slovakia – 50 (0,528), Hungary – 55 (0, 520), Moldova – 59 (0,512), Bulgaria – 71 (0, 500), Czech Republic – 92 (0,466), Poland – 105 (0,450), Ukraine – 110 (0,447).

Table 1.12.3: Ten best countries of the world according to the Environmental Measure Index

Rating	Country	GNP per capita, purchasing power parity (USA thousand dollars)	Environmental Sustainability Index (ESI)
1	Finland	29,650	0,751
2	Norway	39,590	0,734
3	Uruguay	8,869	0,718
4	Sweden	30,590	0,717
5	Iceland	33,560	0,708
6	Canada	34,150	0,644
7	Switzerland	33,580	0,637
8	Havana	4,575	0,629
9	Argentina	13,350	0,627
10	Austria	31,420	0,627

Table 1.12.4: Ten best countries of the world according to the Social Measure Index

Rating	Country	GNP per capita, purchasing power parity (USA, thousand dollars)	Social Dimension Index (I_{SOCD})	Life Quality Index (LQI)	Human Development Index (HDI)	Information Society Index (ISD)
1	Sweden	30,590	0,839	0,793	0,949	0,776
2	Iceland	33,560	0,839	0,791	0,956	0,770
3	Norway	39,590	0,829	0,805	0,963	0,719
4	Denmark	32,490	0,827	0,779	0,941	0,763
5	Switzerland	33,580	0,820	0,807	0,947	0,706
6	Luxemburg	54,690	0,815	0,801	0,949	0,696
7	Finland	29,650	0,802	0,762	0,941	0,704
8	Japan	30,750	0,792	0,739	0,943	0,696
9	Australia	31,010	0,791	0,792	0,955	0,627
10	New Zealand	25,110	0,789	0,744	0,933	0,692

Table 1.12.5: Best ten countries of the world according to the Sustainable Development index

Rating	Country	GNP per capita, purchasing power parity (USA thousand dollars)	Sustainable Development Index (I_{SD})	Economic Dimension Index (I_{ECD})	Ecological Dimension Index (I_{ED})	Social Dimension Index (I_{SOCD})
1	Finland	29,650	0,786	0,567	0,751	0,802
2	Iceland	33,560	0,778	0,561	0,708	0,839
3	Sweden	30,590	0,776	0,537	0,717	0,839
4	Norway	39,590	0,753	0,488	0,734	0,829
5	Switzerland	33,580	0,735	0,537	0,637	0,820
6	Luxemburg	54,690	0,735	0,557	0,618	0,815
7	Denmark	32,490	0,729	0,563	0,582	0,828
8	Canada	34,150	0,719	0,525	0,644	0,777
9	Ireland	36,790	0,716	0,559	0,592	0,779
10	Australia	31,010	0,714	0,532	0,610	0,791
Average for 10 leaders			0,744	0,542	0,659	0,811
Average "great eight" countries			0,651	0,473	0,553	0,740
Average for post-socialist countries			0,580	0,408	0,512	0,640

Table 1.12.4 shows ranking according to the Social Measure Index.

Over the last 15 years, the group of post-socialist countries has exhibited significant fluctuations regarding social development level. Currently their ratings are: Czech Republic – 25 (I_{SOCD} = 0,703), Hungary – 26 (0,686), Slovakia – 29 (0,673), Poland – 30 (0,667), Estonia – 33 (0,658), Latvia – 34 (0, 649), Bulgaria – 38 (0,628), Ukraine – 44 (0,554), Moldova – 46 (0,529).

Finally, table 1.12.5 shows ranking according to the composite Sustainable Development Index.

Details

The rating of the post-socialist countries according to the Sustainable Development Index is as follows: Estonia – 18 (I_{SD} = 0,662), Latvia – 24 (0,618), Czech Republic – 28 (0,602), Slovakia – 29 (0,633), Hungary – 30 (0,601), Poland – 38 (0,559), Bulgaria – 39 (0,549), Moldova – 43 (0,506), Ukraine – 45 (0,485).

1.13. Sustainable development as a form of ideology of the XXI century

Criteria to realize sustainable development include first of all economic efficiency, ecological safety and social justice.

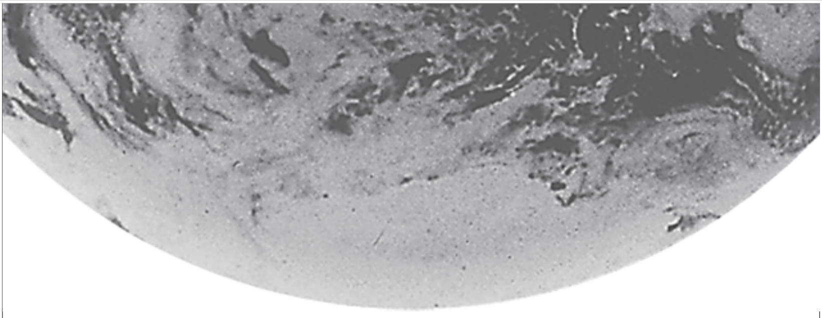
Particular aspects of sustainable development in the interpretation of the United Nations are:

Table 1.13.1: Key problems of sustainable development

Ecological	During 10 thousand years evolution was merely limited by spontaneous development of the restrictions of the local ecosystems. During the XX century the limits became worldwide and global changes started to harm the environment. The massive exploitation of nature caused a severe ecological crisis which is a signal that the limits are reached and new laws of the biosphere have to be established.
Economic	The problem is however how to balance the environmental quality. In particular how to deal with (regional and local) financial crises, trade wars, depressions and stagnation, economic migration and unemployment. Economic growth often caused the destruction of nature and resulted in ecological crisis (exhaustion of resources, raw material and energy, pollution). Ecological costs of civilization translate in economic, social and demographic effects. On their turn, in a reciprocal way, they reduced economic profit, investment activities, delays of growth rates, increase of poverty and disease.
Social – demographic	The main issue is the divide between the poor and rich. Moreover there is a growing divide between the rich and poor countries worldwide. Millions of people born in the XXI century are doomed to be poor and hungry. During the last decade of the previous century, the number of poor increased with more than 500 million. The demographic evolution (the population increases faster in the poor countries) increases the social crisis and results in a reduction of the arable lands and the available food per capita, shortage of goods in developing countries. On its turn this contributes to conflicts, migrations, extremism and terrorism and eventually global conflicts.

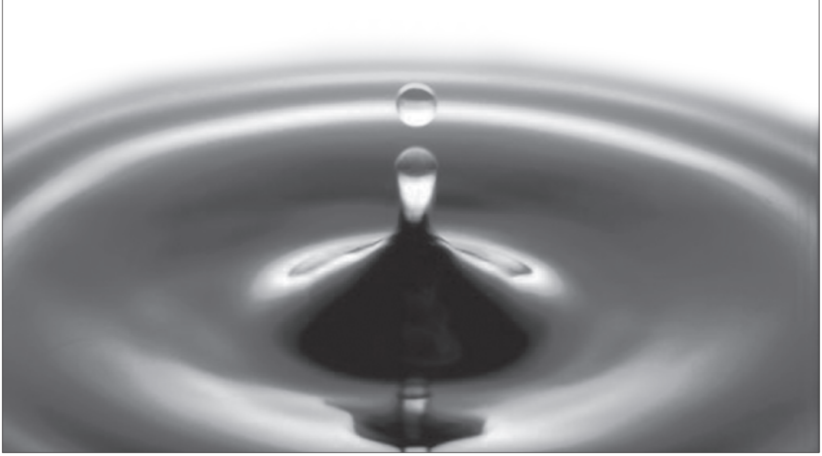
- the stabilization of the population;
- socially and environmentally acceptable production and consumption patterns (people in the developed countries consume 20–30 times more resources, than citizens of developing countries);
- more efficient use of raw material and energy during the life cycle of a product;
- industrial production, energy use, agriculture and transport in harmony with the carrying capacity of environment;
- substitution of nonrenewable raw materials by renewable ones;
- monitoring of the quality of the natural environment;
- monitoring of the performance by the UN member status of the implementation of sustainable development.

The transition to sustainable development requires to address the three fundamental problems listed in table 1.13.1.



PART II

ECOSYSTEMIC DIMENSION OF SUSTAINABLE DEVELOPMENT



2.1. Ecosystemic dimension of sustainable development

Ecosystemic Metabolism and Homeostasis of Ecosystems. In spite of the huge variation of species and other parameters – an ecosystem is rather stable. During evolution, fine and flexible mechanisms emerged that allow this stability of ecosystems.

Evolution of Matter and Formation of the Biosphere. Evolution is a core hypothesis in natural sciences: ***all systems emerged from and are built by evolution.*** General evolution characteristics include: *(non-) directivity*, irreversibility, *irregularity*, acceleration, *selectivity*, *and sampling*. In open systems where energy flows (excitation), dynamic structures appear as cycles, that transmit energy and form substance flows. The most stable of these consist of several associated cycles (Figure 2.1.1), and have consequently more chance to be selected by evolution.

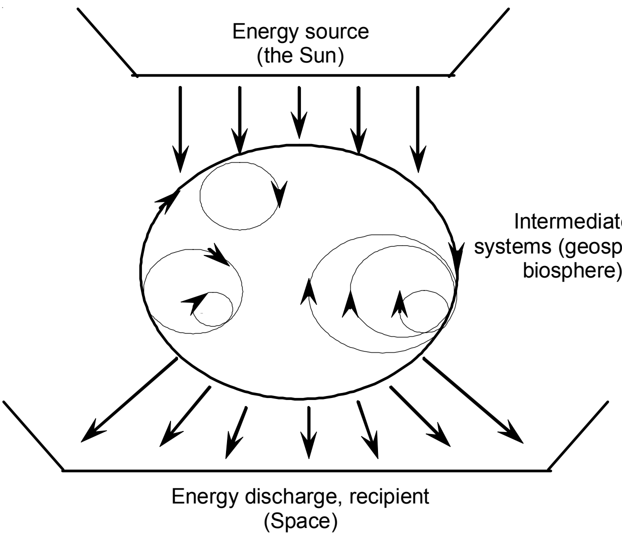


Figure 2.1.1: Three-chain system scheme with energy flows, and circuits of substance

Whenever such dynamic structures emerge, their driver is *energy*. On the Earth energy comes from solar power, which causes turnovers on the ecosystems.

The global evolution concept, incorporates the full set of environmental mechanisms: the big-bang: hypothesis, a model of the evolution of the Universe, the formation of stars and celestial bodies, the concept of chemical evolution, biological evolution and social evolution (Moiseyev, 1999; Ebeling et al, 2001; Khaytun et al, 2004).

Matter may approximately depict a chronological picture of these events with the increasing complexity of the environmental and molecular phenomena (figure 2.1.2). During the inorganic phases of evolution, the figure shows the number of atoms. As soon as life appeared, the number of atoms in information macromolecules (RNA and DNA) is used to describe the "atomic complexity".

Though the details of a number of evolutional processes are unknown, the chemical cycles are an indicator for the biological evolution. In this way one may describe a *pre-biotic phase* and a *biological phase of evolution* (Kalvin, 1971; Fox, Doze, 1975; Grant, 1980; Folsom, 1982; Vorontsov, 1999).

Critical is the moment where DNA appears. Its synthesis and structure demand new biosynthesis controls. Equally critical is the emergence of photosynthetic bacteria that are the main condition for eukaryotes to appear. Eukaryotic organisms contain much more DNA than prokaryotic.

Viruses stem from organelles in bacteria. The appearance of photoautotrophic eukaryotes, photosynthesis and oxygen production allow the gradual transition to an oxidizing atmosphere. Life becomes more complex as colonial forms, appear first, and multicellular organisms (figure 2.1.3). From this point all main groups of plants and animals evolve (points 6, 7, 8 In figure 2.1.2).

Humans appear at point 9 in figure. The speed with which they appear is remarkable: the phenomenon can be described as rapid anthropogenesis. Even faster is the appearance of technology, mainly during the XXth century. As the result the technosphere is formed.

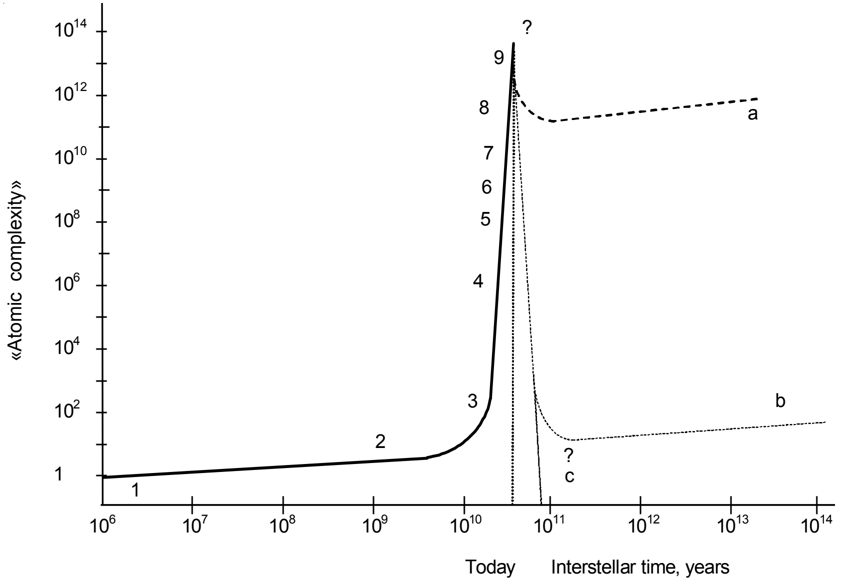


Figure 2.1.2: Global evolution “diagram”. Material evolution phases: (0–1 – cosmic phase): 1 – atom; (2–3–4 – physical and chemical phase): 2 – molecule, 3 – solid-state cluster, 4 – polymere; (4–5 – life origin; 5–9 – biological phase): 5 – protocell 6 – seaweeds, 7 – chordates, 8 – fishes, 9 – human. Interrogations and dotted lines denote possible scenarios in the future: a – telluric anthropogenic, b, c – cosmic.

The acceleration of evolution is noticeable: the chemical phase was 45000 times faster than the cosmologic one, and the biological phase was 300000 times faster than the chemical one.

On the basis of this past, the future is difficult to predict. There is no reliable basis of what will happen during the next million years. High probability that *mankind will scarcely remain in its contemporary quality.*

Ecosystem’s Metabolism – Circulation of Its Basic Elements. **Radiation energy from the sun alters the ecosystem and is used by**

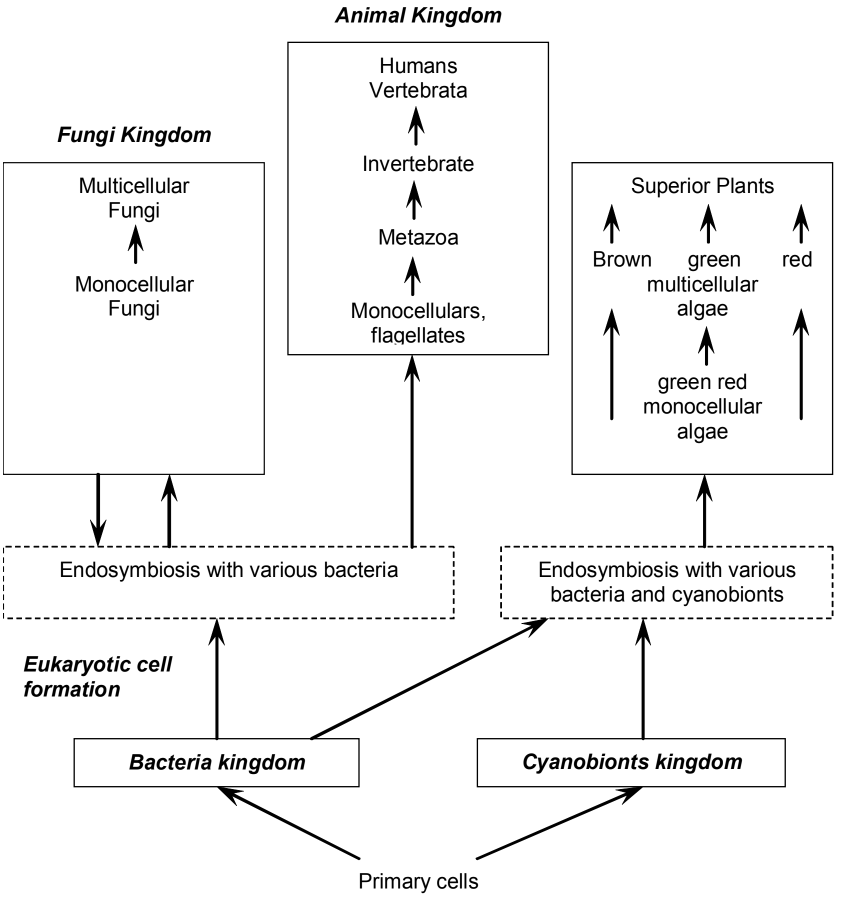


Figure 2.1.3: Evolution of organisms

photosynthesis. The continuous supply of energy by the sun installs energy flows.

Next to energy, there are the chemical resources. Living organisms need six chemical elements: *carbon, hydrogen, oxygen, nitrogen, phosphorus and sulphur*. The cycles of these elements have been established. Figure 2.1.4. shows the carbon cycle.

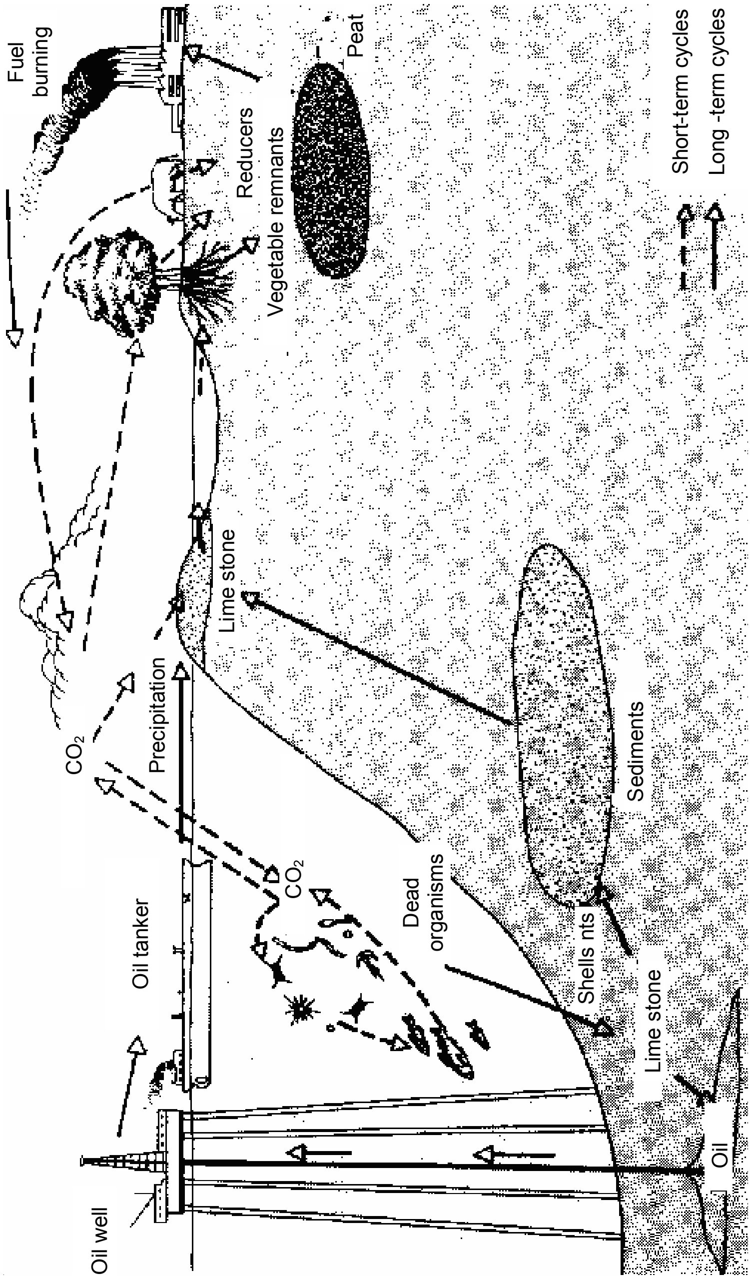


Figure 2.1.4: Carbon cycle

Carbon travels through different ecosystems. Dotted arrows point to processes with slow carbon conversion; continuous arrows, to more rapid ones (according to Kemp and., Arms.,1988).

Nitrogen and ***oxygen*** are also essential chemicals of the atmosphere. Plants cannot decompose nitrogen in the air. To be biologically active it has to be converted in inorganic compounds mainly by bacteria. The similar processes are necessary to use *phosphorus* and *sulphur*.

Homeostasis and dynamic Equilibrium of Ecoystems. Each ecosystem is characterized by its biotic component: the populations of all organisms living in it. Ecosystem stability is largely determined by the stability of the different species. Changes in these populations will inevitably result in ecosystem alterations. Therefore, the equilibrium of the system is closely related to the balance of the populations, living in its niches (Nebel, 1993).

Important characteristics to describe populations in this respect are reproduction_speed_and replenishment of adults by younger individuals.

Other factors that influence the population include: migrations in search of new habitats, the availability protection and resistance to diseases. The totality of these factors is called the ***biotic potential***.

One or more of these factors can become a limiting one. The extent of these limitations is called ***environmental resistance***. The growth, reduction or stability of a population is characterized by the ratio between biotic potential and environmental resistance. This concept results in the ***populations diversity principle:*** changes *are the result of alterations of the ratio between the biotic potential and the environmental resistance.*

The abovementioned ratio is the *dynamic ratio*.

The balance between populations also on the ***populations density***, the number of species per surface unit. Density is related with environmental resistance, higher densities often result in increased mortality and less individuals, and vice versa. The ***criti-***

cal populations number, is the lowest number of individuals that still allows reproduction. If the number is lower than the critical one, the population is sentenced to extinction.

Mechanisms of Homeostasis. A useful illustration is provided by the mechanisms underlying the *predator – victim* relationships. The mechanism is rather simple. The growth of the predator populations reduces the number of jackrabbits. Once the predators have nothing to eat, most of them die from starvation. Environmental resistance declines and the population of jackrabbits will grow. The role of the predator as a critical control factor, is rather rare. Much more important are the relations parasite – host (Nebel B., 1993).

From this the – ***ecosystem stability principle emerges:*** *species or biological diversity is the basis of ecosystems stability* (Zlobin Yu., 1998).

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2.2. Ecosystemic regulation and feedback mechanisms

The biological components of the ecosystem are plants, animals and microorganisms. Regulation of ecosystems includes positive and negative feedback mechanisms that are necessary components of sustainable development processes.

Positive feedback mechanisms. When a part of the system (A) increases, and another part (B) of the system changes in such a way that it contributes to a further increase, this is called a positive feed-back. A positive feedback occurs when A has a positive influence on B, and B has a positive influence on A (Figure 2.2.1). The positive feedback mechanism is a source of unsustainability; it points to necessary changes.

Exponential growth is an example of a positive feedback mechanism (Figure 2.2.2). Exponential population growth occurs, when there is sufficient food, space and resources which allow the population to grow without limitations. Population growth causes high birth rates, and as a result the population increases.

Positive feedback mechanisms strengthen changes, but do not always cause growth. If the ecosystem is on its return, the positive feedback can make the negative change even more pronounced. E.g., when animals, are exposed to a limitating factor, the de-

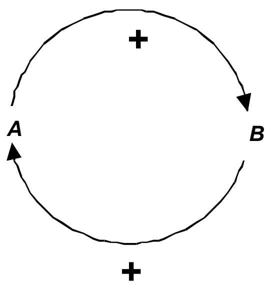

Figure 2.2.1: Positive feedback cycle

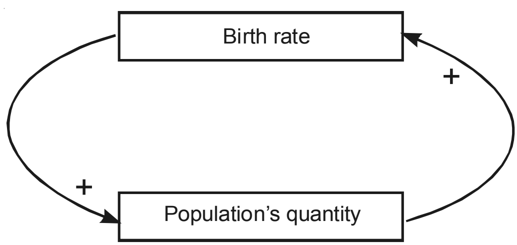

Figure 2.2.2: Positive feedback cycle that generates exponential population growth

crease of the population can be such that meeting for reproduction becomes difficult. This might threaten the population as a whole. Positive feedbacks not only exist in ecosystems but also in social systems.

Negative feedback mechanisms. Negative feedbacks are about effects that resist to the change. Negative feedback contributes to maintaining the balanced state of an ecosystem. When a part of the system changes too much, other parts will change in such a way that the original change is counterbalanced. Negative feedback mechanisms allow to maintain systems within the limits that are necessary for their survival. Negative feedbacks may contribute to sustainability; they prevent the changes.

Maintenance of homeostasis in ecosystems, is regulated by negative feedback mechanisms. For example, when food resources decline the population goes down, and vice versa: there is a population explosion when resources are unlimited.

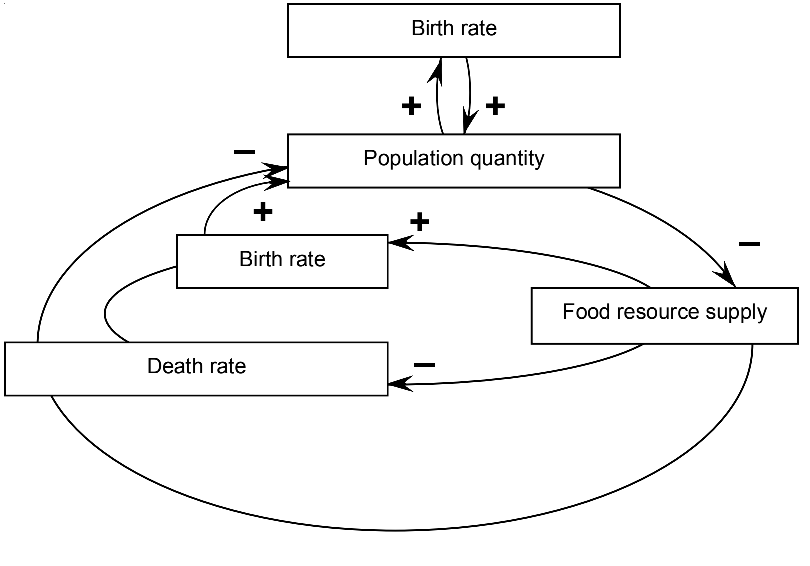

Figure 2.2.3: The cycle of a positive feedback mechanism

Regulation of the population. What regulates the number of plants and animals? Why are the populations not larger? Or smaller? **Population quantity regulation mechanisms** explain these phenomena. They use negative feedback to keep the population numbers within the limits of the capacity of the environment. ***The environmental capacity*** is the population, for which sufficient food and other resources are available to support the population for a long time. As the resources necessary to maintain vital functions of a population are limited, the environmental capacity cannot be exceeded for a long period.

Figure 2.2.1 shows, how positive and negative feedback mechanisms influence populations. Positive feedback mechanisms contribute to population growth: if the birth rate rises, the number of individuals in the population increases. Negative feedback mechanisms control the number of individuals when decreasing food resources results in increasing death rates and a decline of birth-rates.

Practical value of positive and negative feedback mechanisms. All eco- and social systems are controlled by positive and negative feed-back mechanisms. Both types of feedback are essential for the survival. Negative feedback mechanisms contribute to sustainability; they support the functioning of ecosystems. Positive feedback mechanisms support the environment capacity by maintaining the population to acceptable numbers.

2.3. Humans as an environmental factor of ecosystemic regulation

The appearance of humans on Earth and their fast social evolution, introduced a new environmental factor – the anthropogenic one. The general phases of anthropogenesis are briefly described below. They result in the concept of the anthroposphere.

Anthropogenesis and the Formation of an Anthropological Sphere. During the last 30 years, new paleonthological findings, updated methods of refined age determination and use of molecular and genetic devices classified substantially our view on the evolution and the ascent of man (Kharitovov et al., 2003).

Modern man, or neoanthrop – a subspecies of *Homo sapiens sapiens* – descented from an African branch of an ancient human being, the paleoanthrope.

8 to 9 million years ago the climate in the tropical zone of Africa changed, and the forest was converted to savannah over large territories. This forced our ancestors to change their way of life. They started downright walking, and developed instruments. 4,5 million years ago the *Australopithecus* appeared (Fouli, 1990). These were gatherers of food and became a regular component of the savannah. They died out near by a million years ago.

The modern representatives of the *Homo* species are sub-branches of the Australopithecus. They manufactured tools and used stones. Animal food consumption caused changes of digestion and metabolism. The body size increased together with aggression. They used fire, animal bones and skins (Kozlova, 2000). The cultural changes point to underlying development of the brain, intellectual development, memory use, and development of associated thinking. This is also the origin of *speech*.

The final stages of anthropogenesis coincide with climatic deviations – the ice ages and inter-glacial periods in northern hemisphere. Not later than 300 thousand. Years ago *Homo* arrived in Northern Africa, in Middle Asia and Southern Europe. Somewhat later one noticed the co-existence in Europe of Neanderthals and Cro-Magnons. The latter ones survived and are the ancestors of the modern Europeans during the period between 100 and 50 thousand. 10 000 years ago agriculture appeared. From that moment the formation of the human ecosystems starts. Humans have now their own environment, different from the natural one. This is a main turning point in the history of mankind.

Technosphere and Technogenic Material Balance. Currently the human environment is dominated by a set of *artificial objects – the* ***technosphere***.

From an environmental point of view, humans control now thousands of plant and animal species. Figure 2.3.1. represents quantitative estimations of technological flows. Of the 120 Gt of minerals and biomass, used every year by the world economy, only 9 Gt (7,5%) are transformed into material products by manufacturing processes. Over 80% of the used energy is circulated again in general manufacturing funds. Only 1,6 Gt relates to personal consumption of the people. Of that 2/3 is the net-consumption of food products.

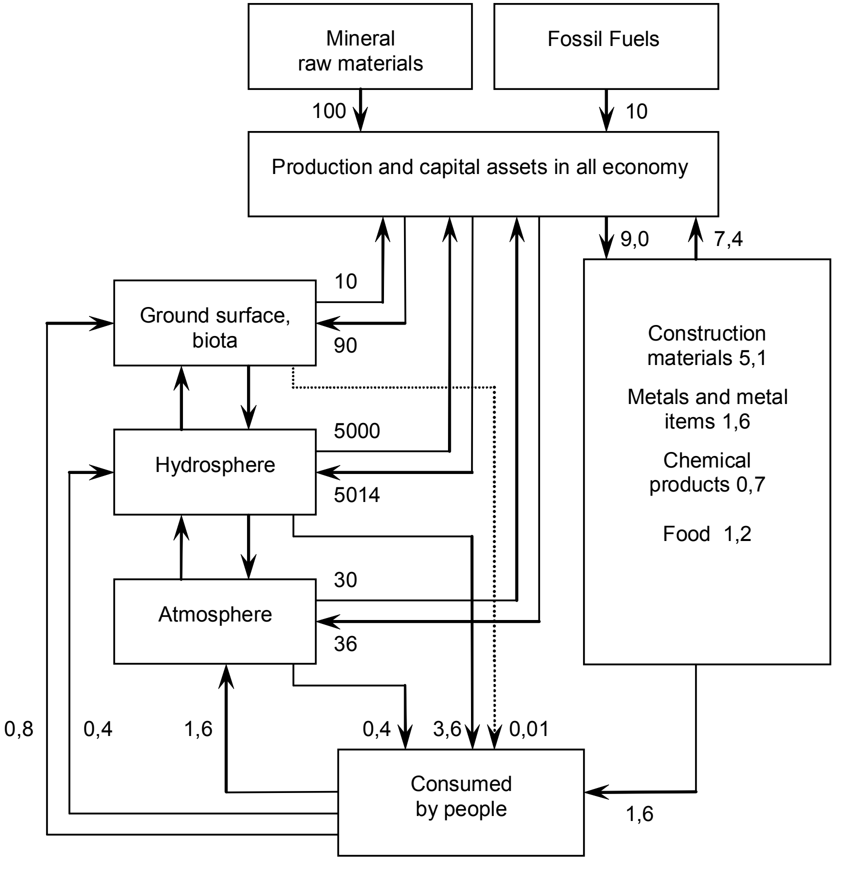

Figure 2.3.1: The global anthropogeneous material cycle (Consumption flows → and wastes flows, Gt/year)

Worldwide people consume 3,6 Gt of drinking water and 1,2 Gt of oxygen per year. Some 1,6 Gt of inhaled carbon dioxide and water vapour are recycled in the atmosphere; 18 Ej of heat is emitted. In water and the soil 4 Gt of liquid and 0,8 Gt of solid waste are released. The most serious impact of technology on the biosphere is however the turnover of organic substances.

Ecosphere – Global Environmental-economic System. The Modern environmental problems result from the collision between the technosphere and the biosphere. In this context, the technosphere is most aggressive.

In the context of this paper, the ecosphere refers to the interaction between biosphere, sociosphere and technosphere: *ecosphere = modern biosphere + sociosphere + technosphere.*

Today memory capacity and information reserves of modern civilization are comparable to these of the natural biota.

An important difference between the biosphere and the technosphere, is the speed with which information evolves. Paleonthological data show that nature needs an average 3 million years to replace a species. This coincides with 1% of the genetic information that is replaced. Technical progress during the XXth century (evolution of the technosphere), is determined by the reserve of scientific and technical information ($\sim 4 \times 10^{15}$ bits) and the average time of technological changes (10 years, or $\sim 3 \times 10^{8}$ s) or near by 10^{7} bit/s. This is 8 times faster than the speed of the biological evolution.

Conclusions

The *balance between biotic potential and environment resistance* is an important environmental principle. The tribal hunters and gatherers were completely subordinated by this principle. With the emergence of farming food was easier to get. The number of citizens on the planet increased slowly until the middle of the XIXth century. Better sanitary standards and the progress of medicine are main causes of increased life expectancy. Since that time planet entered a new phase of explosive population growth.

The huge population started to use natural resources, using technology and agriculture, until their exhaustion. As the result, the biological variation decreases, the populations are reduced, and species disappear.

Another main problem is the abundant use of chemicals that impair living organisms and ecosystems.

The living nature on the planet is the result of a long-term evolution that results in a harmonic, economically and effective balanced with precisely regulated flows of energy. It is unclear where the fast technological evolution will bring us.

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2.4. Biodiversity and problems of its preservation

Biodiversity means the variety of life forms on Earth. During last 30 years, researchers and public leaders came to understanding that evident threats to biodiversity are threats to humanity.

In 1992, 150 states have signed the Convention on Biodiversity (CBD) during the Earth Summit in Rio-de-Janeiro, Brazil. 187 states and European Union have ratified the CBD and integrated this legally binding international treaty in national legal systems, which is an evidence of crucial importance of the biodiversity for the planet and for human life and development.

Thus, juridical status was given to the term "biological diversity" practically everywhere. The CBD provides following definition of this term: "Biological diversity" means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems». Fundament of biodiversity is based on species, which are discrete communities of living organisms having the same set of genes (genotypes) and capable to reproduce organisms similar to themselves.

Complex of living organisms of different species, which are in interactions with surrounding environment and each others in order to exchange the energy and substances, represents **ecosystem.** Sustainability and evolution of the ecosystems depends on the balance of the processes of assimilation and dissimilation of the energy and substances as well as on organisms' resistance and adaptability to external pressures.

General scheme of the levels and composition of biodiversity is depicted in the table 2.4.1.

Totality of the ecosystems forms special part of the planet occupied by living organisms which are key peculiarity of this field. The term biosphere was given to this part of the planet.

Table 2.4.1: Biodiversity components and levels (Global, 1995)

Ecological diversity	Genetic Diversity	Organisational diversity
Biomas		Kingdoms
Bioregions		Phylum
Landscapes		Families
Ecosystems		Genus
Habitats		Species
Niches		Subspecies
Populations	Populations	Populations
	Individuals	Individuals
	Chromosomes	
	Genes	
	Nucleotides	
Cultural diversity: Human relations at all levels		

From human point of view, biological productivity is key characteristic of ecosystem. Biological productivity depends on the composition of biodiversity and environmental conditions. Natural environment is a source of raw materials for processing the food, clothes and footwear, construction of dwellings, means for health treatment and other purposes. According to the definition given in the Convention, "biological resources" includes genetic resources, organisms or parts thereof, populations, or any other biotic component of ecosystems with actual or potential use or value for humanity.

As it follows from the table 2.4.2, 1.75 mln species of living organisms are discovered and described by present. However, according to modern scientific assessments, this constitutes only the eighth part of total biodiversity of the planet and many new species will be discovered in future.

On other hand, many species are under threats of extinction, and situation is getting worse and worse. Extinction of species is irre-

Table 2.4.2: Quantitative assessment of the species diversity of the planet (Global, 2001)

Kingdoms	Number of described species	Total number of species (estimated)
Bacteria	4000	1000000
Protozoa	80000	600000
Animals	1320000	10600000
Fungi	70000	1500000
Plants	270000	300000
Total	1744000	14000000

versible process leading to deterioration of the ecosystem. Scientific assessments based on geological data shows that "normal" average rate of species extinction is five multi cellular organisms as per two years. The same indicator for vertebrate is much less. The planet is losing one bird species per 400 years and one species of mammals per 800 years. Regretfully, real picture is different. According to the preliminary estimations, 350 species of vertebrates and 400 species of invertebrates were disappeared from the planet during last 400 years. It means that registered losses are as much higher as hundreds times as to compare to estimated figures.

There are two main causes of biodiversity deterioration. The first very obvious cause of the decreasing of populations' number is uncontrolled and unsustainable extermination of living organisms, first of all fauna species representing some values for humanity. The second, not less important cause is as well human activity aimed at extension of the habitat areas. Urbanisation and development of rural settlements, extension of arable lands for agricultural practices, industrial constructions, building the roads and pipelines, increasing the shipping activities, natural resources extraction and other kinds of economic activity inevitably decreasing the habitat areas of wild plants and animals. Both direct (extermination of organisms) and indirect (destroying the natural habitats) influence of human activity are key treats for biodiversity.

Details

Few hundreds years ago, territory of modern Ukraine was covered by forests (55%), steppes (32%), wetlands (5%), meadows 1%). However, since beginning of the 20th century the picture has been significantly changed. As of now (2007), the forests are covering only 14,6% of the territory of the country and half of them are man-made ones. Steppes represent less than 1% of territory, bogs and swamps – 3%, meadows' area has been increased up to 9%, and arable lands cover 56% of the country (highest level in Europe). 30% of arable lands are deteriorated by erosion. Sharp decrease of territory of virginal natural lands causes significant reduction of habitats of wild species of animals and plants.

Biodiversity conservation is aimed at achievement at least of two objectives: first one is conservation of genetic resources constituting basis of species diversity, and second one is conservation of etalon ecosystems of biosphere for sustainable development and reproducing of species.

There are two systematic practical approaches for biodiversity conservation. Approach ***in-situ*** is focused on conservation of biodiversity at natural conditions. Approach ***ex-situ*** envisages conservation of organisms and their derivatives in artificial conditions out of ecosystems and native habitats. Both of them are important and mutually complementary.

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2.5. Econet in the framework of sustainable development

An econetwork is a complex of interconnected nature territories (i.e. conservation areas, national and natural parks, refuges etc.) that are interconnected with "green corridors". The aim is to preserve natural, ethnic, cultural, social and/or economical peculiarities of a region. The idea of econetworks was launched in the 1970ies to counteract fragmentation of nature.

«From Islands to the Econets». Isolated protected territories, are environmental the islands which loose their biological balance after time and will not provide the nature preservation they are aimed at. This explains the slogan "From Islands to Econetworks!" Setting up an Econetwork assumes a specific territorial system, which aims to improve the environment, to increase the natural and resort potential, to preserve the landscape and the biological variation by bringing together in a functional way natural reserves and other territories of environmental value.

The idea to reassemble ecosystems became popular in Eastern Europe. Since 2000, CIS countries established national concepts of environmental networks. The planning involves regions and cities.

The Concept of Econet. Econet is the system of connected biotops (areas with biocenosis) at local, regional or other levels, presented as natural complexes, having a special legal and ecosystematic status, and reestablishing the natural basis (framework), primary natural environment, the landscape characteristics, and the vegetation, of the given territory.

The functional elements of an econetwork are their nucleus (as a rule a nature reserve), connecting corridors among them (forests, rivers valleys, protective woodland belts), recovering and buffer zones (pastures, meadows, deserted fields), which all together an integrated system.

The structural elements of an Econetwork (econetwork objects) are forests, steppes, water zones, coastal areas other natural formations.

Underlying the econetworks is the idea that ecosystems are able to restore themselves, to regulate themselves and to develop functions even after they were fragmented or harmed in another way. These characteristics are connected with the role of biota, in particular their ability to produce organic matter. On its turn, organic matter is the basis of the trophical pyramid.

What are the basic aspects of econetworks? This paper deals with its ecosystemic economic, legal and normative, and social aspects.

Ecosystemic Aspects. Ecosystemic aspects of an econetwork deal with the practical implementation of how to put together an ecosystem. To achieve this goal physical, chemical, geological (including the level of biogenochemical cycles), biotical (populational, cenotoxical, peculiarly ecosystematic) and geographical (landscape) processes should be integrated in a holistic view on the ecosystem.

Econets in Ukraine

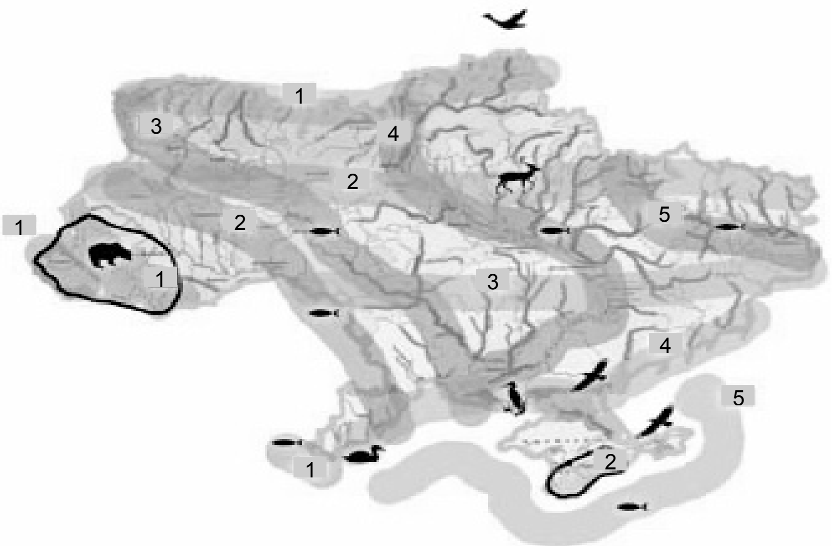

Figure 2.5.1: Number of Econets in Ukraine

Highlands	*Longitudal corridors*	*Meridian corridors*
1. Highland Carpathians	1. Polessky	1. Dunaysky
2. Crimean Highland	2. Galichsko-slobozhansky	2. Dnestrovsky
3. Podoliya	3. Steppe	3. Bugsky
4. Donetsk hills	4. Coastal	4. Dneprovsky
	5. Sea	5. Siversko-Donetsky

Economic Aspects. The economic value of econetworks is related to its non-exhaustive use: green, scientific or «sustainable» tourism, biofarming, etc. In Europe (and abroad) tourism is the economic sector that grows fastest. Within this sector ecotourism is the fastest growing segment.

Normative and Legal Aspects. Environmental and economical aspects necessitate to specify a political positions, forming the certain political and legal context.

Social Aspects. Social aspects are connected with the social support for an econet. A related aspect is the preservation and renewal of the traditions of local communities.

Institutions and organizational works. Ukraine starts to implement econets at five levels: international, national, regional (embracing several regions), district and local. At these levels the administrative and coordination measures are taken. They include the implementation of officially approved programmes, plans of actions that are based on scientific analysis. The Ukrainian Ministry of Nature and acts as the coordinating body. National and regional coordination committees assist the ministry.

Conclusions

The econet concept is an attractive idea, which combines ecological, economic, and social aspects of nature conservation. More in depth knowledge of its theoretical basis and the implementation methods is necessary. This should result in the renovation of natural territories, preservation the ecosystemic and landscape complexes and components, and the sustainable use of natural, in particular, biotic resources.

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2.6. Constraints as a factor of sustainable development

Constraints are one of the key issues which a systems in the process of its functioning faces on this stage of socio-economic development. ***Constraints*** are obstacles (phenomena, actions, factors, descriptions, signs, qualities) in a system or in its environment, in case of occurring of which a system slows, halts, stops or changes parameters of development.

In the case of origin of any type of constraints a system reacts on them definitely. On the degree of surmountable we will divide constraints on adaptation constraints (surmountable) and bifurcation constraints (insuperable).

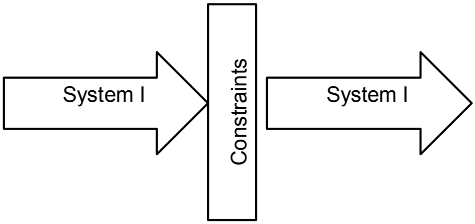
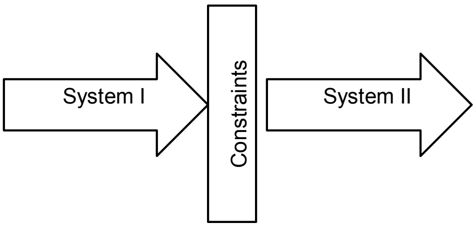
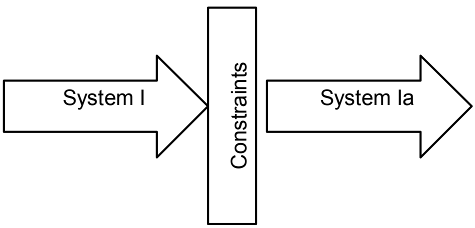
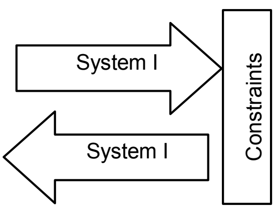
Adaptation (surmountable) constraints are constraints, running into which system is able to develop in future expending it and/or external (additional) energy, saving the basic parameters of functioning inherent to it.

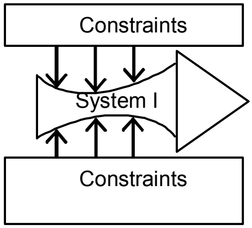
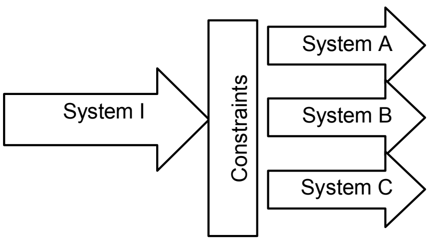
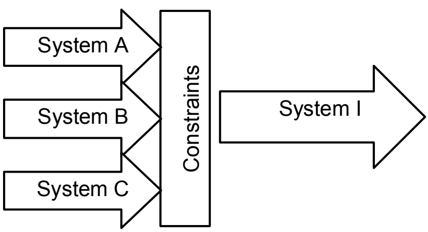
Bifurcation (insuperable) constraints are constraints, running into which system is not able to develop in future even expending it and/or external (additional) energy without violation (rebuilding) of basic parameters of the functioning (homeostasis).

The examples of influence of adaptations and bifurcation constraints are represented in table 2.6.1.

Studying of constraints influence on sustainable development processes is an important aspect of study and analysis of constraints influence. Influence of constraints on sustainable development can be positive and negative simultaneously. Such dualistic character of constraints factor action is important as for economic subjects, as for society at all. Constraints factor enables to estimate its influence on the processes of sustainable development. According to constraints classification we can define positive and negative directions of constraints influencing the processes of sustainable development.

Table 2.6.1: Adaptation and bifurcation constraints

Constraints	Schematic image	Contents
1	2	3
	Adaptation constraints	
1. Unimportant		System due to the internal mechanisms or involving the energy got from an external environment, saves the basic parameters of functioning
2. Changeable		A system substantially changes all basic parameters or greater part of the basic parameters of functioning will be changed
3. Correcting		A system partly changes all basic parameters, or less part of basic parameters of functioning will be changed
4. Vectorial		A system radically changes the vector of the development

1	2	3
5. Supervisory		In the process of the development the system constantly is under act of constraints which is not allow the system to change the parameters in accordance with desired by the system
	Bifurcation constraints	
1. Dividing		System halts the existence, growing into energy which other systems can eat up, or can disintegrate, forming a few more simple system, or grow into energy which other systems can eat up
2. Unifying		Few systems can unite, forming a new system due to mutually beneficial existence

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2.7. Properties of ecosystemic regulation and relationship between society and nature

The concept of sustainable development supposes the scientifically grounded management of the triune «man–economy–nature». This knowledge is based on the behavior of separate components in the system, e.g. realization of interconnections between them and process characteristics (Figure 2.7.1). *Regularity* is a property of the system to correspond to certain laws, i.e. constantly repetitive, necessary, substantial, cause and effect links.

Russian scientist-encyclopaedist M. Reymers systematized the regularities of an ecosystem as following (Reymers, 1990, 1994):

- formation (13 laws, axioms, principles, rules);
- internal development (12);
- thermodynamics (9);
- hierarchy (5);
- environmental influences (8);
- physics, chemistry and molecular-biological of the organisms (9);
- development (7);
- adaptation (5);
- "organism – environment" interactions (21);
- population development (21);
- species geography (23);
- distribution of as**sociations** (11);
- energy of **biotsenozis** (10);
- forming and functioning of **biotsenoz**is (23);
- forming and functioning of ecosystems (9);
- ecosystems dynamics (10);
- biosphere regulation (14);
- evolution of the biosphere (13).

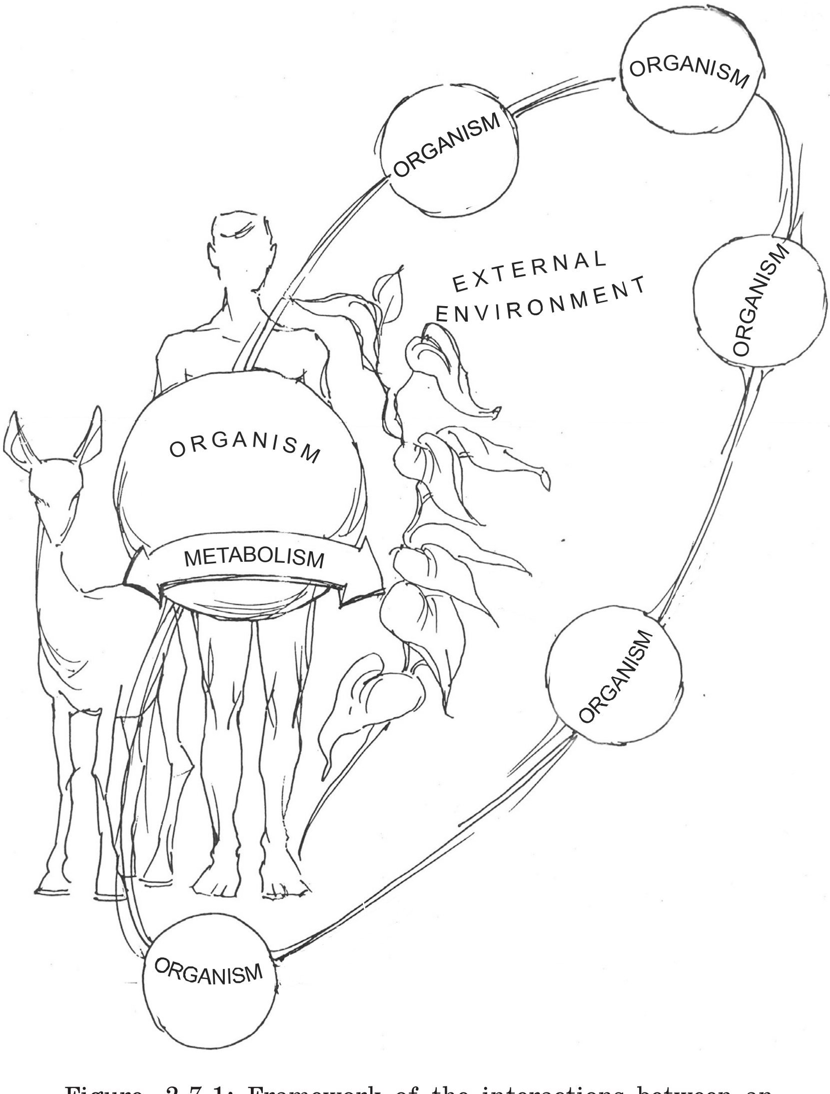

Figure. 2.7.1: Framework of the interactions between an organism and its environment

Table 2.7.1: Overview of some regularities

Title	Contents/Characteristic
1	2
Regularities of organism functioning and adaptation	
Adaptation axiom (Ch. Darwin's ecological axiom)	Each specimen is adapted to a certain ecological niche which contains a specific combination of environmental conditions.
S. Schvartz's ecological rule	Each change of environmental conditions causes directly or indirectly a change in the energy balance of an organism.
The law of "organism – environment" unity	Life develops as a result of a constant information exchange of energy in the unity of the environment and organisms.
The principle of ecological conformity	The existence of an organism always corresponds to its life conditions.
Separate regularities in "organism – environment" system	
J.Libich's laws of a minimum	Any ecological factor, that appears to be scarce, determines species development.
Population laws	
J.Oduma's law (rule) of a population maximum	The number of individuals within a population is limited by the maximum population density in a certain habitat.
Ecosystem regularities	
Principle of ecological ***complementary***	All components of any ecosystem are so closely interrelated with each other, that make single integral functional formation, i.e. no separate component can exist without other functionally complementary parts. Component parts of ecosystem are connected by food relations, mutually complement each other and simultaneously depend on each another.
Regularities of ecosystem dynamics	
The law of subsequent development.	Phases of development of natural system may follow only in evolution fixed order (historically and ecologically caused)
Rule of automatic maintenance of global environment of existence (follows from V.I. Vernadsky biochemical principles)	Living substance during self-control and interactions with ***abiotic*** factors supports ***autodynamicly*** an inhabitancy, suitable for its development.

1	2
N.F. Reymers' rule of socially-ecological equilibrium	Society develops until it keeps balance between the pressure on the environment and renewal of this environment, i.e. natural and artificial.
V.G.Gorshkov's principle of cultural management of development	Culture (religion, traditions, habits, ethics) corresponds to the purposes of maintenance of equilibrium between developing society and the environment of its development.
Laws of environmental management	
N.F. Reymers` law of accordance between development of public productive progress and natural-resource	There is a concordance between development of public productive progresses and natural resource. Critical situations can arise from unbalances not only on the right but also on the left part of the following dynamic system: natural resource – productive forces – production relation. This dynamics, in general, is an external reason of the social development that suffers from numerous ecological crises.
Rule of «soft» management of nature	«Soft» control of natural processes corresponds to management of natural resources in a more effective and natural way; that is always better than techno-genic interference. Such management is built on initiation of useful natural chain reactions including processes of renewal (for example, biological methods of running «organic» farming).

Table 2.7.1 gives an overview of some of the regularities noted above.

2.8. Environmental factor in development of socio-economic systems

The development of any system depends on two kinds of factors – endogenous, defined by inner characteristics of the system itself (its ability to store and fix information, possibility to adapt to environmental changes, etc.) and exogenous, defined by external factors.

Scientists (Bystryakov, 1997; Kohn, 1998, Roginskiy, 1983), speaking about direct and indirect impact of natural factors on a human being (his health, possibility of creative impulse formation, conditions of migration activity etc.) distinguish 5 main ways of exogenous factors activity on a human being and society:

1) direct influence on human health, physical, efficiency, birth rate and death rate;
2) through human dependence on natural means of existence, in particular abundance or lack of food (wild fowl, fish, plants);
3) influence of presence or absence of necessary labour tools;
4) natural creation of incentives, making people to act, stimuli to activity in accordance to changing environmental conditions;
5) presence or absence of natural barriers, that impede meetings and contacts between groups (oceans, deserts, mountains, swamps).

From the point of view of natural services provision two marginal states of exogenous factors can be conditionally distinguished: *favorable* and *unfavorable*, between them there are real conditions of natural environment.

Result processes of the conventionally favorable state of exogenous factors on the social-economic system, can be presented by the following scheme (Figure 2.8.1).

Investigations show that natural – resource crises were the main reasons of any small and big socio-economic revolutions, happening in different places of the world. As N. Reimers said "there always has been a correspondence between the development of production forces and nature-resource potential of the social progress" (Reimers, 1994). Critical situations appear when a dynamic system is in the disbalance (Figure 2.8.2).

From the environmental – economic view point it is extremely important to follow the change of three key parameters of socio-economic system in the framework of three basic social formations: two in retrospective and one in perspective direction.

- *postneolitic epoch* (from agricultural production based on human labour – cattle-breeding and farming to industrial revolution);

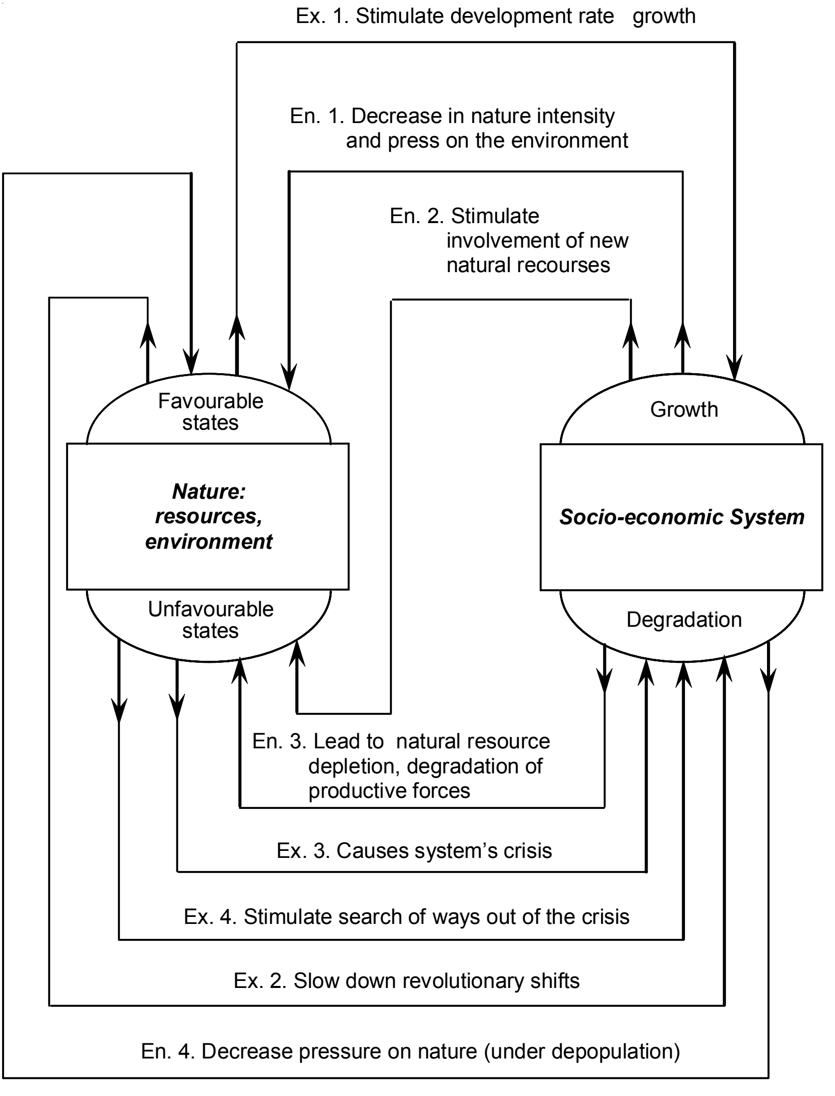

Figure 2.8.1: Impact of endogenous and exogenous factors on the transformation processes of socio-economic system

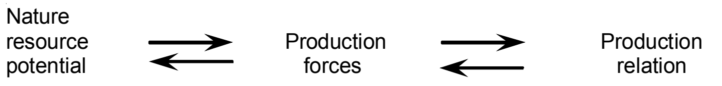

Figure 2.8.2: Interaction of factors in a dynamic system "nature – society"

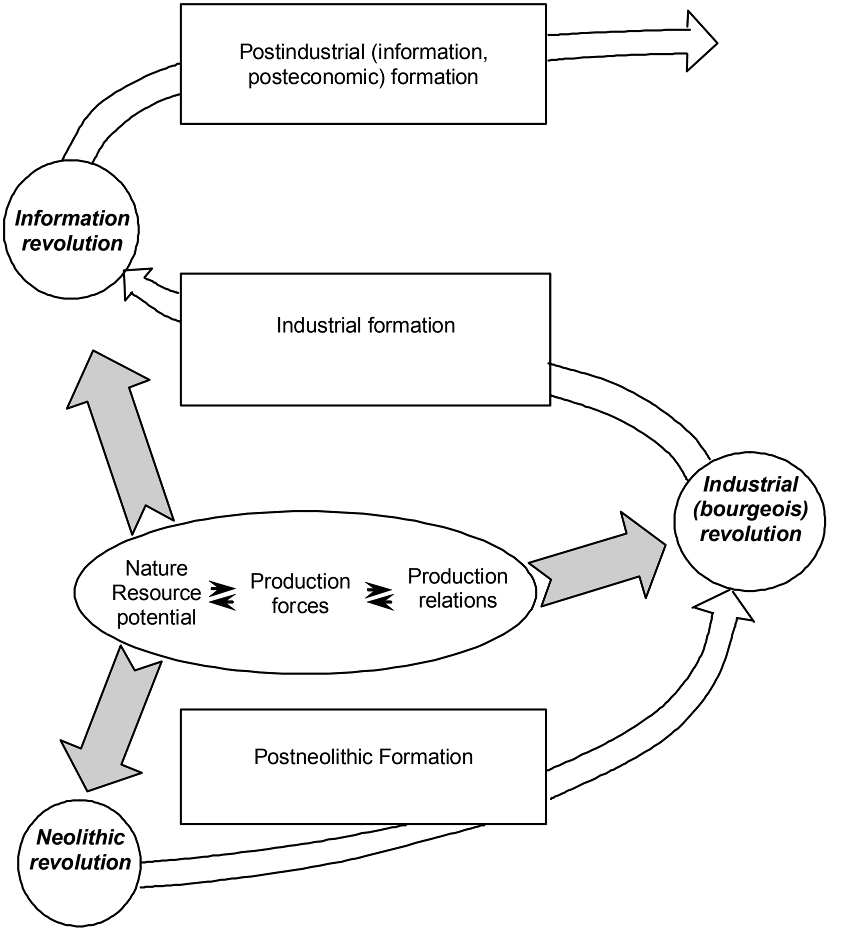

Figure 2.8.3: Main stages in socio-economic development

- *industrial epoch* (from the beginning of industrial revolution to present days);
- *postindustrial period* (under formation).

Let's pay attention to changes:

- in relationships between humans and nature;
- in human himself;
- in industrial relations.

Table 2.8.1: Basic economic, social and environmental parameters of three socio-economic formations

Parameter	Formation		
	Postneolitic	Industrial	Information
Basic natural substances	substance	energy	information
Dominant system in human triad	bio-	labour-	socio-
Prevailing nature functions	physiological, ecological	economic	social, ecological
Prevailing type of consumption	materials	material-energy	information
Basic factors of production system	labour/nature	machine	information
Basic factors of social structure	labour/land (nature)	capital	Information
Coordinating class (social group) in the society	slave owners, landlords	bourgeoisie	intellectual elite
Basic form of production relations	forced compulsion	economic agreement	free labour
Dominate type of "human – nature" relations	dependence of humans from nature	attempts of penetration into nature	harmonic attitude
Basic reason for environmental crisis	productive natural potential depletion	destruction of reproduction potential, reproduction of energy	information overproduction, information destruction of nature

This analysis can be fulfilled only after the investigation of the nature of transformation processes, occurring in the contents of basic factors, that form the contour of social formations (Table 2.8.1).

Transition to postindustrial (information) society can become next revolutionary stage if ecologization of production forces. For sure, without this it will be impossible to reach sustainable development. Basic purpose of information technology is revolutionary increase of life support processes efficiency, and consequently, processes of natural factors use.

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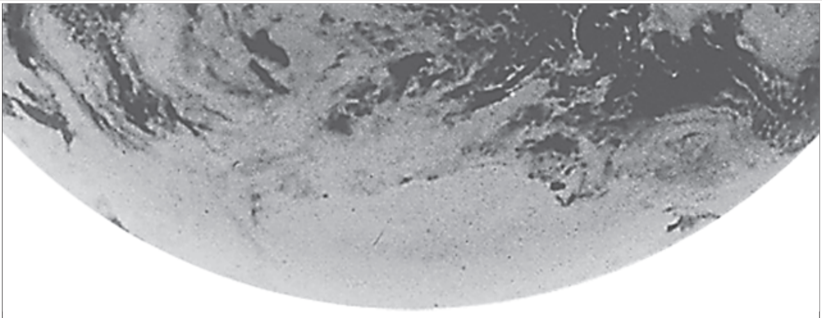
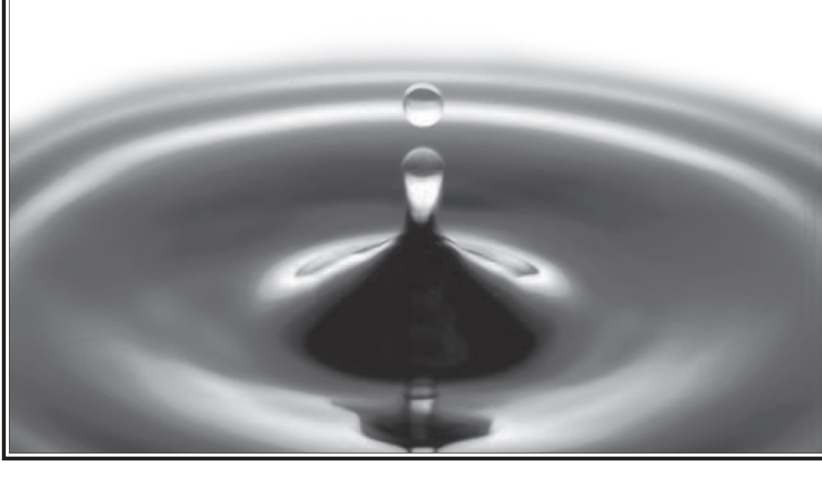


Part III

ECONOMIC DIMENSION OF SUSTAINABLE DEVELOPMENT (ASSESSMENT OF ENVIRONMENTAL AND ECONOMIC ACTIVITY)



3.1. Natural factors as components of economic system

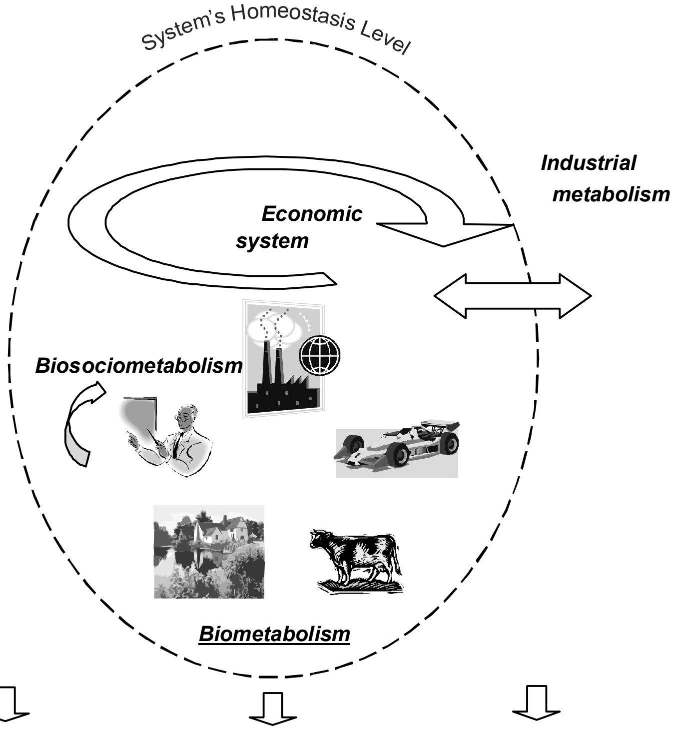
The main function of any *open stationary system* is extraction of "free energy" from the environment. This very function is realized during metabolism. When conditions of the environment change the system has to sustain its homeostasis level (negative feed back mechanisms) due to additional energy costs or due to additional energy costs to transform in such a way that the level of its homeostasis (positive feed back mechanisms). What is an economic system of any level? This is a symbiosis oa separate biological systems (people and cultivated by natural systems: lands, plants, animals) with technogenic systems. Each of the mentioned subeconomic systems has its own homeostasis and metabolism measures. (Figure 3.1.1).

When environmental parameters deviate from the optimal level (as a result of pollution or environmental destruction) in each of the mentioned economic sub systems such processes occur. Some of the subsystems can sustain the homeostasis level due to quazienergy losses, others have to change it due to quazienergy costs, the third die, because they can do neither the former nor the latter.

Illnesses, people's, animals, plants, microorganisms deaths; high destruction, are the external appearance of these processes. As a result productivity reduction of economic systems, medical services costs increase, additional production costs etc can happen. All these phenomena are specific characteristics of economic system quazienergy losses as a result of environmental destruction.

Two forms of buy-sell processes, in which natural factors are involved, can be mentioned.

1) Processes of *direct realization of market relations* happen when buying and selling object is a natural factor. Mineral resources, forest producer, seas, natural resources for ornament art, etc.
2) Process of *indirect realization of market relations* happen when the object of buying and selling is not the natural factor itself, but its functions, which are realized in the selling process of other goods and services.



The increase of dissipative component of quazienergetic balance

- losses of agricultural and forest products
- capital assets losses due to premature depreciation
- additional costs for treatment
- losses due to labour productivity

Increase of quazienergetic costs:

- additional costs for protection of people;
- additional costs for production systems protection;
- additional costs for compensation of productivity

Additional costs due to homeostasis change

- additional costs for production transformation
- opportunity costs due to forced refuse from profitable kinds of activity

Figure 3.1.1: The scheme of negative consequences as a result of environmental degradation in a conventional economic system

All these *subjects* and *services*, which are objects of buying and selling, are the goods through which the selling of physiological and social functions of natural services (in this case sun raise and sea) is mediated. The mentioned goods and services have their own monetary values (prime cost of production and selling price). But the mentioned natural services, which motivate the selling of these goods, form high demand for them in *this time and in this place*. Human's need for fresh air and silence are realized through a desire to buy a more expensive house, situated far from production plants or noisy highways, and needs for information contact with nature through ecoturism costs.

Theoretically, indirect monetary value of any natural service can be measured through additional volume of selling and/or high price level for a definite good comparing to economic indicators in those places and in that time, where and when there is no high demand for these services. Schematically it can be expressed by the following equation:

$$Э_{on} = \sum_{i=1}^{n} \left(П_i' \cdot Ц_i' - П_i \cdot Ц_i \right) \qquad (3.1.1)$$

where $Э_{on}$ – indirect monetary value of natural service;

$П_i'$ – volume of selling of *i* good in high demand (due to the need for a natural recourse) and in the absence of high demand;

$Ц_i'$; $Ц_i$ – price of *i* good in high demand and in its absence;

n – number of goods (subjects and services), due to which the demand of this natural service can be realized.

3.2. Natural capital in the context of sustainable development

Analysis of social and economic factors of development usually imply three kinds of capital:

1) human;
2) physical;
3) natural.

It is obvious, that all three kinds of capital are interconnected and interdependent.

We can identify three basic functions of natural capital:

1) resource – maintenance of goods and services production;
2) eco-system – maintenance of various adjusting functions: pollution and waste assimilations, regulations of temperature and water mode, preservation of ozone layer, etc.;
3) social – provision of a society with so-called aesthetic, ethical, moral, cultural, historical and scientific services of nature.

The estimation of the world riches nations and their share of natural capital is represented in table 3.2.1 (Peculiarities, 2006).

Currently, in the theory of natural capital in the economy of wildlife management such new concepts, as "global ecological services", "the ecological donor", "compensatory payments for preservation of eco-system" appear.

Table 3.2.1: National wealth of the world at the beginning of the XXI century (PPP)

The world, region	National wealth		Kinds of capital, trln USD		
	Total, trln USD	Per capita, thousands USD	human	natural	reproductive
Countries of the world, total	550	90	365	90	95
Great Seven and the EU	275	360	215	10	50
OPEC countries	95	195	45	35	15
CIS countries, total	80	275	40	30	10
Russia	60	400	30	24	6
Other countries	100	30	65	15	20

In the majority of publications it is marked, that territories which provide eco-system services are to bear significant economic costs (additional expenses for preservation and restoration of natural complex, missed benefits from industrial development, etc.). At the same time it is ascertained, that consumption of eco-system services can bring significant social and economic benefits.

It is suggested to implement payments from subjects, addressees of ecological benefit (physical persons, enterprises, regions, countries), to subjects, ecological donors, i.e. those who give such benefits.

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3.3. Ecological component of natural resource rent

Natural resource rent is a part of the surplus profit, which originates as a result of the use of natural resources (goods) in the process of the social production. In the social-economic aspect the natural resource rent is a form of specific economic relations about the appropriation, ownership and use of natural resources (as a mean of production) and about the income from their exploitation between the owner and economic agents- users of natural resources.

The need to create an effective mechanism of incorporation of the natural resource rent by the budgetary-tax system stirs up the scientific search for the workable rent-generating sources of the public revenue, which were not either appropriately accounted for, or enabled previously (non-traditional). These rent generating sources include the ecological rent as a component of the natural resource rent together with the other (Figure 3.3.1).

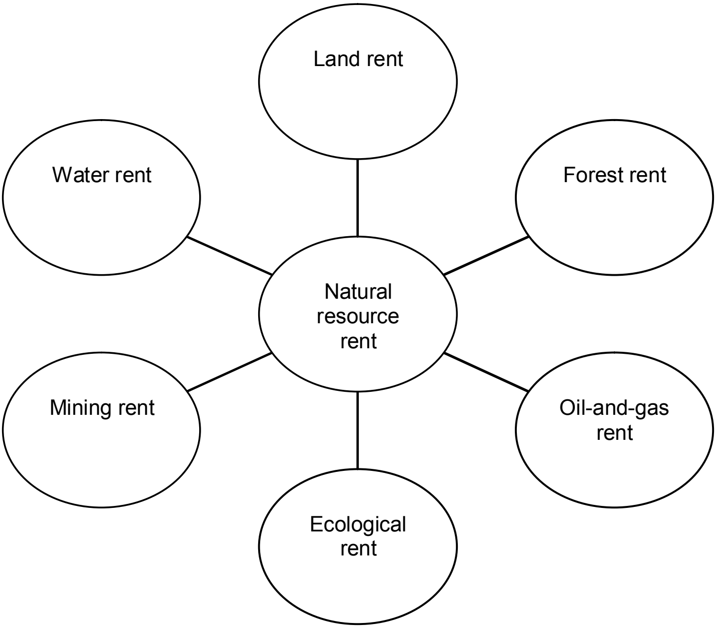

Figure 3.3.1: The main structural components of the natural resource rent

Ecological rent emerges in the form of the additional income of economic activity agents (natural resource users) as a result of the appropriation of a certain ecological-economic effect – either in the monetary or in natural forms – from exploiting (using) different by quality ecological properties, conditions, resources of the natural environment as the environment for carrying out a production process (or the environment for the reproduction of labour-power).

Kinds of ecological rent:

(1) *strictly* ecological rent;
(2) *resource efficient rent;*
(3) *environment protecting rent;*

(4) resource *wasting rent*;
(5) *environment polluting rent*;
(2) + **(3)** = *ecological quasi-rent* **(6)** – at the same time is a component (a sort) of the *technological* quasi-rent.

Resource efficient ecological rent – is a surplus profit, which evolves in the fields of the natural resources management and exploitation as a result of the use of the more effective ecologically designed equipment and technology, resource efficient ways of organization of production, etc. *Environment polluting* ecological rent – is a surplus (unearned) profit, received by economic agents as a result of the wasteful use of natural goods via environmentally unfriendly methods of economic activity. *Ecological quasi-rent* – is a surplus profit, received from the innovative de-

Table 3.3.1: Forms of ecological rent and its content

Rent form	Content
Absolute	Economic form of realization of the total rights of the owner of environmental goods (as limited natural resource) to receive income from the property, if it is of demand by the natural resources user.
Monopoly	Economic form of realization of the total property rights on the income, generated as a result of the use of rear, unique, nonrenewable freely, exclusive characteristics, qualities, parameters of the ecological recourses, which have high public benefits.
Differential rent I	A form on the differential rent, which evolves under the conditions of the unevenness of an ecosystem, natural living environment, when under the equivalent investment on the same territorial spaces with different natural conditions one can receive different result of the economic activity (profit).
Differential rent II	A form on the differential rent, which evolves as a result of the nature reproduction and environmentally oriented economic activity that is via consistent expenditures in creating the conditions for the quality level of the natural goods maintenance. Intensification of the nature recreation activities leads to the fact that the environmental destructive, technologically more advanced productions receive a surplus income.
Differential rent III	A form on the differential rent, which reflects a surplus income, received as a result of additional investment in the production of the environmental clean goods and services, neutral or improving the attributes of the natural environment, environmentally safe in the process of their production and consumption. This surplus income (super-profit) is defined as a difference of the market (public) and private costs.

velopment of the environmentally and economically effective technologies, that it the result of innovations in the environmental protection, pollution reduction.

The experience suggests that better local environmental conditions for the operations and living of economic agents create certain preconditions for the extraction of incomes not related to the personal labor contribution per se, including those which emerge as a result of the free of charge use of the territorial advantages, conditioned by the quality of the natural environment. Thus, there is the need to extract the ecological rent in order to, first, level the ecological and economic conditions for economic activity, and secondly, direct the respective revenues to the budgets. The today's agenda therefore require to include the scientifically grounded flexible system of the ecological rent taxation, which implies broadening and deepening of the important fundamental block of the economic mechanism of environmental regulations " the ecological (environmental) taxation.

3.4. Environmental and economic safety in a sustainable development context

Economic growth strategies require, first of all, to address the of country's national safety. It allows the integration of the national interests of the country, with global world processes. It further allows to classify threats and to foresee mechanisms that point to danger and catastrophes.

The "danger concept" refers to a situation where there is a possible danger to the system (i.e. worsening of its functional characteristics). The *protection* from unfavorable, undesired and harmful events is defined by the *safety* concept (Economic, 1998; Muntiyan, 1998).

Economic safety suggests maintaining the economy at the level, that ensures the normal functioning of industrial and distribution systems, the possibility of sustainable economic growth, the integrity of the environmental systems, and safeguards employment, welfare, and decent life conditions.

Economy on at levels is the *object of safety*. Safety must guarantee the sustainability of economic systems. The balance between benefits and damage is the main function of safety (Economic, 1998).

The process of economic transition necessitates the ensuring environmental and economic safety, to make sure that the new economic development does not result in a new unbalance and a new ecological catastrophe. Instead, the new economic growth should be realized in conditions of environmental and economic safety.

Environmental safety ensures the natural resource potential of the country in such a state that it provides three groups of nature services over a long period of time:

- social (ensuring human health and social development);
- environmental (maintaining the integrity of ecosystems)
- economic (the use of renewable and non-renewable resources must be kept within acceptable limits)

Environmental-economic safety is a state of the economy in which economic and environmental safety are in balance.

A policy to regulate this environmental-economic safety on both micro- and macro-level (tax and credit systems) entails regulators and stimuli. The problem is how to create adequate motivation for a producer and for a consumer, that stimulates additional value while the environmental pressure decrease.

Substitution of nonrenewable natural resources by renewable ones is the main driver of *environmental-economic safety. Innovation and information* are essential elements in a strategy on renewable resources. Today, innovations become the leading factor in the *environmental-economic safety* of the country. The role of innovations is related to their unique potential to influence regeneration processes in economy and environmental quality. This can be realized in the following way:

- Innovations help to increase the efficiency of using nonrenewable natural resources and decrease the need for raw material.

- Innovations allow transition to resource saving technologies and, decrease the need to extract raw materials and their use in the production process.
- Innovations allow substitution of materials and energy), of nonrenewable resources by renewable natural resources (for example, petroleum, black oil, biofuel, and biogas).
- Innovations allow to offer renewable natural resources at a rate that is compatible with nature and the needs of the future generations.
- Innovations allow to decrease the need for environmentally harmful industries, production processes and products.

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3.5 Effective waste management as a component of sustainable development

An effective waste management system is an important prerequisite to sustainable development. The Basel Convention on transborders movements of dangerous waste is important in this respect. This Convention was implemented in May 1992.

The main goal of the Basel Convention is the implementation of an "environmentally friendly treatment" of the whole cycle of dangerous wastes.

Typical scheme of solid industrial waste treatment (HIW or MSW) is shown in figure 3.5.1.

The so called "dematerialization of economy" considered by the EU countries as an instrument to safeguard the natural capital, is

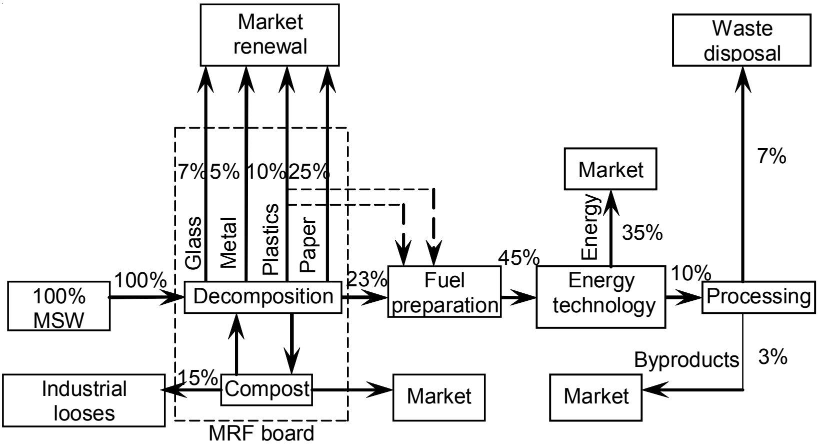

Figure 3.5.1: Scheme of waste management (with nominal percent flows)

based on changes in natural resource use and substitution of non-renewable resources by renewable ones. Physical indicators of the "industrial metabolism" are used to evaluate such correlation as well as "material flows accounts". "Physical indicators" are compared with "monetary indicators". All in all the discussion is about "eco-efficiency" indexes, material use, and resource productivity. The concept of "industrial metabolism", based on the thermodynamic laws and systemic analysis, describes industrial activity as a metabolic chain: resource extraction – extraction of materials – transformation into end-use products – transport – (land) disposal of waste in the environment.

3.6. Efficient and sustainable resource use; the consumer surplus, the producer surplus and the social surplus; the role of markets

Introduction

Economics is universally regarded as a social science that focuses on how to best allocate scarce resources to satisfy human needs and wants. If done successfully, the allocation of scarce resources is considered to be *efficient*. However, in two main ways, the economics of sustainability goes much further than standard economics:

- It deals more specifically at the efficient allocation of *natural resources* and *environmental systems*. There is less emphasis on labour and manufactured capital (e.g., plant, machinery, and equipment).
- It also deals with the *sustainable* use of natural resources and environmental systems - that is, how natural resources can be exploited in a manner that does compromise the ability of future generations to meet their own needs and wants.

The best way to understand the difference between: (a) an efficient allocation of resources, and (b) a sustainable rate of resource use, is to first recognise that the economy is a subsystem of the natural environment. Consider Figure 3.6.1, which represents the economy as the biological equivalent of a 'parasite' and the natural environment as the biological equivalent of its 'host'.

The sustainable rate of resource use. On the left-hand side of Figure 3.6.1, we have resources extracted from the natural environment entering the economy as 'usable' forms of matter and energy. Without the input of resources, the economic process cannot function and, thus, the sustainability of the economic process depends entirely upon the natural environment (natural capital) being able to continually supply resources both now and into the future. On the right-hand side of Figure 3.6.1, we have waste from economic activity re-entering the natural environment as 'useless' forms of matter and energy. Without the capacity of the natural environment (natural capital) to safely assimilate wastes and return them as usable resources, the economy is again unable function sustainability.

Overall, to ensure sustainability, the rate at which resources are harvested from the natural environment must not exceed the carrying capacity of the natural environment. Similarly, the rate at which wastes are generated must not exceed the natural environment's waste assimilative capacity. We shall return to the issue of a sustainable rate of resource use shortly and establish two important sustainability rules. The problem of non-renewable resources

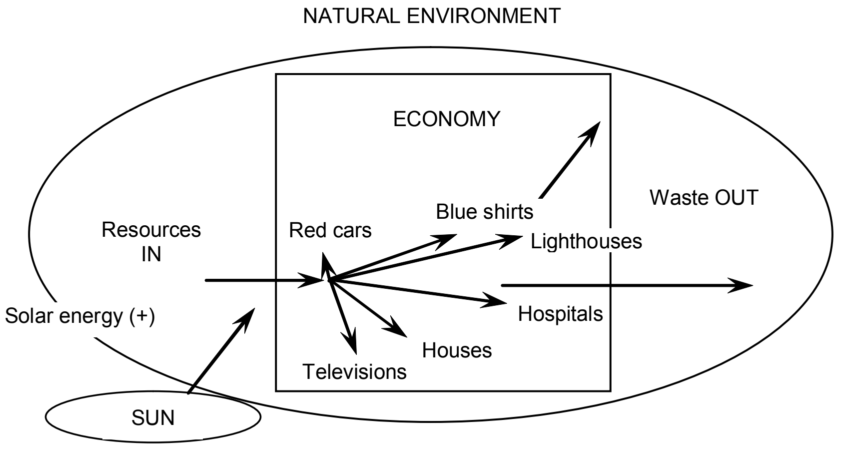

Figure 3.6.1: Economy as a subsystem of the natural environment

will also be briefly discussed, although a thorough treatment of non-renewable resource depletion is provided in a later chapter.

The efficient allocation of resources. Returning to Figure 3.6.1, it can be seen that, as the resource flow enters the economy, it must be allocated to produce the various goods and services to satisfy human needs and wants. Ideally, the resource flow will be divided up in the exact proportions necessary to maximise the welfare or surplus of society. In other words, the resource flow will be allocated in such a way that any subsequent reallocation of the resources would be unable to improve the welfare of one person without reducing the welfare of another person (Pareto efficiency). In this situation, the correct amount of the various resource types (oil, timber, stone, iron ore, cotton) is allocated to produce red cars, blue shirts, lighthouses, hospitals, etc.

If the allocation of the resource flow is efficient, nothing more and nothing less than the correct amount of the resources will be allocated to produce the different goods and services demanded by society. We shall see what is required in order for the allocation of resources to be efficient very shortly. Suffice to say now, in the case of each type of good produced, allocative efficiency occurs when the quantity of each good produced - and, therefore, the amount of resources allocated to produce it - results in:

- The difference between the total social benefit (TSB) and the total social cost (TSC) associated with the production of each good being maximised.
- The maximisation of the social surplus from each good occurring at the output level where the marginal social benefit (MSB) and the marginal social cost (MSC) associated with the production of each good is equal.

By now, the distinction between a *sustainable rate of resource use* and an *efficient allocation of resources* should be clear. The sustainable rate of resource use relates to the volume of the resources flowing into the economy from the natural environment and the volume of waste exiting the economy back into the natural environment. For the rate of resource use to be sustainable, we must comply with our two sustainability rules.

The allocation of resources relates to what happens to the resources once they enter the economy. A society will endeavour to allocate the resource flow to the production of each type of good so that the social surplus is maximised. If it achieves this, it has allocated the incoming resource flow efficiently.

The sustainable rate of resource use is important for one obvious reason - a society will want the welfare generated by economic activity to be sustainable into the future. The efficient allocation of the incoming resource flow is also important for an obvious reason - a society will want to generate the maximum social welfare/surplus from the resources entering the economy at any point in time. If a society can achieve both a sustainable rate of resource use and an efficient allocation of resources, it is well on its way to achieving what is often referred to as 'sustainable development'.

Maximisation of the social surplus

Social surplus and Pareto optimality. The social surplus (SS) from the production and consumption of a good, say blue jeans, which we want to maximise from the market allocation of the incoming resource flow, is very easily measured by the sum of CS and PS. Clearly, the social surplus is only maximised when MPB = MPC.

But there is still an important question that needs to be answered: Can we be absolutely certain that the SS from the production and consumption of blue jeans has been maximised by the market? In effect, we cannot. This is because the D (MPB) curve is the aggregation of the marginal private benefit (*mpb*) curves of consumers and the S (MPC) curve is the aggregation of the marginal private cost (*mpc*) curves of producers. For the SS to be maximised, the MPB and MPC curves must be representative of the marginal social benefit (MSB) and marginal social cost (MSC) curves - that is, the social benefits and social costs of producing and consuming blue jeans must be *fully* represented by the MPB and MPC curves (i.e., MPB = MSB and MPC = MSC). If the MPB = MSB and MPC = MSC, the social surplus will be maximised and Pareto efficiency will be achieved.

Unfortunately, Pareto efficiency and the maximisation of the social surplus does not always occur because of the problem of 'market failure'. We will look at the five main forms of market failure soon. For now, we can summarise this section by stressing the following:

1. The quantity of a particular good generated by the market allocation of scarce resources occurs where D (MPB) = S (MPC).
2. The quantity of a particular good that maximises the social surplus (SS) occurs where MSB = MSC.

The quantity where D = S will only lead to the maximisation of the social surplus (Pareto efficiency) if MPB = MSB and MPC = MSC.

The Sustainable Rate Of Resource Use

Because we are concerned about the sustainable use of natural resources, and not simply their efficient allocation, there are some rules we need to follow if the economy is to operate sustainably.

The sustainable input of resources from environment to economy. If we denote the rate at which resources are harvested from the natural environment as h and the regeneration rate of the natural environment as y, the input of resources is sustainable so long as the rate of resource harvesting is no greater than the rate at which the natural environment can regenerate new resources.

This leads to the emergence of a fundamental sustainability rule regarding the sustainable input of resources from the natural environment to the economy. In order to sustain the input of resources into the economy:

$h \leq y$.

Despite this sustainability rule, we are still left with a problem. There are two main categories of natural resources:

- renewable resources (timber, fisheries, etc.);
- non-renewable resources (oil, coal, iron ore, etc.).

The latter cannot regenerate and so the quantity of non-renewable resources remaining diminishes by an amount equal to the amount extracted. Whilst discoveries of non-renewables resources can offset the loss of extracted resources, this only reflects an increase in known non-renewable resource assets. Given the finitude of the resource stock, the extraction of resources must exceed new discoveries and, as such, non-renewable resource stocks must eventually decline. In sum, we are ultimately dependent upon renewable resources to sustain the economy.

The rule for exploiting renewable resources is quite simple. We must make sure the rate at which they are harvested (h) to the rate at which they can regenerate, in other words, its natural yield rate (y) - that is, $h \leq y$.

The rule for exploiting non-renewable resources is more complicated. We must make sure that, as they are exploited, some of the proceeds from the sale of iron ore, coal, oil, etc., are set aside to cultivate a renewable resource substitute. By doing this, a replacement asset can provide the same resource flow previously provided by the non-renewable resource while it was being exhausted. The difficulty associated with non-renewable resource depletion is having to determine what portion of the depletion proceeds need to be set aside to establish a replacement asset. We shall look at how this can be achieved in a later chapter.

The sustainable generation of pollution. There is one indisputable fact about pollution - all of it eventually ends up in the natural environment. Fortunately, the natural environment has the capacity to assimilate waste, that is, to absorb so much pollution and to convert it (with the aid of solar energy) to more benign substances.

To what extent environmental sinks can assimilate pollution depends on two things:

1. The *quality* of the waste. Some substances cannot be readily absorbed by natural environmental sinks. Indeed, some are so bad (toxic) that even small quantities can lead to the destruction of environmental systems.

2. The *quantity* of waste. Even if the pollution is relatively benign in nature, natural environmental sinks have only a limited capacity to absorb wastes. The limit is determined by the waste assimilative capacity of the natural environment. If the level of pollution exceeds the environment's waste assimilative capacity, the natural environment is adversely affected. This has two implications:
   - it reduces the capacity of the environment to assimilate the same quantity of pollution in the future;
   - it reduces the capacity of the environment to provide natural resources (e.g., an excess of pollution in a river reduces the number of fish that can be sustainably harvested; an excess of air pollution can lead to acid rain which can reduce the amount of timber that can be sustainably harvested).

The second of these factors enables us to establish a basic rule regarding pollution. The rule for generating pollution is to make sure the quantity of pollution/waste (W) no greater than the waste assimilative capacity of natural environmental sinks (A).

This leads to the emergence of our second fundamental sustainability rule, this time in relation to sustainable output of wastes from the economy to the natural environment. In order to sustain the rate at which wastes can be generated and re-admitted into the natural environment:

$W \leq A$.

When To Abandon The Efficiency Rule Of Msb = Msc

We may, if we like, rely entirely on markets to allocate the incoming resource flow and to determine the rate of resource use. If both are determined as a consequence of the market equating the MSB of consumption (D) and MSC of production (S), we may find that:

- $h > y$;
- $W > A$.

In other words, the Pareto efficiency may lead to the quantity of resources being harvested exceeding the regenerative capacity of natural resource assets. It may also mean a level of pollution that exceeds the capacity of environmental sinks to safely assimilate them. To produce, for example, 4000 pairs of blue jeans, resources are required. Also, a certain amount of waste will be generated. What if the required resource flow exceeded the regenerative capacity of the natural environment or the quantity of waste generated exceeded the natural environment's waste assimilative capacity? Indeed, the maximum sustainable quantity of blue jeans might be 2000 pairs. If so, the allocation of the incoming resource flow would be Pareto efficient but it would be unsustainable. That is, adhering to the efficiency rule would lead to the unsustainable rate of resource use.

In this situation, we may be better off abandoning the efficiency rule of MSB = MSC. We will enjoy fewer welfare benefits in the short run, but at least we know we can sustain high welfare benefits in the long run. Continuing to adhere to the efficiency rule of MSB = MSC would result in maximum welfare benefits in the short run but the possibility of much fewer and decreasing welfare benefits in the long run.

This doesn't mean that efficiency is not important. We can still facilitate an efficient outcome by, for example, having a government authority sell off limited resource use permits or pollution permits and then allowing firms to trade or exchange permits with each other. The limit in the number of permits sold ensures the rate of resource use is sustainable. The market price for permits ensures that resource prices and pollution are appropriately valued which, in turn, facilitates the efficient allocation of resources. It also encourages resource-saving and pollution-reducing technological progress because if a firm requires fewer resources to produce or generates less pollution, it doesn't need to purchase as many permits as it did previously. The potential conflict between sustainability and efficiency is revisited at the end of this chapter.

Why do environmental problems occur?: the problem of market failure

Whilst it is universally recognised that markets are the best mechanisms available to achieve allocative efficiency, environmental problems arise because of two main features of markets:

- Markets from time to time 'fail' - that is, they can't always bring about the most efficient allocation of scarce resources (although they always can do a better job than any alternative mechanism and hence why we do abandon their use).
- Markets cannot sense what is a sustainable rate of resource use - that is, they cannot recognise when $h > y$ and $W > A$.

Market failure: Why do markets fail? Markets do not always bring about a situation where MSB = MSC because, as has been mentioned, they can 'fail'. There are five main reasons why markets fail. All have some implications for the efficient allocation of resources and the sustainable rate of resource use. These are:

1) imperfect competition;
2) imperfect information;
3) inappropriate government intervention;
4) the existence of public goods;
5) externalities.

Market failure usually justifies government intervention, since it is usually only through government intervention that markets can be steered in the right direction to bring about an efficient allocation of scarce resources. We shall now consider two forms of market failure that impact on the natural environment.

Public goods. A pure public good has the following two characteristics:

1. *Non-rivalry* in consumption/use. This is where the consumption or use of a public good does not affect someone else's ability to consume or use the good.
2. *Non-excludability* of consumption/use. This is where the owner or provider of the public good cannot exclude someone from consuming or using the good if they do not pay for its consumption or use.

There are both human-made public goods (e.g., lighthouses) and naturally-occurring public goods (e.g., life-support services provided by ecosystems). In general, if we rely on markets to determine the use of naturally-occurring public goods, there is a tendency for them to be overused and abused. Imagine an area of grazing land as an example of a naturally-occurring public good. Assume the land belongs to no-one and therefore anyone can put cattle on the land to graze.

Consider the benefits first. There are benefits to gained by the individual cattle owners. The sum of the benefits equals the total private benefits (TPB) from cattle grazing. We shall assume that the benefits to the individual cattle owners equal the benefits to society at large or what we would call the total social benefits (TSB). Therefore TPB = TSB.

Now consider the costs. Invariably, the total private costs (TPC) of having cattle grazing on the land are very small because it costs virtually nothing to have the cattle grazing on the open land. However, the total social cost (TSC) is much larger because of the spillover costs of cattle grazing. In other words, as more cattle graze on the land, the land becomes less productive (i.e., the land becomes degraded). The difference between the TPC and TSC curves therefore increases as the number of cattle increase.

From a social perspective, the social surplus is maximised (*SS**) when the difference between the TSB and TSC curves is at a maximum. It is also where MSB = MSC. This occurs at a grazing level of G*.

Because the number of cattle put on the grazing land is determined by individual cattle owners (a free market situation), the amount of cattle put on the land to graze occurs where the difference between the TPB and TPC curve is maximised. This usually occurs at a grazing level of G_0. It is also where MPB = MPC but is where MSB < MSC and where $G_0 > G^*$. That is, the grazing level that maximises the net benefits of the cattle owners does not coincide with the grazing level that maximises the social surplus. Since $G_0 > G^*$, there is too many cattle on the grazing land. Eventually, the land is destroyed because of overgrazing.

Open access and common property resources.
We have already seen that a public good is determined by its physical characteristics - the non-rivalry and non-excludability of consumption/use. In terms of naturally-occurring public goods, they can either be:

- an open access resource
- or a common property resource.

Which of the two they are depends on their *legal* status (i.e., how they are owned and what rules govern their ownership and use). That is, a naturally-occurring public good (say an open parcel of grazing land) can be either an open access resource or a common property resource; it simply depends on the legal status of the parcel of land.

An *open access* resource is one where the resource is owned by no one individual or no particular group, and there are no rules governing the use of the resource. Open access resources are almost always abused.

A *common property* resource need not be abused. This is because a common property resource is one that is jointly owned by a group of individuals; there are explicit rules as to how the resource is used and what use each individual can gain from it (e.g., a maximum of 20 head of cattle); and only those individuals who jointly own the resource can use it.

In a modern society, very few naturally-occurring public goods are common property resources. Most are open access resources. Hence, most naturally-occurring public goods tend to be abused when their management is left to market forces. As a form of market failure, this justifies government intervention. The government will often take possession of the resource and manage it (hopefully) in the most appropriate manner.

Externalities. Externalities can either be: (a) *positive* externalities, or (b) *negative* externalities. An externality occurs whenever the actions of one or more parties imposes costs or benefits on another party or parties and these so-called spillover effects are not *fully* reflected in market prices. The last part of this definition is important. Pollution, which can be a negative externality, need not be an externality if the spillover costs of pollution are fully, not partially, reflected in market prices.

Positive externality.

A positive externality is where the actions of one or more parties impose benefits on another party or parties and these spillover benefits are not *fully* reflected in market prices. In other words, the benefactors (the parties providing the spillover benefits) are not receiving the full remuneration for their positive spillover effect.

A positive externality occurs whenever there is a disparity between the marginal private benefits (MPB) and the marginal social benefits (MSB) of a particular activity. In other words, it occurs whenever there are additional spillover benefits to people who do not directly consume the good in question.

When positive externalities exist, MSB № MSC (indeed, MSB > MSC). In effect, there is *too little* of a good thing. Governments must intervene to increase the activity to the level which maximises the social surplus.

Negative externality.

A negative externality is where the actions of one or more parties impose costs on another party or parties and these spillover costs are not *fully* reflected in market prices. In other words, the transgressors (the parties imposing the spillover costs) are not paying the full cost of their negative spillover effect.

A negative externality occurs whenever there is a disparity between the marginal private costs (MPC) and the marginal social costs (MSC) of a particular activity. In other words, it occurs whenever there are additional spillover costs that people must endure who do not directly consume the good in question.

When negative externalities exist, MSB ≠ MSC (indeed, MSB < MSC). In effect, there is *too much* of a bad thing. Governments must intervene to reduce the activity to the level which maximises the social surplus.

Markets are not able to sense sustainability. Not only do markets sometimes fail to bring about an efficient allocation of scarce resources, they are unable to ensure a sustainable rate of natural resource use. That is, they cannot feel, smell, taste sustainability - i.e., they cannot recognise when $h > y$ and $W > A$. As mentioned previously, if sustainability is a critical concern, the sustainable rate of resource use is as important as the efficient allocation of scarce resources.

By saying that markets cannot sense sustainability simply means that while markets can ensure an efficient allocation of scarce resources, they cannot prevent the rate of resource use from becoming increasingly unsustainable.

Why can't markets sense sustainability?
There are many reasons for this - some of them are a bit complex. Very briefly, here are a few of them:

1. Markets are allocative mechanisms. Markets allocate resources to various uses and do this job very well (despite the existence

of market failure). However, being an allocative mechanism, they are unable to determine the sustainable rate of the resources they allocate. Allocation of scarce resources is one thing; the sustainable rate at which the scarce resources are extracted from the natural environment is another matter entirely.

2. Sustainability concerns the *absolute scarcity* of natural resources, that is, how scarce the total pool of resources are relative to the amount needed to satisfy human needs and wants. Markets, through prices, reflect the *relative scarcity* of natural resources, that is, how scarce oil is to coal; and how scarce timber is to stone. The ability of markets to reflect relative scarcities well is why markets are good at solving the allocation problem. As oil gets scarcer than coal, the price of oil rises relative to coal. This induces the more efficient use of oil and encourages both the exploration for new reserves and research and development into more efficient ways of using oil. It can also encourage the development of a new substitute energy for oil, perhaps a renewable energy resource such as solar energy. The inability of markets to reflect the absolute scarcity of the total pool of natural resources is why markets cannot sense sustainability.
3. The sustainable use of resources is not an allocation problem because an efficient allocation must reflect the preferences of all people concerned. Sustainability is an issue that affects future generations yet their preferences are not revealed in present-day markets. For this reason, decisions regarding how many resources should be left for future generations are a distributional problem, not an allocation problem. This is why sustainability is regarded as a case of ensuring *intergenerational equity*. Economists already acknowledge that markets cannot be relied upon to ensure intragenerational equity (the equitable distribution of income and wealth among the present generation of people). Therefore, economists should acknowledge that markets cannot be relied upon to ensure intergenerational equity (the sustainable rate of resource use).

Because markets do not ensure a sustainable rate of resource use, we may have to abandon, to some degree, the optimising rule of MSB = MSC if:

- the Pareto efficient rate of renewable resource use is such that $h > y$;
- the Pareto efficient rate of pollution is such that $W > A$.

3.7. Benefit-cost analysis and project evaluation

The use of monetary values to value environmental services

Since projects will in some way impact on the natural environment, to assess their economic and environmental viability it is necessary to determine the economic values of environmental services. To do this in a useful way, environmental services (such as the ability of the natural environment to provide a steady stream of resources over time; its ability to assimilate wastes; its ability to provide clean air and water; its ability to provide habitat for fauna and flora; and its recreational and aesthetic values) must be assigned monetary values. Assigning monetary values to these important environmental services often offends people, many of which believe the environment is too important to be measured in this way. These people may have a good point. However, there are good reasons for placing monetary values on environmental services. These include the following:

- Since a BCA is the main way in which projects are evaluated and appraised, it is better to have some monetary value assigned to environmental services than no value at all. No monetary value means that the cost of losing valuable environmental services will not show up in the BCA. This would result in more not less environmentally destructive projects going ahead.
- If environmental services are so important, a proper economic evaluation of these services should reveal them as having very high economic/monetary values. That is, economic valuation of environmental services should offer a compelling argument for environmental quality and sustainability. Because the present tendency is to not assign monetary values to environmental services, the arguments put forward for environmental quality do not have full support. They may have biological and ecological supporting evidence, but they do not have eco-

nomic supporting evidence. In these modern times where economic values are considered to be the most important of all (rightly or wrongly), the failure to assign monetary values to environmental services means many sound arguments for environmental protection are not supported by perhaps the most important evidence - the economic evidence.

- Assigning monetary values to environmental services does not mean that sustainability rules have to be ignored. As we shall see later, BCA can incorporate sustainability rules to ensure the sustainable use of natural resources. However, because it is important to ensure sustainable resource use is achieved in the most cost-effective manner, it is necessary to have monetary values assigned to all benefits and costs, including environmental benefits and costs.

Value and non-market goods. How can we measure the economic value of environmental goods and services if they are non-market goods and do not have an explicit price attached to them? When people give up money to purchase things they give up the opportunity to purchase something else. When a person buys something (say a house), they are not paying an amount just for the benefits provided by the house. They are also paying for the location of the house - whether it be next to a park; close to shops and schools; in a low crime neighbourhood; or in a neighbourhood full of very nice houses. A person will have to pay more for the same size house in a pleasant neighbourhood compared to a noisy and polluted neighbourhood. By paying more for the same size house, the person is making a trade-off in the sense that will be unable to afford as many other goods than if they were to buy the same size house at a lower price in the less amenable suburb. We can examine these trade-offs more closely as a basis for valuing non-market goods that have no market price.

Non-market goods can have both direct and indirect use values.

- *Direct use values*. These are values associated with the tangible use of the natural environment, such as clean water used in the manufacturing of food; when environmental resources are used for recreational purposes; or when environmental quality affects human health.

- *Indirect use values*. These are values associated with more intangible uses of the environment, such as aesthetic benefits or the satisfaction of knowing that certain living creatures exist (say whales) even though it is known by the person that they are unlikely to ever see a whale in its natural environment. Indirect use values are sometimes refered to as 'passive' use and 'non-use' values, the latter because the environment is not being exploited to get the benefits from it.

Apart from existence values, indirect use values include:

- *Bequest value*. These are values a person may have for the environment in terms of ensuring environmental services are available for descendants.
- *Option value*. This refers to the fact that a person's current value for the environment may include the desire to ensure environmental goods and services are available for use in the future.
- *Altruistic value*. In this instance, a person values the environment not just because they can benefit from it use, but also because it can benefit other people. That is, a person might care about how environmental quality effects on other peoples' health as well as their own.
- *Ecological values*. Ecological systems yield benefits in the form of life-support services as well as the capacity to provide a steady stream of resources and assimilate waste. Ecological values are somewhat different to other forms of indirect use values because, in the case of bequest, option, and altruistic values, people recognise the benefits they obtain from environmental quality and preservation. With ecological services, this is not the case. People might know that ecological systems are important to their well-being, but they may not exactly how important they are. This makes it difficult for a person to trade off ecological values for other values.

Clearly, to obtain monetary measures of non-market goods, we need to employ valuation techniques that are able to capture as many non-market values as is possible. We shall now look at some environmental valuation techniques.

Environmental Valuation Techniques

This section covers three widely used environmental valuation techniques. They are:

- The 'hedonic price' technique
- The travel cost method
- Contingent valuation studies.

The hedonic price and travel cost methods are *revealed preference* approaches. Revealed preference approaches estimate the monetary value of environmental qualities by looking at the decisions people have already made regarding activities related to environmental quality and services. Contingent valuation is a *stated preference* technique. A stated preference technique is useful when values given to the environment are not easy to identify simply by looking at the decisions people have made regarding activities related to environmental quality. What a stated preference technique attempts to do, is to elicit values directly from individuals by use of a survey or a questionnaire.

The hedonic prices technique. Hedonic pricing techniques are based on the theory that people value a good because they value the characteristics of the good and other related characteristics rather than just the good itself. Consider the house example again. When a person buys a house, it is not simply because the house offers protection from the elements, safety, and a convenient place to enjoy other in-house activities (watching TV, being with friends). How much a person pays for the house will also depend on factors related to the location of the house - that is, whether it is close to a park; close to shops and schools; in a low crime neighbourhood; or in a neighbourhood full of very nice houses.

Let's say we are interested in the economic value of urban air quality. There is a proposal to build a lead smelter which will cause air quality to greatly deteriorate. We want to know the EV of clean air so we can determine the cost of building the lead smelter in terms of deteriorating air quality. Because living further away from the smelter is less unpleasant, we can expect a negative relationship between housing prices and the proximity of a house to the lead smelter. Hence we can expect a positive relationship between housing prices and air quality.

Assume for the moment that the characteristics of all houses in this metropolitan area are the same except for the proximity to the lead smelter (and therefore the quality of surrounding air). Houses located in areas with better air quality will have higher prices. This can be represented by a scatter diagram, where each dot represents a different house price-air quality combination (Figure 3.7.1).

Figure 3.7.1 indicates a *positive* relationship between housing prices and air quality. This is why the regression line is upward sloping. A regression line is based on the process of *minimising the sum of the squared values of the distances between each point and the regression line*.

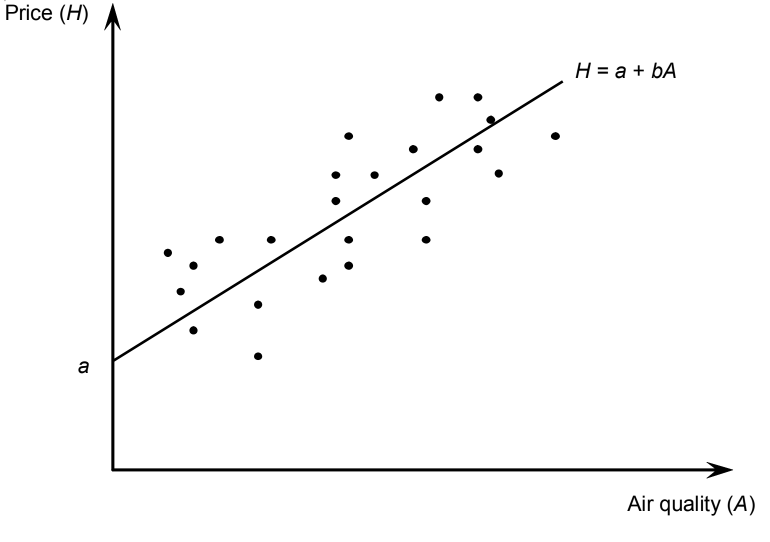

Figure 3.7.1: Scatter diagram and regression line representing a different house price-air quality combination

If H denotes the prices of houses, and A air quality, then an equation can be written to show the relationship between the two:

$$H = a + bA \tag{3.7.1}$$

where:

H = housing price in \$000s;

a = an independent variable that affects all house prices by the same amount;

A = air quality;

b = variable describing how much house prices change as air quality improves.

If b, which represents the slope of the regression line, can be estimated, then we can gain an understanding of the extent to which air quality affects housing prices. For instance, if $b = 5$, then a one unit change in the quality of surrounding air will cause the price of a house to change by \$5000. If the change is a one unit improvement in air quality, then housing prices will increase by \$5000. If the change is a one unit deterioration of air quality, then housing prices will decrease by \$5000.

The difficulty lies in the fact that so many factors will affect housing prices. It will not be air quality alone which explains the entire difference in housing prices. We must therefore include into equation (3.7.1) as many factors which significantly affect house prices. Minor factors can be ignored.

If house prices are also positively related to the size of the house (S) then equation (3.7.1) may instead look like the following:

$$H = a + bA + cS \tag{3.7.2}$$

where:

H = housing price in \$000s;

a = an independent variable that affects all house prices by the same amount;

A = air quality;

b = variable describing how much house prices change as air quality improves;

S = size of house;

c = variable describing how much house prices change as house size increases.

It doesn't matter if there a lot of additional variables included into the house price equation, although it is best to minimise the number of variables included in the regression equation. So long as we can still estimate *b*, we can estimate the EV of air quality. Let's say after including a lot more variables, $b = 1.5$, so that it is estimated that a one unit change in air quality causes housing prices to change by $1500. Let's also assume that the lead smelter will result in air quality deteriorating by an average of 2 units across this metropolitan area. Assume there are 10000 houses in the area. The air quality deterioration cost (*C*) would equal:

$C = \$1500 \times$ 2 units (average) $\times$ 10000 houses = $30 000 000

If were conducting a BCA on the proposed lead smelter, the $30 million air quality deterioration cost would be assigned to the cost side of the BCA equation.

The travel cost method. The travel cost method (TCM) is a method used predominantly for valuing environmental resources for their recreational, cultural, and wilderness qualities. The basic premise behind the TCM is that the cost a person is willing to pay to travel and visit a natural area (say Kakadu National Park in Australia), can be regarded as the access price of the National Park. So long as we can gather enough information about the number of trips people take to visit Kakadu NP and the cost of travelling to see it, a demand curve for Kakadu NP can be generated. Figure 3.7.2 shows a scatter diagram with each point being a travel cost-visitation combination for a society.

Figure 3.7.2 is an estimated *travel cost demand curve* (TCDC). It indicates that a *negative* relationship exists between the cost to travel to Kakadu NP and the number of times people will travel to visit Kakadu NP. The higher the travel cost, the fewer number of trips people will make. For this reason, we would expect, on average, people in Darwin (very close to Kakadu NP) to more frequently visit Kakadu NP than people who live in Hobart (a long distance from Kakadu NP). This is not going to be the case for all comparisons between people living in Darwin and Hobart. A person living in Hobart who values the visitation of Kakadu NP more highly than someone in Darwin could conceivably visit the NP more often even though their travel cost is much higher.

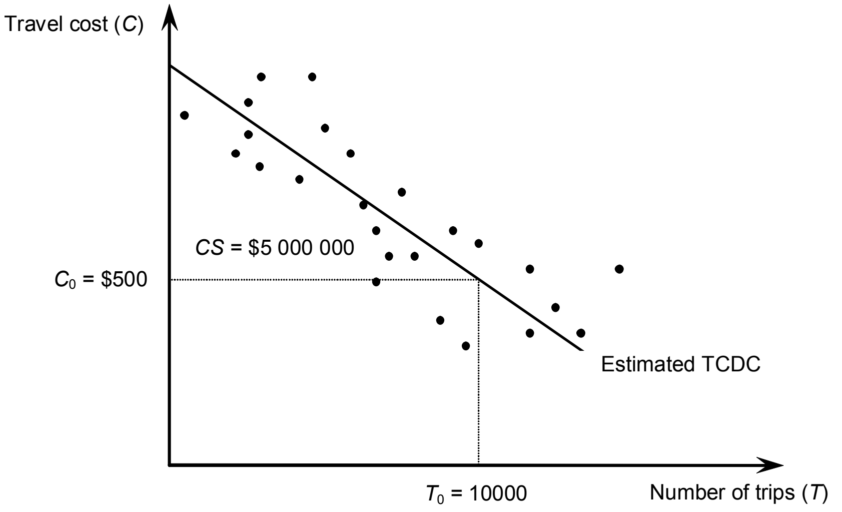

Figure 3.7.2: Scatter diagram and travel cost demand curve (TCDC)

Figure 3.7.2 shows that if the average travel cost (C_0) = $500, the estimated number of trips (T_0) = 100000. The area below the TCDC and above the travel cost line (C_0) is the consumer surplus (CS). The CS equals:

$$CS = \frac{(\$2500 - \$500) \times 500000}{2} = \$5\,000\,000$$

Suppose there is a proposal to mine inside Kakadu NP and that, if mining goes ahead, it will affect the qualities of the NP. This will affect peoples' desire to visit Kakadu NP. Assume the cost of travelling to Kakadu NP remains unchanged. A survey is undertaken to reveal how often people will visit a damaged Kakadu NP. This enables us to construct a new TCDC (Figure 3.7.3).

Figure 3.7.3 reveals the following:

- The higher $TCDC_0$ is the curve applicable to an unaffected Kakadu NP.

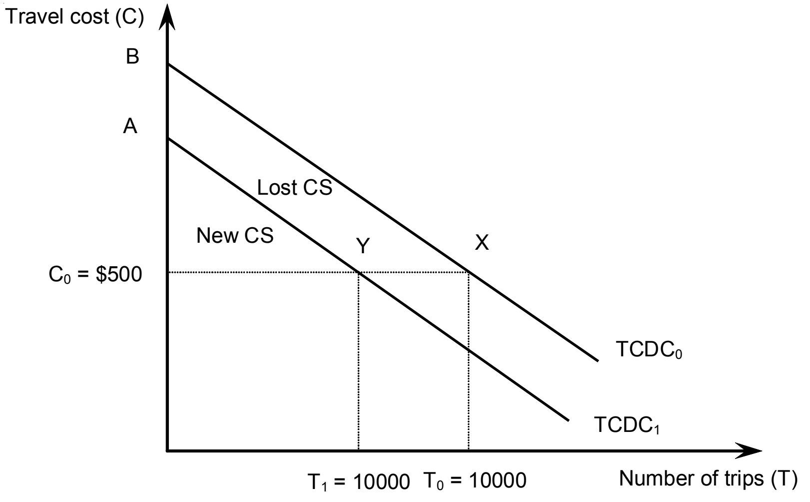

Figure 3.7.3: Original and new travel cost demand curve (TCDC)

- the lower $TCDC_1$ is the curve applicable to a damaged Kakadu NP.

- If C_0 remains the typical travel cost paid to visit Kakadu NP, then two things occur:
  1. There will be fewer trips to Kakadu NP (T_1 instead of T_0) because people prefer a pristine National Park to a damaged one.
  2. The area DABXY represents the loss of consumer surplus (cost) in terms of the damage to Kakadu NP if the mining proceeds. This cost would be included in the cost.

The new consumer surplus (CS_1) would be:

$$CS_1 = \frac{(\$1500 - \$500) \times 300000}{2} = \$1\,500\,000$$

The loss of consumer surplus (cost) of mining damage to Kakadu NP would be:

$CS - CS_1 = \$5\,000\,000 - \$1\,500\,000 = \$3\,500\,000$

If were conducting a BCA on the proposed lead smelter, the $3 500 000 damage cost would be included the cost side of the BCA equation.

Problems with the TCM. While the TCM holds great promise for measuring economic values of natural areas of recreational, cultural, and wilderness qualities, there are some problems that remain. These include:

- There is a need to incorporate the opportunity cost of travel time to get a *full* measure of travel cost (time is costly). The travel cost usually includes the direct cost of travel only (airfares, accommodation, National Park entry fees, etc.). However, time spent at Kakadu NP prevents a person from earning income and the loss of income associated with travelling to and visiting Kakadu NP should be included in the total travel cost.
- How does the existence of substitute natural areas (other National Parks) affect the estimation of a TCDC? We would expect the TCDC for Kakadu NP to also be affected by improvements or a deterioration of other substitute natural areas.
- One of the usual ways of finding out the alternative TCDC is to ask those who are visiting Kakadu NP. The problem with this is that results in sampling bias - those who are visiting Kakadu NP are likely to place higher value on the NP than the average person interviewed if the survey was done on the streets of Sydney.
- Do recreational, cultural, and wilderness qualities of Kakadu NP fully reflect the total values of the NP? What about ecological values?

Contingent valuation. The contingent valuation method (CVM) is the most widely used stated preference valuation technique. The CVM ascertains the economic value of the natural environment by asking people, usually in a survey, one of the following questions:

- What are you willing to pay to secure an environmental benefit? (i.e., how much are you willing to pay to have cleaner water?).

- What amount of compensation are you willing to accept to forego a benefit? (i.e., how much compensation are you willing to accept to forego cleaner water?).
- What are you willing to pay to prevent the incursion of a loss? (i.e., how much are you willing to pay to prevent a project going ahead that will dirty the water?).
- What amount of compensation is necessary for you to accept a loss? (i.e., what amount of compensation is necessary for you to accept dirtier water brought on by a project going ahead?).

The questions asked by a CVM survey can be either open-ended or close-ended.

- *Open-ended question*. Respondents are asked to reveal the maximum they would be willing to pay to secure a benefit or to prevent the incursion of a loss; or the minimum they would be willing to accept to forego a benefit or to accept a loss.
- *Close-ended question*. Respondents are asked to reveal whether or not they would be willing to pay a particular amount to secure a benefit or to prevent the incursion of a loss; or whether or not they would be willing to accept a particular amount of compensation to forego a benefit or to accept a loss.

There is some debate as to which type of question is best. Many believe open-ended questions are better and more revealing than close-ended questions. For instance, with a close-ended question, a person may say they are unwilling to pay a particular amount ($50) to secure a benefit, but may have been willing to pay another lower amount (say, $20) had an open-ended question been asked. Then, again, they may not have been willing to pay anything at all ($0) or perhaps something much higher (say, $100). We simply don't know. By asking a close-ended question, we may get the impression that a person is unwilling to pay anything just because they are unwilling to pay the amount asked in the survey.

The problem with open-ended questions is that:

- People tend to exaggerate how much they are willing to pay or accept. What people say they are willing to pay in a hypothetical situation is different to what people will actually be willing to pay if they are then asked to 'pay up'.

- Because people will often not have given much thought to the amount they are willing to pay or accept, they may give a ridiculous answer. A close-ended question can at least provide a more realistic figure for people to think about.

Specifying the mechanism of payment.

For a CVM survey to be effective, the mechanism by which a payment is made by the respondent (if the question is "how much are you willing to pay?") or a payment is received by the respondent (if the question is "how much are you willing to accept?"), must be specified in the survey. The reasons for this are as follows:

- If a respondent is asked to pay 'in full' they might give a different answer than a situation where they can pay 'in instalments'.
- A respondent must be confident the money they agree to pay would actually go to securing the benefit or to the prevention of a loss.
- A respondent must be confident the money they are promised in order to accept a loss would be received. Whether they receive their payment immediately 'in full' or 'in instalments over time' will also affect their response. Given the propensity of people to discount the future, being paid over time means the net present value of the total payment will be less than if they receive it immediately in full.

Deriving the EV of environmental qualities and services.

By finding out what people are willing to pay or accept for benefits/losses, we are able to estimate the total environmental cost of a project that might damage the environment. For instance, say a survey asks people how much they are willing to pay to have Kakadu NP spared from mining. Assuming there is no sampling bias (the sample of respondents represents the broader population) we can determine the average amount that people are willing to pay. Let's say, on average, its \$20 per person (10000 people are surveyed and collectively they say they are willing to pay \$500 000 (i.e., \$20 = \$500 000 ÷ 10,000). The population of Australia is approximately 20 million. The environmental cost of mining Kakadu NP is equal to the total value that people are willing to pay to have it spared from mining. This is calculated in the following manner:

Environmental cost = 20 million × $20 = $400 million

Conducting a benefit-cost analysis

Let's assume we work for a government department and we are given the task of assessing whether a dam and associated hydro-electricity facility should be built on a major river. To undertake the assessment, we must conduct a BCA and report back to our supervisor.

Step 1 – What are the potential benefits and costs of building the dam and hydro facility?

We need to first gather a list of all the possible benefits and costs that are applicable to the dam's construction. We must also work out when and for how long these different benefits and costs will be received (in terms of benefits) and incurred (in terms of costs).

We shall assume the following about the dam project:

- The dam and hydro facility take 5 years to build.
- The flow of the river is very spasmodic and often dry and, after heavy rain, leads to the flooding of adjacent farmland and a nearby town. A flood can be expected once every ten years without the dam. With the dam, there is no flooding.
- Because the river is, in an average year, dry for 6 months, irrigation water is available for half a year only. Construction of the dam will allow irrigation over the full year.
- The population is constant.
- There is no inflation s the price levels remain constant.

Table 3.7.1. is an example of the benefits and costs that may have to be considered.

Step 2 – How do we go about measuring these benefits and costs?

We can use the three environmental valuation techniques above to estimate the individual benefit and cost items that appear in Table 3.7.1. These are usually estimated on an annual basis (i.e., cost of maintaining the dam = $2 million per year).

Table 3.7.1: Potential benefits and costs of building a hydro electricity plant

Potential benefits	Potential costs
• ydro electricity generation (beginning in year 6 and continuing indefinitely) • Flood control (beginning in year 6 and continuing indefinitely) • Extra irrigation water for half a year, per year (beginning in year 6 and continuing indefinitely) • Additional recreational value created by lake (beginning in year 6 and continuing indefinitely)	• Cost of construction (Years 1 to 5) • Cost of maintaining the dam (beginning in year 6 and continuing indefinitely) • Cost of maintaining and operating the hydro facility (beginning in year 6 and continuing indefinitely) • Opportunity cost of land inundated by dam (beginning in year 6 and continuing indefinitely) • Loss of services of free flowing river, including: (a) Lost river recreation (beginning in year 6 and continuing indefinitely) (b) Lost riverine ecosystem (beginning in year 6 and continuing indefinitely)

Step 3 – Calculating the net present value (NPV) of the project.

To determine whether the dam and hydro project should go ahead, a decision has to be made in the present. Because people discount the future, they will not value a $1 million benefit or cost that occurs now in the same way as a $1 million benefit or cost that occurs in the future. As we can see from Table 3.7.1, not all benefits and costs of the project occur immediately. They also occur over time. We must therefore calculate their present value since our initial aim is to calculate the *net present value* (NPV) of the project.

NPV=Present value benefits (PVB) - Present value costs (PVC) (3.7.3)

Our ultimate aim is to determine whether the NPV of the project is positive. If it is not, then the project should not go ahead under any circumstances. To calculate the present value of benefits and costs occurring in any given year, the following present value (PV) formula needs to be used:

$$PV = \frac{FV}{(1+d)^t} \tag{3.7.4}$$

where:

PV = present value of a benefit gained or cost incurred at some time in the future;

FV = the future value of the benefit gained or cost incurred;

d = the discount rate;

t = the length of time before the benefit is gained or the cost is incurred.

Once the individual present value benefits and costs have been calculated, the PVB and PVC columns are summed (Table 3.7.2 below).

Now we can calculate the NPV of the proposed hydro dam and facility.

***NPV* = $130 million - $165 million = -$35 million (loss)**

Table 3.7.2: Present value benefits and costs of hydro facility ($ per year)

Potential benefits	PVB	Potential costs	PVC
• Hydro electricity generation	• $50 million	• Cost of construction	• $100 million
• Flood control	• $40 million	• Cost of maintaining dam	• $10 million
• Extra irrigation water	• $30 million	• Cost of maintaining and operating hydro facility	• $10 million
• Additional recreational value created	• $10 million	• Opportunity cost of land inundated by dam	• $30 million
		• (a) Lost river recreation	• $5 million
		• (b) Lost riverine ecosystem	• $10 million
	$130 million		$165 million

With a NPV loss of $35 million, the project should not go ahead under any circumstances.

Conducting a sensitivity analysis of a BCA study

A sensitivity analysis of a BCA study is conducted to determine how sensitive the final result of the BCA is to changes in the discount rate and assumptions/techniques used in estimating benefits and costs. It is important to see whether such changes can radically affect the final result. If so, it will be necessary to include this information in the final report so decision makers can make a more informed judgment about whether to allow a development project to proceed. A sensitivity analysis should always be included in the final report of a BCA and should indicate to the reader of the report just how sensitive the final result is to parameter changes - that is, how much of an effect an 'X%' change in the discount rate can have on the NPV of a development project.

Integrating sustainability conditions into the BCA process

So far we have only been concerned with the NPV of a project. The sustainable rate of resource use is also something that must be taken into consideration.

Assume that a different development project (e.g., new housing estate) has a NPV of $50 million and is able secure funding from a local government to proceed. Let us also assume that an environmental impact study has been conducted which shows that, if the project proceeds, the sustainability rules outlined in Chapter 1 will be violated (i.e., it will result in $h > r$ and/or $W > A$). In other words, the loss of any ecosystem services will result in net environmental losses.

If a proposed development project does violate one or both sustainability rules, should the project be rejected? Not necessarily. In the case of the housing estate, the economic efficiency objective of maximising the NPV can be modified by introducing the concept of a 'shadow 'project'. A shadow project is an environmental rehabilitation exercise that is undertaken to offset the environmental damage of the original project - in this case, the housing estate.

The cost of the shadow project is included in the calculation of PVC which, in turn, alters the estimated NPV of the project. Let's assume that it was necessary for the proposed housing estate to be accompanied by a five year restoration programme involving tree planting on a large scale (to restore a cleared forest). Let's assume that the PVC of the shadow project is $40 million. The adjusted value of the NPV is:

***NPV*=$50 million - $40 million (shadow project) = +$10 million**

We shall also assume that there are a number of alternative projects involving no net environmental losses and not requiring a shadow project. The local government should finance the projects in the following order (Table 3.7.3).

Previously, the housing estate would have been ranked first (unadjusted NPV of $50 million). Whilst the housing estate project has been rendered 'environmentally viable' by the shadow project, it has, from an efficiency perspective, been relegated to third position behind the public library (adjusted NPV of $10 million).

This is significant for a number of reasons. First, if the local government has insufficient money to fund the housing estate (having already funded the highway and bridge beforehand), the housing estate would not go ahead.

Table 3.7.3: Comparing the NPV of alternative development projects (shadow project taken into account)

Project	NPV
Highway	$35 million
Bridge	$18 million
Housing estate	$10 million
Public library	$5 million

Second, in some instances, private developers become involved to help finance development projects. They often require funding from financial institutions in order to proceed with projects. If they are subject to a BCA analysis that requires sustainability considerations to be taken into account (this could be achieved through changes in planning legislation), there will be an incentive for private developers to minimise the initial impact on the environment, since this will reduce the need for costly shadow projects that would relegate them down the list of preferred clients amongst financial institutions.

Sustainable development programmes. Because shadow projects have the potential to render individual development projects unviable, a collective approach can be adopted to more projects to proceed. This maybe important in a depressed region of a country where unemployment is high and new development projects are urgent to revitalise the regional economy.

To allow some of these projects to go ahead, we can look at development projects from the point of view of a *sustainable development programme* (a series of projects), where the net effect of the programme rather than individual projects ensures that the sustainability conditions are not violated.

A *sustainable* development programme is a set or portfolio of development projects which, when taken together, maximise the NPV without undermining the sustainable use of resources. To bring about such a programme, we need to categorise each project according to what type of environmental impact they involve.

Imagine that three proposed development projects (project A, B, and C) involved forest clearance so that each required a shadow project to meet sustainability conditions. Let us also assume that the cost of the shadow projects was:

- Project A: \$30 million (restoration of 100 hectares of forest).
- Project B: \$20 million (restoration of 50 hectares of forest).
- Project C: \$50 million (restoration of 200 hectares of forest).
- Combined cost = \$100 million.

It is possible that the 350 hectares of forest restoration could be achieved in a single shadow project in one location rather three separate locations. The combined cost might be $70 million, much less than the $100 million if the shadow projects are undertaken individually, because it will be possible to take advantage of *economies of scale*. If this is the case, the shadow project cost assigned to each project is:

- Project A: $70 million × 0.3 = $21 million.
- Project B: $70 million × 0.2 = $14 million.
- Project C: $70 million × 0.5 = $35 million.
- Combined cost = $70 million.

This amounts to a significant saving (i.e., lower shadow project cost for each development project) and an increased degree of economic efficiency. **As you can see, introducing the concept of a sustainable development programme can be beneficial from both a sustainability level and an economic efficiency level. This is the key to the economics of sustainability.**

3.8. Economics of non-renewable resource use

Introduction

Non-renewable resources are resources which, when exploited, are no longer available for use. Hence, barring discoveries, the stock of a non-renewable resource declines by the amount extracted. The question that needs to be asked if we are to maximise the social surplus from the use of non-renewable resources is this: "What is the optimal rate of non-renewable resource depletion?"

To answer this question, we will be looking at a few models. They include the Gray Model of the mining firm, the Hotelling Model, and the El Serafy Rule of non-renewable resource depletion. However, we shall begin with a look at the Gray Model which deals with the theory surrounding the mining firm.

The Gray Model

The Gray Model is a basic model explaining the likely behaviour of a mining firm. The model is designed to provide a basic insight into the rate of non-renewable resource depletion. There are various aspects of the Gray Model that first need to be outlined.

Assumptions of the Gray Model. It is assumed that:

- The economy and all industries (including resource extractive industries) are perfectly competitive.
- The mining firm faces a given price for its output (the mining firm is a price taker).
- The marginal cost (MC) of mining is constant over time (i.e., the MC curve does not shift).
- Mineral stocks are finite.
- Mining occurs over two time periods (t_1 and t_2).
- The more that is mined in period t_1, the less is available to be mined in period t_2.
- The mining firm is a profit maximiser.
- The conditions that must hold to ensure the mining firm maximises profits are:

Rule 1: Price = MC + the opportunity cost of lower deposits.

- In most industries, the profit maximising condition is P = MC because, with perfect competition, price is the same as marginal revenue (MR).
- However, because a mining firm has a limited life-span (determined by the size of the resource deposit in its possession and the rate of resource extraction), it has an additional opportunity cost to consider. This opportunity cost reflects the fact that as the resource is depleted, there are fewer profits to be earned in the future. Higher profits today mean lower profits tomorrow.
- As such, the opportunity cost of mining equals the rental value received from the marginal unit of the resource mined.

Rule 2: For mining to occur in both periods (and not just one).

$$R_{t1} = \frac{R_{t2}}{(1+r)} \qquad (3.8.1)$$

where:

R_{t1} = the rental value of the reserves in period t_1;

R_{t2} = the rental value of the reserves in period t_2;

r = the interest rate on alternative assets;

$\frac{R_{t2}}{(1+r)}$ = the net present value (NPV) of reserves in period t_2.

Rule 2 is the *flow constraint* in the Gray Model. Rule 2 is essentially saying that for mining to occur in both periods, the NPV from mining in period t_2 must equal the rental from mining in period t_1 (i.e., the NPV from mining in both periods must be the same).

We can rearrange equation (3.8.1.) to get:

$$R_{t1}(1+r) = R_{t2} \qquad (3.8.2)$$

$$R_{t1} + r.R_{t1} = R_{t2} \qquad (3.8.3)$$

where:

R_{t1} = the rental value of the reserves in period t_1;

$r.R_{t1}$ = the amount that can be earned in period t_2 by investing the proceeds from resource extraction in period t_1;

R_{t2} is the amount earned from mining in period t_2.

Why must both sides of the equation be equal to have mining in both periods? If $R_{t1} + r.R_{t1} > R_{t2}$ it is more profitable to mine the entire mineral deposit in period t_1 and invest the proceeds than mine in both time periods. We can assume that the flow condition is justifiable on the basis that, in reality, firms do mine in each time period.

Rule 3: The quantity of resources extracted in the two periods is constrained by the deposit of the resource, that is:

$$q_{t1} + q_{t2} = S \qquad (3.8.4)$$

where:

q_{t1} = quantity mined in period t_1;

q_{t2} = quantity mined in period t_2;

S = the total quantity of the resource available for mining.

Rule 3 is the *stock constraint* in the Gray Model.

Proposition: The initial output level of q_{t1} in period t_1 is uniquely determined. That is, there is only one output level of q_{t1} that simultaneously satisfies Rules 1, 2, and 3. The proposition effectively implies the following:

- The initial output level in period t_1 that simultaneously satisfies Rules 1, 2, and 3 = q_{t1} where the initial rental value = R_{t1}
- Given the stock constraint of $S = q_{t1} + q_{t2}$, this means q_{t2} must be mined in period t_2 where the rental value in this final period = R_{t2}.

Profit earned by the mining firm. The Gray Model assumes the NPV of the rental (profit) in period *t+1* = the rental (profit) earned in period *t*. To recall equation (3.8.1)

$$R_t = \frac{R_{t+1}}{(1+r)} \qquad (3.8.6)$$

We can rearrange (6) to get:

$$R_t(1+r) = R_{t+1} \qquad (3.8.7)$$

$$R_t + r.R_t = R_{t+1} \qquad (3.8.8)$$

$$r = \frac{R_{t+1} - R_t}{R_t} \qquad (3.8.9)$$

Note: $\frac{R_{t+1} - R_t}{R_t}$ = the proportional change in the rental (profit) earned from period t to period $t+1$.

Therefore, the proportional change in the mining firm's profit (from period t to period $t+1$) = the interest rate on alternative assets.

The Hotelling Model (Hotelling's Rule)

The Hotelling Model (Hotelling, 1931) extends the Gray Model of the mining firm in order to consider the socially optimal level of non-renewable resource extraction. Out of this analysis emerges a rule known as *Hotelling's Rule*. Some of the assumptions of the Hotelling Model are similar to the Gray Model. It is assumed that:

- The social surplus or social welfare (W) must be maximised to have a socially optimal rate of resource extraction.
- Social welfare (W) = consumer surplus (CS) + producer surplus (PS).
- All the resource must be extracted to ensure society is not deprived of any surplus.
- The extraction of the non-renewable resource is controlled by a government-owned social planning authority.
- The following are assumed to be constant:
  (a) the interest rate on alternative assets (r);
  (b) the price of a backstop technology or substitute resource (the choke price);
  (c) the stock of the resource;
  (d) the marginal cost (MC) of resource extraction;
  (e) the demand for the resource.

The Flow Constraint.

The flow constraint of the Hotelling Model is similar to the Gray Model except we now have mining in more than two periods. The

NPV of the welfare generated from mining must be the same in each time period to ensure mining in all time periods (i.e., from the initial period to the terminal period) must be equal to have mining in each time period.

This means that the NPV of the welfare gained from extracting the marginal tonne in period t_0 must equal the welfare gained from extracting the marginal tonne in period $t = T_D$ (the terminal period). In addition:

- MC is constant over time.
- MC is constant over all levels of output.
- The relevant demand curve is downward sloping because we are concerned with the industry as a whole not the individual mining firm. This means: (a) price is no longer exogenously determined s it varies according to the extraction rate (the more is extracted at any point in time, the greater is the supply of the resource in the market, and the lower is the resource price); b) price marginal revenue (MR).

The Stock Constraint.
The total amount of the resource that can be extracted is limited by the stock, that is:

$$S = q_0 + q_1 + \dots\dots. + q_T \quad \textbf{(3.8.10)}$$

Hotelling's Rule

To maximise the social surplus/welfare it means having to do the following:

$$\text{maximise } W = W_0 + W_1/(1+r) + W_2/(1+r)^2 + \dots + W_T/(1+r)^T \quad \textbf{(3.8.11)}$$

subject to $S = q_0 + q_1 + \dots\dots. + q_T$.

Assume the following:

- There are two periods over which to mine s periods t_0 and t_1
- CS = 0. This means all welfare from PS only (P s MC)

To maximise social surplus/welfare over periods t_0 and t_1:

$$W_0 = \frac{W_1}{(1+r)} \quad \textbf{(3.8.12)}$$

$$(P_0 - MC_0) = \frac{(P_1 - MC_1)}{(1+r)} \quad \textbf{(3.8.13)}$$

$$(P_0 - MC_0)(1+r) = (P_1 - MC_1) \quad \textbf{(3.8.14)}$$

$$(P_0 - MC_0) + r(P_0 - MC_0) = (P_1 - MC_1) \quad \textbf{(3.8.15)}$$

$$(P_1 - MC_1) - (P_0 - MC_0) = r(P_0 - MC_0) \quad \textbf{(3.8.16)}$$

$$\frac{(P_1 - MC_1) - (P_0 - MC_0)}{(P_0 - MC_0)} = r \quad \textbf{(3.8.17)}$$

Since the rental from mining = P - MC, the percentage change in the rental must equal the interest rate on alternative assets. This is also what was concluded from the Gray Model on the mining firm.

Assume, for the moment, that extraction costs = 0. This would mean that $MC_0 = MC_1 = 0$. It would also mean:

$$\frac{P_1 - P_0}{P_0} = r \quad \textbf{(3.8.18)}$$

This now means that the percentage change in non-renewable resource prices must be equal to the interest rate on alternative assets. This is *Hotelling's Rule*.

Objective of the welfare-maximising agency.

The main objective of the welfare-maximising agency is to extract the resource so that its price reaches the choke price just as the last tonne of the resource is extracted. To do this, the welfare-maximising agency must be very specific about the initial price of the resource (i.e., what the price of the resource is at time t_0), which means it must choose the quantity of the resource it extracts in the first time period very carefully. Remember, the price of the resource must rise at the rate of interest to satisfy the *flow condition* of the Hotelling Model.

A range of formulas can be devised that the welfare-maximising agency can follow to maximise welfare (Table 3.8.1). The derivation of the following formulas can be found in Perman et al. (2003).

Table 3.8.1: Optimal non-renewable resource extraction (MC of extraction = 0)

	Initial (t = 0)	Interim (t = t)	Terminal (t = T)
• Price (P)	$P_0 = K \exp - \sqrt{2rSa}$	$P_t = K \exp(r(t-T))$	$P_T = K$
• Extraction quantity (R)	$R_0 = \sqrt{\frac{2rS}{a}}$	$R_t = \frac{r}{a}(T-t)$	$R_T = 0$
• Depletion time			$T = \sqrt{\frac{2Sa}{r}}$

where:

P = resource price;

R = extraction quantity;

K = choke price;

r = interest rate;

S = resource stock;

a = price elasticity of demand (how sensitive demand is in relation to a change in the price of the resource);

t = time;

T = terminal period (final period).

The entire Hotelling Model is illustrated in Figure 3.8.1:

- Panel 3.8.1.B shows the price path of the non-renewable resource. The price begins at P_0 in period $t = 0$ and then rises exponentially at the rate of $r\%$ before reaching a price of P_T in the terminal period. P_T is also the choke price (K) indicating that the price of the resource reaches the choke price just as the last tonne of the resource is extracted.
- Panel 3.8.1.A shows the demand (D) curve for the resource. At an initial price of P_0 in period $t = 0$, q_0 of the resource is harvested. As the price of the rise rises over time, less of the resource is extracted to reflect the decrease in the demand for the resource as the price rises.
- Panel 3.8.1.C shows that, over time, less of the resource is extracted in each time period. Eventually, in the terminal period, the extraction of the resource reduces to zero. The area enclosed by the area $\Delta q_0 0 T_D$ represents the entire quantity of the resource (S) that has been all been extracted.
- Panel 3.8.1.C is simply a 45^0 line.

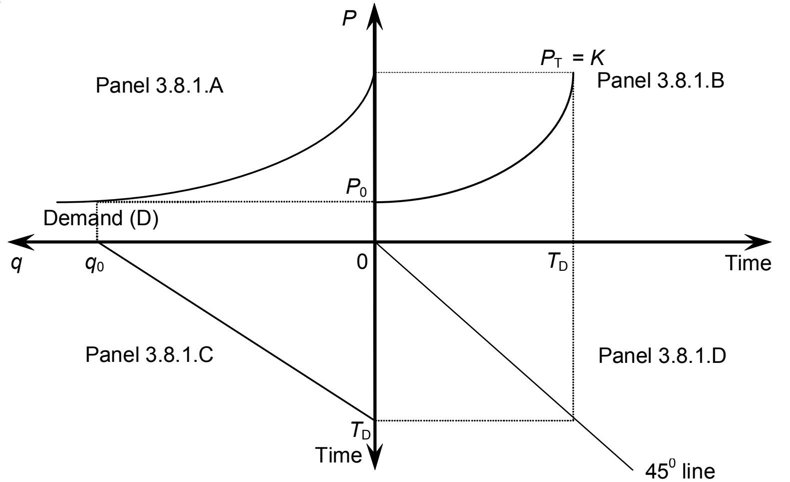

Figure 3.8.1: Hotelling Model

The effects of changing parameters on the optimal rate of resource extraction

With the Hotelling Model, a number of parameters were assumed to be constant. These included:

- the interest rate on alternative assets (*r*);
- the choke price of the resource;
- the size of the resource stock;
- the demand for the resource.

What we now need to consider is what is likely to happen to the price path of a non-renewable resource if these parameters are varied? More importantly, we need to know how these parameter changes affect the optimal rate of non-renewable resource depletion.

Changing interest rate (*r*). Let's assume that the interest rate on alternative assets rises. The increase in *r* must lead to a change in the optimal price path of a non-renewable resource. To satisfy the flow condition, the welfare-maximising agency must now extract the resource at a much slower rate than previously planned to ensure the price rises at a faster rate. Slowing the rate of extraction increases the rate at which the price of the resource rises because less will be supplied to the resource market in each period.

The problem for the welfare-maximising agency, however, is that the price of the resource reaches the choke price before the entire stock of the resource has been depleted. The resource is no longer demanded yet there is still some of the resource left unextracted. The welfare of society is not maximised.

To ensure maximisation of the social surplus, the welfare-maximising agency must lower the initial price of the resource, which it can do by extracting more of the resource in the initial time period. It will then extract the resource at a slower rate so that the price rises at the higher interest rate. Overall, the additional extraction of the resource in the initial time period exceeds the reduced extraction resulting from a slower extraction rate policy.

The resource is fully depleted, therefore ensuring that social welfare is maximised, however, the new terminal period is much shorter than the original terminal period.

This last point highlights an important fact. Non-renewable resources are depleted more rapidly the higher is the interest rate on alternative assets.

Changing choke price (*K*). The choke price for a particular non-renewable resource can fall when substitute resources become cheaper due to some technological innovation. For example, oil from shale is currently very expensive. A technological breakthrough in the future which greatly reduced the cost of producing oil from shale (makes the process simpler) can reduce the choke price for crude oil.

Again, since the price of a non-renewable resource must grow at the market rate of interest, a fall in K must lead to a change in the optimal price path of a non-renewable resource. To satisfy the flow condition, a welfare-maximising agency would need to continue extracting the resource at the same rate to ensure the price rises at the rate of interest.

The problem for the welfare-maximising agency, however, is that the price of the resource reaches the choke price before the entire stock of the resource has been depleted. The resource is no longer demanded yet there is still some of the resource left unextracted. The welfare of society would not be maximised.

To ensure maximisation of the social surplus, the welfare-maximising agency must lower the initial price of the resource, which it can do by extracting more of the resource in the initial time period. It will then extract the resource at the same rate it had previously planned so that the price rises at the rate of interest. The resource is fully depleted ensuring that social welfare is maximised. Once again, the new terminal period is much shorter than the original terminal period.

The conclusion that arises is this: Non-renewable resources are depleted more rapidly the lower is the choke price of the resource.

Increase in the resource stock (S). The stock of a non-renewable resource does not increase to the extent that it grows. There is only so much oil, coal, and iron ore on the planet or in any given country. The stock increases insofar as two things can happen:

- Previously unknown reserves are discovered.
- A technological advance makes a previously inaccessible deposit accessible.

There is eventually a limit to how much the stock of available non-renewable resources can increase due to these two factors.

Since the price of a non-renewable resource must grow at the market rate of interest, an increase in the stock of the resource will again result in a change to the optimal price path of a non-renewable resource. If the welfare-maximising agency does not change the rate of extraction, the price of the resource will reach the choke price with some of the resource left unextracted. The welfare of society would not be maximised.

To ensure maximisation of the social surplus, the welfare-maximising agency must lower the initial price of the resource, which it can do by extracting more of the resource in the initial time period. It will then extract the resource at the same rate it had previously planned so that the price rises at the rate of interest. The resource is fully depleted, ensuring that social welfare is maximised. Although more of the resource is extracted in the first time period, there is much of the resource remaining and, as such, it takes longer to exhaust the resource. The new terminal period is much longer than the original terminal period.

The conclusion that arises on this occasion is an obvious one: Non-renewable resources take longer to deplete as more of them are discovered over time.

Change in the demand for a resource. The demand for a non-renewable resource can increase/decrease for a variety of reasons. For instance, it can increase because of:

- a growing population;
- rising real incomes;
- a relative rise in the price of resource substitutes.

Demand can fall because of:

- a relative fall in the price of resource substitutes;
- the growing awareness of the ill-effects of the pollution generated whenever the resource is used (e.g., coal and acid rain and greenhouse gas emissions).

If the demand for a resource increases, there will effectively be a rightward shift of the demand curve. Consequently, for any given resource price, there will be additional demand for the resource. To meet the extra demand, the resource would need to be extracted at a much greater rate, thereby resulting in the resource being exhausted before the price of the resource reached the choke price. In effect, the original terminal period would no longer be the terminal period.

What must the welfare-maximising agency do in this situation? It must raise the initial price to reduce the demand for the resource. However, the rate of extraction is still higher in each time period. Why is this so if the price in each period is higher? At the higher price, the amount of the resource that needs to be extracted with a new demand curve is still greater than the extraction quantity when the price was lower for the original demand curve. Overall, The new terminal period is much shorter than the original terminal period.

The conclusion on this occasion is: Non-renewable resources are depleted at a more rapid rate as the demand for a resource increases over time.

El Serafy's Rule: The "User Cost" Of Non-Renewable Resources

There are a number of problems with the Gray and Hotelling Models. Of the more critical problems with the Gray and Hotelling Models is that they both ignore externalities and environmental damage caused through non-renewable resource depletion. That is, they assume the non-existence of externalities.

Another important deficiency of the Hotelling Model is that it assumes the prior existence of a backstop technology or substitute resource. Even before a non-renewable resource is fully depleted, it is assumed there is always an alternative technology or resource available to replace it. What, however, if these do not already exist? What does it mean if there is no backstop technology or no substitute resource available when a non-renewable resource is fully exhausted? If the definition of 'income' is considered more closely, it can have some considerable impact on the true rents or profits being derived from non-renewable resource depletion. This, in turn, can have some impact on the price path of non-renewable resources.

According to El Serafy (1989), an owner of a non-renewable resource (say a mining firm) must reinvest some portion of its receipts to establish a capital asset that generates the same consumption stream once the non-renewable resource is gone. To achieve this, the following must be done:

- The *finite* series of earnings from the sale of the resource has to be converted to an *infinite* series of true income such that the capitalised value of the two series are equal. They must be equal, that is, the capitalised value of the infinite series of true income must not be less than the finite series of earnings from the sale of the resource, otherwise the newly established capital asset will not be generating the same consumption stream once the non-renewable resource has gone.

- Two portions of the annual earnings from resource sales must be identified:
    1. An 'income' portion - this is the amount that can be spent on consumption goods. This constitutes the true income from non-renewable resource depletion.
    2. A 'capital' portion - this is the amount that must be set aside year after year (until the resource is fully exhausted) and invested to produce a capital asset to create a perpetual stream of income. This capital component is effectively equal to the 'user' cost of non-renewable resource depletion because it constitutes the opportunity cost of not having the non-renewable resource available in the future. This

is an additional cost to consider (apart from the extraction cost) and we shall soon look at what impact this can have for the price path of non-renewable resources.

Calculating the income and capital (user cost) components.

To calculate the income and capital components of the receipts from non-renewable resource depletion, the following equation can be used:

$$X / R = 1 - \frac{1}{(1+r)^{n+1}} \quad \textbf{(3.8.19)}$$

where:

R = the total receipts (net of extraction costs) – i .e., the rent from mining

X = "true" income

$R - X$ = the "capital" component or user cost of non-renewable resource depletion

r = the discount rate or interest rate on a replacement asset

n = the number of periods (years) over which the resource is to be liquidated (i.e., the life of the mine).

To give an example, the following are the known details from mining a particular resource:

- $n = 20$;
- $r = 7\%$.

The income component would be 76% of net receipts; the capital component or user cost (set-aside amount) would be 24% of net receipts. Hence if the annual net receipts were $10 million, $7.6 million would be legitimate income; $2.4 million would need to be set aside to establish a replacement asset. If this was done, the replacement asset, in twenty years time, would be able to generate a perpetual income stream of $7.6 million per year, exactly equal to the income generated during the twenty year life of the mine.

When the El Serafy Rule is adopted (i.e., when we account for the cost of non-renewable resource depletion), the rate of depletion is slowed. We not only end up with a replacement asset, but we preserve the resource to some extent while it still exists.

How can the El Serafy Rule be operationalised? To operationalise the El Serafy Rule it would be necessary to legislate to change the accounting practices of owners and miners of non-renewable resources. Legislation already exists in regards to accounting practices, so this could simply be added to current legislation. Owners and miners of non-renewable resources would be compelled to set up a capital account where some of the proceeds from mining would have to be invested to ensure the establishment of a suitable replacement asset.

3.9. Economics of renewable resource use

The basic bioeconomic model

The basic assumptions of the bioeconomic model of a renewable resource are as follows:

1. Renewable resources have a natural regenerative capacity. This constitutes its natural yield or growth rate (y).

2. The natural growth rate (y), which we will now denote as $G(X_t)$, is a function of the stock level (X_t) and the carrying capacity of its natural habitat.

3. The biological production function of a renewable resource is:

$$G(X_t) = \frac{\Delta X_t}{\Delta t} \qquad (3.9.1)$$

where:

$G(X_t)$ = natural growth rate;

ΔX_t = change in stock levels;

Δt = change in time.

4. The industry harvest level (H_t) is a function of current stocks (X_t) and the industry harvesting effort level (E_t). Hence:

$$H_t = f(X_t, E_t) \qquad (3.9.2)$$

5. As stocks rise, the harvest will rise for any given effort level. That is:

$$\frac{\Delta H}{\Delta X} > 0 \qquad (3.9.3)$$

6. As more effort is applied by the harvesting industry, the harvest falls for any given stock level. That is:

$$\frac{\Delta H}{\Delta E} < 0 \qquad (3.9.4)$$

7. The change in the stock of a renewable resource is equal to the natural growth rate less the harvest rate of stocks. That is:

$$G(X_t) = \frac{\Delta X_t}{\Delta t} = G(X) - H_t \qquad (3.9.5)$$

We therefore need to consider what the natural growth rate of a renewable resource typically looks like without human intervention (e.g., harvesting of the resource). Having done that, we need to consider what the impact of harvesting is on the growth rate and on the stocks of a renewable resource.

We shall begin by examining the natural growth rate of a renewable resource. Figure 3.9.1.B illustrates a conventional *logistic growth curve* function for a renewable resource (e.g., a fish species).

Figure 3.9.1.B indicates the following:

- At low stock levels (low population numbers), the fish species multiplies rapidly over time because there is less competition amongst each other for food.

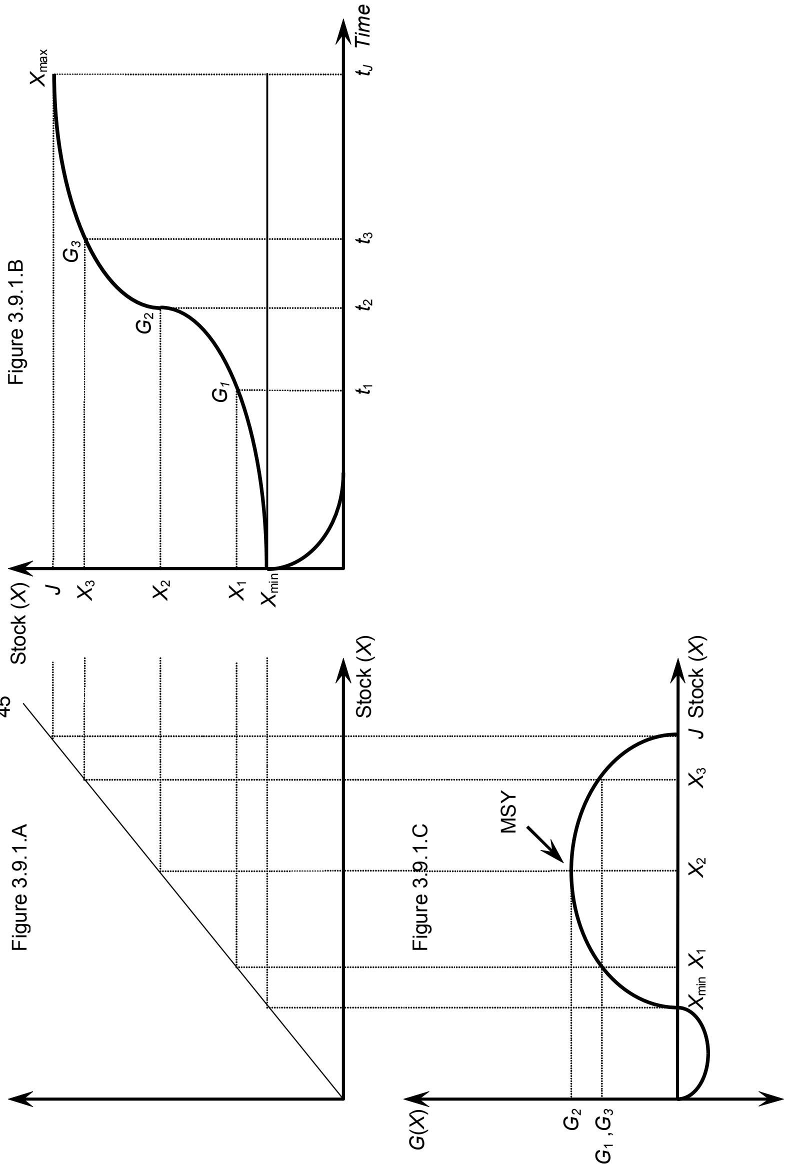

Figure 3.9.1: The bioeconomic model

- As fish numbers multiply, competition for food reduces the rate of increase until eventually the stock converges on a maximum steady-state number of X_{max} or J.
- X_{max} is determined by the biological carrying capacity for the fish species.
- The logistic growth curve begins at X_{min} because this denotes the critical minimum for the species. If fish numbers fall below X_{min} the fish species is driven to extinction.
- When the stock = X_2, the growth rate is at a maximum (G_2) (see Panel 3.9.1.C). When the stock = X_1 and X_3, the growth rates are G_1 and G_3 respectively (see Panel 3.9.1.C). $G_1 = G_3$ to indicate that the growth rates at X_1 and X_3 are the same. The difference is that the growth rate is still increasing at X_1 but is declining at X_3.

Figure 3.9.1.C indicates the same information as figure 3.9.1.B but specifically focuses on the growth rate of the species as the stock level changes:

- When the stock = X_2, the growth rate (G) is at a maximum (G_2). This is also known as the maximum sustainable yield (MSY) of the resource. It is called this because, ignoring economic factors, this would be the maximum amount that could be harvested on a sustainable basis.
- When the stock = X_1 and X_3, the growth rates are G_1 and G_3 respectively. Despite the growth rates being the same at X_1 and X_3, the growth rate is still increasing at X_1 but is on the way down at X_3.

We now consider the impact of harvesting on stocks of a renewable resource with the aid of figure 3.9.2. Assume that a harvest level of $\underline{H}$ has been chosen by the industry and is maintained for as long as is biologically feasible.

- If the stock is initially at J then, since the stock is not growing (i.e., it is at a maximum), there will be a decline in stocks. Stocks will fall but stabilise at X_2.
- If the stock is initially at X_3 then, since $\underline{H} > G_3$, the species will be driven to extinction.
- If the stock is initially X_1 or X_2 then, since $\underline{H} = G_1 = G_2$, the stock will remain steady at these levels.

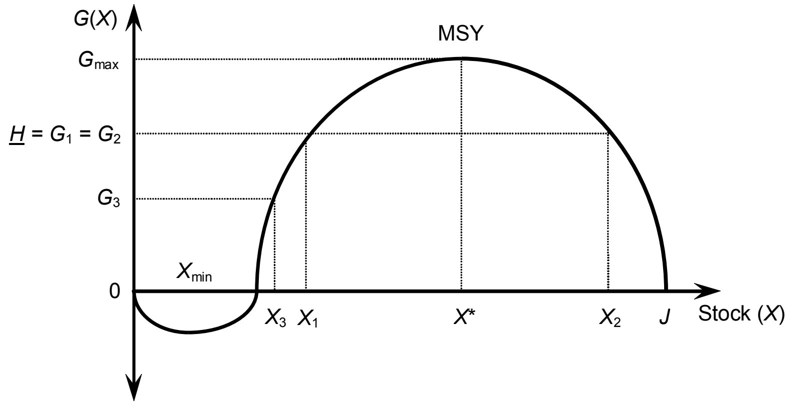

Figure 3.9.2: Impact of a given harvest level ($\underline{H}$) on stocks

- If the stock is between X_1 and X_2 then, since $\underline{H} < G$, there will be an increase in stocks until the stock reaches X_2 (where $\underline{H}$ eventually equals G_2). That is, stocks will stabilise at X_2.

All up, if the harvest level is maintained at $\underline{H}$, the following can be concluded:

a) If stock levels are initially left of $X_1 \rightarrow$ stock levels decline to extinction.
b) If stock levels are initially at $X_1 \rightarrow$ stock levels remain at X_1.
c) If stock levels are initially right of $X_1 \rightarrow$ stock levels stabilise at X_2.

It is also important to note that:

- a) is unsustainable;
- but b) and c) are sustainable.

In the end, the choice of industry harvest level depends very much on initial stock levels of the renewable resource. If desired, the maximum sustainable harvest level would be $\underline{H} = G_{max}$ (with stock level at X*).

8. The total cost of harvesting (*TC*) is such that:

$$TC = c{\cdot}E \qquad (3.9.4)$$

where:

c = the marginal cost per unit of effort (i.e., *MC* of effort);

E = total effort.

9. Entry into the industry entry and exit by firms is free and non-restricted. For this reason, the renewable resource is an *open access* resource.

   - New firms will enter the industry when there are *super-normal* profits being earnt by incumbent firms (i.e., $MR = MC$ and $P > AC$).
   - Existing firms exit the industry when there are *losses* being suffered by incumbent firms (i.e., $MR = MC$ and $P < AC$).
   - There is no entry/exit when firms are earning *normal* economic profits (i.e., $MR = MC$ and $P = AC$).

10. The total revenue (*TR*) of each firm is such that:

$$TR = P{\cdot}h \qquad (3.9.5)$$

where:

P = price per tonne of fish;

h = number of fish caught (harvest) per firm (Note: H denotes industry harvest level; h denotes harvest level of each firm in the industry).

11. The industry equilibrium is reached when economic profit of all firms (P) = $TR - TC = 0$ (i.e., where $[(P - AC) \cdot h] = 0$.

12. All fishing firms are assumed to be identical.

13. All firms are profit maximisers and thus aim to exert a level of effort where $MR = MC$ (the profit-maximising condition).

14. The fishing industry is characterised by imperfect competition. Hence all firms face a downward sloping demand (*D*) curve and marginal revenue (*MR*) curve.

Three Bioeconomic Propositions

There are three critical bioeconomic propositions that need to be put forward and proven before we can consider the policy aspects relating to the exploitation of renewable resources.

Proposition #1: At an open access equilibrium, price equals the average cost of harvesting (i.e., $P = AC$).

This is because, when $P = AC$, it means there is no incentive for new firms to enter the industry.

Proposition #2: An open access equilibrium is 'economically' inefficient.

This is because, at the equilibrium effort level, $P = MC > MR$. Since this means that $MR \neq MC$, firms are unable to maximise profits and is due to the fact that the desired harvest level requires greater effort to obtain when there are more firms in the industry.

Proposition #3: An open access equilibrium may be biologically 'unsustainable'.

This is because the long-run equilibrium industry harvest ($H = m \cdot \underline{h}$) exceeds the growth rate (G) at the equilibrium stock level. In other words, the industry's harvesting rate is exceeding the natural regeneration rate of the renewable resource. This is biologically unsustainable.

Why is this the case? It is due to an externality that is implicit in the model. As each firm increases its effort to obtain more fish, the stock of fish declines. This reduces the harvest per unit of effort. That is, **as effort increases, the harvest per unit of effort falls**. Unfortunately, with open access resources, the negative effect of an increase in effort by one fishing firm is too small to deter the firm from increasing effort. This is because the negative effect is not borne entirely by the firm which increases effort, but by all fishing firms (*free rider effect*). Hence, firms ignore the stock externality. If all firms do likewise, the fish species is harvested to extinction.

***Fundamental Rule*: In a steady-state equilibrium, the net marginal social surplus from harvesting must equal the discounted value of the future losses brought about by lower stocks.**

Achieving a bioeconomic equilibrium.

We can attempt to achieve a bioeconomic equilibrium (i.e., an equilibrium situation that is both economically efficient and ecologically sustainable) through the use of the following instruments:

- taxes on both the harvest and effort,
- quotas on the amount,
- tradeable harvesting permits.

So which of the instruments is best? Taxes, quotas, or permits? To answer this question we need to look at advantages and disadvantages of them.

Harvest taxes.

Advantages include:

- The tax system is a relatively simple and cheap system to introduce - the administrative element already exists in regards to general taxes. There would only be an additional need to monitor harvest levels (output) to ensure correct amount of tax was paid.
- A harvest tax is more flexible than a quota system.
- Taxes raise revenue for the government, which can be used, if necessary, to rehabilitate the environment - particularly a depleted renewable resource.

Disadvantages include:

- A harvest tax does not guarantee that harvest levels stay at the sustainable level - there is no quantitative restriction on harvest levels. A harvest tax simply taxes harvest levels, but what is to stop the industry from harvesting the resource to extinction?
- There is a difficulty in calculating the optimal rate of tax - how does a government know what tax rate is required to ap-

propriately shift the *TR* curve? What if the government gets it wrong and the resource is harvested to extinction? The government could simply impose a very high tax rate to ensure the industry harvest is biologically sustainable, but this could destroy the industry.

- Since changing prices and technology mean that the *TR* and *TC* curves are always shifting/rotating, there is a need to constantly adjust the tax rate. There are two problems associated with this: (a) again, it makes calculating the optimal tax rate a difficult if not impossible exercise, and (b) it results in industry instability which can affect investment and technological innovation.
- Not all firms are profit maximisers, that is, firms have different objectives and so a single tax rate cannot be fully effective.

Effort taxes.

The advantages and disadvantages of effort taxes are the same as harvest taxes. The advantage of effort taxes are threefold:

- In the end, it is the effort level which has greater impact on stock levels than the actual harvest. Note that the same harvest level can be achieved with two different effort levels - one is sustainable (stocks are high when effort is less) and the other is unsustainable (stocks are low when effort is high). Given the differing objectives of firms (some profit maximisers, some revenue maximisers, some market share maximisers), an effort tax is likely to be more effective in ensuring a sustainable industry.
- Effort taxes provide better and more flexible incentives for firms than harvest taxes. A firm's *TR* depends on the harvest level so a harvest tax offers no flexibility for firms. An effort tax affects a firm's *TC* curve. Firms are able to reduce their tax burden and make the industry more efficient through technological progress that reduces the per unit effort per tonne of fish caught.
- Effort taxes are easier and cheaper to implement. A harvest tax requires the monitoring of harvest (output) levels. An effort tax does not necessarily require the monitoring of effort - it depends on the nature of the tax. For instance, a fuel or bait tax does require monitoring of effort.

All up, an effort tax is probably a better form of taxation than a harvest tax.

Industry quota.

Advantages:

- Industry quotas involve the setting of a harvest level beyond which a violator of the quota pays a heavy penalty. Provided the penalty is sufficiently large, standards are a good way of increasing the possibility of achieving an optimal harvest level.
- Although it is necessary for the government agency to estimate the optimal harvest level, there is no need to set a tax rate to try and achieve it. This minimises the probability of bureaucratic error.
- The setting of industry quotas is a simpler system than a tax system.
- **Overall, quotas increase the chance of the optimal harvest level being achieved.**

Disadvantages:

- Because there is no additional charge for harvesting the renewable resource, a firm does not pay for any environmental impact (spillover cost) from harvesting up to the permissible quota level. There is no incentive to develop better harvesting techniques and equipment. It is also unfair since those affected by overharvesting have to bear the cost - not the harvesting firms.
- Because there is no charge on harvesting a renewable resource, the cost of harvesting does not increase (neither the TB nor the TC curves shift, unlike the impact of taxes). The restriction in the harvest caused by the industry quota increases the size of the super-normal profits being earned by existing firms. This induces entry of new firms. Entry of new firms means that all firms have to reduce output further (to meet the industry quota). The end result is far too many firms catching the industry quota. This not only threatens the economic viability of the industry, it results in all firms having massive excess capacity. This is wasteful because resources are being tied up in the firm and not being used for another useful purpose. This is inefficient.

Overall, standards are an inefficient way of achieving the optimal and sustainable harvest level.

Tradeable harvesting permits.

Advantages include:

- A permit system places a quantitative restriction on harvest levels. This ensures biological sustainability (provided the penalty for excessive harvesting is adequate).
- There is no need to calculate an effort tax. Because the permits are auctioned off and can then be traded amongst firms, the premium paid for the permits acts as an effort tax. That is, the market will determine the 'tax' rate, which is likely to be both more accurate and less costly than if it were left to bureaucrats. This means economic efficiency is more probable than with taxes.
- Since the premium paid for permits is equivalent to a tax, permits raise revenue for the government which can be used to rehabilitate the environment.
- Permits enable environmental groups to reduce the total industry harvest. Members of environmental groups can pool their funds together, purchase some of the permits, but choose not to use them or sell them to fishing firms. While a permit system enables environmental groups to further reduce harvest levels, they do have to pay for the privilege of doing this (i.e., in terms of the number of permits they purchase). Taxes, however, offer no opportunity for environmental groups to reduce the industry harvest.

Disadvantages include:

- A permit system is more costly to administer than taxes. There is a need to establish an agency to issue the permits; to auction off the permits; and to monitor firms to ensure: (a) harvesting firms have permits in the first place, and (b) permit holders harvest no more than what they are permitted to harvest.
- A permit system has the potential to reduce competition. If only a small number of large firms buy all the permits, they can secure market power. This reduces competition and leads

to inefficiencies. The permit system would have to be set up in such a way as to limit the total number of permits any one firm can purchase.
- The auctioning off of permits (say at the beginning of a year) is a potentially cumbersome way of achieving targets. Also, firms are required to engage in the initial auctioning process every year (depending on the life of the permits).
- What if too many permits are issued at any one time? If too many permits are auctioned by the government agency, there is the potential for the resource to be overharvested. However, this problem is applicable to any policy measure taken, since to be effective, it is necessary to estimate the maximum sustainable harvest. If the agency gets its estimation wrong, then any policy measure will fail, not just a permit system. To prevent this problem from emerging, it has been suggested that the number of permits issued should be reduced to 70–80% of the estimated maximum sustainable harvest. Known as the 'precautionary principle', doing this ensures an overestimation does not result in the extinction of a species.

Summary on policy instruments

We can briefly summarise the efficacy of the various policy instruments.

- Taxes are an efficient way of achieving a bioeconomic equilibrium. However, the small penalty associated with over-fishing does not guarantee biological sustainability.
- Quotas are very ineffective.
- An industry quota can bring about biological sustainability but it is an inefficient means of doing so. An industry quota ultimately threatens the economic viability of the industry.
- Tradeable permits combine the benefits of an industry quota (sustainability) and a tax (efficiency). Tradeable permits are probably the most effective way of achieving a bioeconomic equilibrium.
- **Overall, many people believe that tradeable permits are the most effective way of achieving a bioeconomic equilibrium.**

3.10. Environmental efficiency indicators of economic systems

While calculating indicators of ecological efficiency, first of all we have to define the type of an indicator. Absolute versus relative value of an indicator is the first point of our concern. Emissions, profit and GDP are good examples of absolute indicators. Relative indicators can be measured in terms of rates of return. Return on investment, return on assets, return on equity and internal rate of return – all these indicators represent relative values.

Suppose that a representative agent (household, enterprise) produces x units of output (for example 3000 tons of steel, 157 thousand centners of grain) and the unit price of output is given by $f(x)$. In addition, total costs function is given by $c(x)$. The cost function incorporates externalities (for example environmental damage to human health). Let us assume that emissions are given by $E(x)$. Emissions are linear increasing function of output. Let us specify the following functional forms: 1) $f(x) = 100 - x$; 2) $c(x) = 1000 + 5x$; 3) $E(x) = 1000x^*$ (where x^* is the optimal value).

Using information specified above we can compare the following two cases which are shown in Fig. 3.10.1. In the first case, a representative agent maximizes profit $\pi(x)$ - an example of an absolute indicator. Formally : $\pi(x) = f(x)x - c(x)$.

In the second the agent maximizes total cost recovery ratio (TCRR). We define TCRR as a relative indicator which indicates the ratio of total revenue to total costs. Formally : $TCRR = \frac{f(x)x}{c(x)}$. These functions are concave and differentiable for $x > 0$.

From the above diagram, we can see that these two cases differ not only in optimal level of optimal output (A $\approx$ 45 < B $\approx$ 48) but also in the level of emissions ($E(45)=45000 < E(48)=48000$).

In this example, we have incorporated specific functional forms.

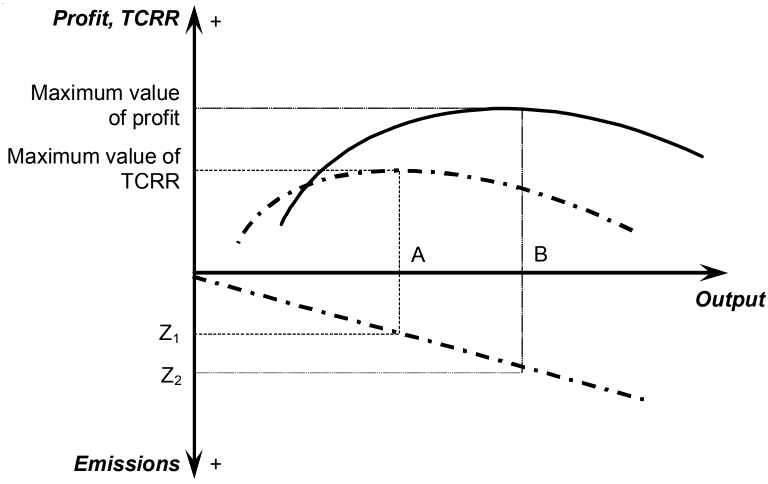

Figure 3.10.1. Profit vs. total costs recovery ratio

In general, specification and estimation of these forms is a matter of empirical analysis.

Formally an indicator of negative externalities (*Z*) can be expressed as a regression function of the vector of social, political, economic determinants (*X*) and the error term (*e*). Negative externalities can be measured in physical and/or monetary units. In fact, we can define tones of $S0_2$, NOx, NH_3, BOD, environmental damage as a dependent variable.

In our opinion, socio-economic determinants at macro-level can be incorporated into regression equation using the following set of factors: circulating assets, fixed capital stock, the share of employers with tertiary education, the structure of output (in terms of value-added by sector), type of economic system, abatement costs, state of environmental legislation, real GDP per capita, Index of economic freedom (and it's components), type of political system, development of infrastructure, and others.

An interested reader can find some useful data at:

- www.worldbank.org
- www.europa.eu.int
- www.heritage.org
- www.ebrd.org

3.11. Conceptual framework for examining the links between socio-economic pressures and impacts on the environment

What is an eco-social system?

In this chapter we put the focus on the links (exchanges and products of the relation) and interconnections (the nature of the relation) between two broad systems: the ecosystem and the social system (Gunderson and Holling, 2002). The term eco-social system is used to emphasize this integrated concept. Social systems deal with governance; ecological systems refer to communities of organisms interacting with one another and with their environment (Berkes et al., 2003). We use "links" to mean a relation (causal, parallel, reciprocal, or otherwise) or connection between ecosystem health and social system well-being.

Describing an eco-social system involves both a scientific description of the ecosystem and the creation of a "framework" based on an understanding of the culture and values of the people who live in the system.

Generally, the investigation and modelling of a particular local system requires the integration of socio-economic and natural science data in order to:

- provide an understanding of the forcing effects of socio-economic changes such as, for example, population growth, urbanisation, and other land use changes;
- assess the human welfare impacts of changes due to consequent processes and functions changes in coastal resource systems.

In our case, the accepted paradigm is that biophysical environment with its structure and ecological processes produce a suite of services; the social actors use the resources to pursue their goal and objectives. Perceived conflicts and trade-offs among economic and ecosystem services come up from different views of management alternatives. The schema is reported in figure 3.11.1.

Methods from natural and social sciences can be used in a complementary way. A whole range of methods from the social sciences – questionnaires, face-to-face interviews, documents (literature survey) and personal observation – can be used in order to investigate perceptions of people on the environment. Indeed perceptions of environmental resources determine not only how a resource is utilized, but also its relative value to the community. The value that a community places on natural resources can have significant implications on how those resources are managed (Cinner and Pollnac, 2004). The integration of qualitative approaches with quantitative ones can be used to obtain a holistic picture of the use and management of ecological resources (White et al.,

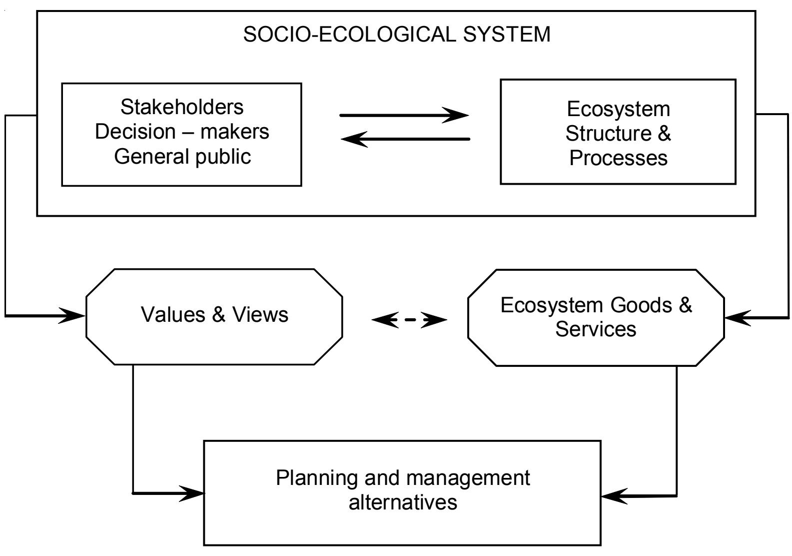

Figure 3.11.1: Methodology of analysis of an eco-social system

2005) and to review how much public policy are appropriate to the context.
Ecosystem goods and services. The first step towards a comprehensive assessment of ecosystem goods and services involves the translation of ecological complexity (structures and processes) into a more limited number of ecosystem functions. These functions in turn, provide the goods and services that are valued by humans. In the ecological literature, the term 'ecosystem function' has been subject to various, and sometimes contradictory, interpretations. Sometimes the concept is used to describe the internal functioning of the ecosystem (e.g. maintenance of energy fluxes, nutrient (re)cycling, food-web interactions), and sometimes it relates to the benefits derived by humans from the properties and processes of ecosystems (e.g. food production and waste treatment).

In this context, ecosystem functions are defined as 'the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly', as defined by de Groot (1992). Using this definition, ecosystem functions are best conceived as a subset of ecological processes and ecosystem structures (Figure 3.11.2.). The wide range of ecosystem functions and their associated goods and services are grouped into four primary categories (de Groot et al., 2000).

1. *Regulation functions*: this group of functions relates to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes through bio-geochemical cycles. In addition to maintaining ecosystem health, these regulation functions provide many services that have direct and indirect benefits to humans (such as clean air, water and soil, and biological control services).
2. *Habitat functions*: natural ecosystems provide refuge and reproduction habitat to wild plants and animals and thereby contribute to the (in situ) conservation of biological and genetic diversity and evolutionary processes.
3. *Production functions*: photosynthesis and nutrient uptake by autotrophs convert energy, carbon dioxide, water and nutrients into a wide variety of carbohydrate structures which are then used by secondary producers to create a variety of living biomass. This broad diversity in carbohydrate structures provides

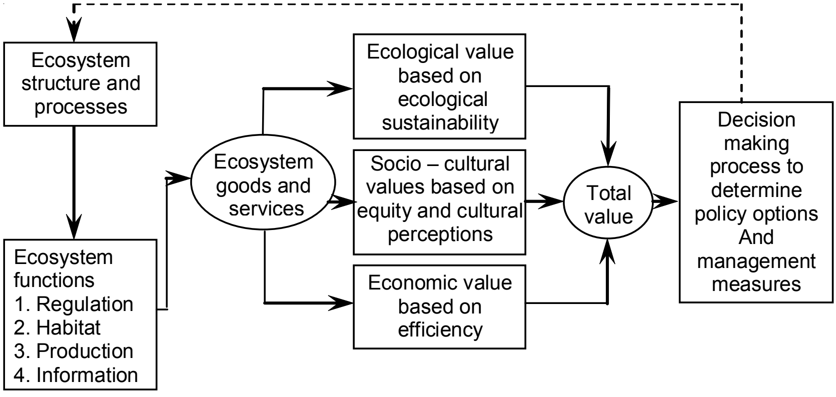

Figure 3.11.2: Framework for integrated assessment and valuation of ecosystem functions, goods and services (de Groot et al., 2002)

many ecosystem goods for human consumption, ranging from food and raw materials to energy resources and genetic material.

4. *Information functions*: natural ecosystems provide an essential 'reference function' and contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, recreation and aesthetic experience.

As shown in figure 3.11.2, the importance of ecosystems is roughly divided into three categories: ecological, socio cultural and economic value. The ecological value, or importance, of a given ecosystem is determined both by the integrity of the regulation and habitat functions of the ecosystem and by ecosystem parameters such as complexity, diversity and rarity. Economic valuation methods fall into four basic types, each with its own repertoire of associated measurement issues: direct market valuation, indirect market valuation, contingent valuation, and group valuation. In addition to ecological criteria, social values (and perceptions) play an important role in determining the importance of natural ecosystems, and their functions, to human society.

Values and views. Traditionally, ecology has focused on the analysis of factual information. The importance of stakeholder perceptions is increasing and policy-making for the management of ecological resources is receiving greater inputs of diverse interest groups. Therefore ecologists are embracing more diverse paradigms. Quantifying public perceptions is becoming a key component in translating ecology into management.

The social actors are asked about the value they pose on the natural resources they use. Value determines the priorities and the objectives. The participation of the local actors generally helps the researchers in highlighting criticisms and hot spots in natural resource management. There are a lot of methods with whom incorporating social perspective. Here after a brief selection will be presented: Delphi method, in-depth interviews, focus groups and questionnaires.

Delphi method. This method will be illustrated by a hypothetical example: suppose we want to establish a forecast for the date by which oil reserves would exhaust at a planetary scale. With the Delphi method, experts from interested disciplines (for instance geology, geochemistry, economy, others...) are first identified and asked to participate in the inquiry. During the initial contact, the nominated persons are told about the Delphi and invited to participate. They are assured of anonymity in the sense that none of their statements will be attributed to them by name.

The questions are refined by the researchers and pursued through a number of sequential questionnaires. In the first questionnaire, participants might be asked to provide their judgment on a date at which oil depletion might take place. The analysis would identify the range of opinions about the date. In a second questionnaire, the range would be presented to the group, and persons holding opinions at the extremes of the range would be asked to reassess their opinion in view of the group's range and provide reasons for their positions. In the third questionnaire, the new group judgment on a date would be presented to the participants, along with reasons for the extreme opinions. Each member of the group would be asked to reassess his or her position in view of the reasons presented. They might also be asked to refute, if appropriate, the extreme reasons with any fact at their disposal.

In a fourth and final round, these arguments would be presented, along with the evolving group consensus, and a reassessment requested. In a sense, the Delphi method is a controlled debate. The reasons for extreme opinions are made explicit and often groups move toward consensus. The important thing is, anyway, that even when this does not occur, the reasons for disparate positions become crystal clear. Planners reviewing this material will make judgments based both on these reasons and their own knowledge and goals.

Because the number of respondents is usually small, Delphi method does not produce statistically significant results; in other words, the results provided by any panel do not predict the response of a larger population or even a different Delphi panel. They "only" represent the synthesis of opinion of the particular group.

The value of the Delphi method rests with the ideas it generates, both those that evoke consensus and those that do not. The arguments for the extreme positions also represent a useful product.

Focus groups. Focus groups are group discussions designed to learn about subjects' perceptions on a defined area of interest. They involve as many as 12 participants and are conducted by a skilled moderator using a discussion guide. Focus groups rely on the dynamics of group interaction to reveal participants' similarities and differences of opinion (Krueger, 1994; Morgan, 1997). They generate data subject to group effects, both positive and negative. Group interaction may facilitate an exchange of ideas and information stimulating individual group members thinking on different ideas. However, members of groups may fail to exchange all information they have and groups may focus only on shared information. Problems of dominant group members and other group dynamics may be responsible for incomplete or biased information processing.

In depth-interviews. Interviews are used as a resource for understanding how individuals make sense of their social world and act within it (May, 2001). In-depth interviews are guided one-on-one sessions. The researcher uses the same interview guide for each session and makes comparisons of the interview data to determine similarities and differences (Weiss, 1994). In-depths interviews can be used in order to analyze how the actors react and perceive the different use and value of the natural resources. The interviews can be structured or semi-structured: in the first case, the interview is very rigorous and strictly follows the prepared structure. In the second case the respondents provide answers when required, but also share their opinions and wishes with the researcher, making detailed and comprehensive statements. In this type of interviews questions are normally specified, but the interviewer is freer to probe beyond the answers.

Questionnaires. Where researchers attempt to integrate ecological data with socio-economic or political data, questionnaires are often used in some aspect of the study. In this type of social research, the emphasis is on producing data based on real-world observations. The search is then purposeful and structured. Survey research generates indeed a large volume of quantitative data that can be subject to statistical analysis.

Questionnaires are used to determine actual or hypothetical behaviour. For instance, questionnaires are used to provide data for economic valuation studies, for example by using methods such as contingent valuation and attribute-based choice modelling to determine willingness to pay (WTP) for increased utility arising from the provision of a public good, or willingness to accept (WTA) compensation for the loss of utility resulting from a decline in a public good (Garrod and Willis, 1999; Carson, 2000;). Most questionnaires have been carried out in North America and Western Europe, and have addressed species-level issues, principally focusing on mammals. The majority have been concerned with impacts of species and/or their conservation, and with human–wildlife interactions (Howard and Parsons, 2006; Sutherland, 2006). Recent research concerning natural resource management highlights the importance of understanding and incorporating local perceptions into management actions, i.e. conservation initiatives (Smit, 2006). In a study of perceptions of local resources in the Philippines, Nazarea et al. (1998) note that individuals and communities utilize their surrounding resources based on a variety of social and cultural factors that shape their perceptions of the resource. These factors can determine whether a potential resource is perceived as useful for extractive purposes or dismissed as useless.

Understanding the system behaviour

The Pressure–State–Response (EEA, 2005), and the following extension to the Drivers-Pressures-State-Impacts-Response (DPSIR) scheme, has been quite successful in combining natural and social sciences and offering a common framework of analysis. It is based on the notion of causality: it is used worldwide as a reporting tool to describe human activities (driving forces) that exert pressures on the environment, changing the quality and quantity (the state) of natural resources. Human management responses to the changes include any form of organised behaviour that seeks to

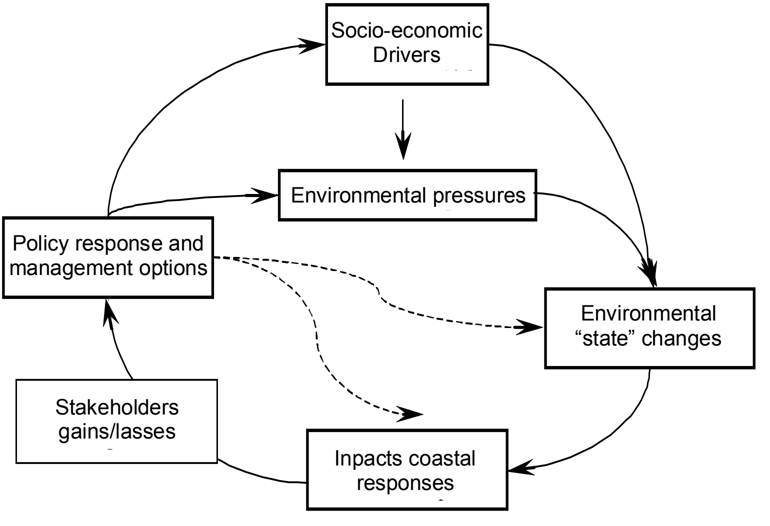

Figure 3.11.3: The Drivers-Pressures-States-Impact-Response framework

reduce, prevent or ameliorate undesirable changes.

This approach presupposes substantial understanding of the underlying causal relationships between human activities and impacts on ecosystems and human response mechanisms. In a policy-making context, this conceptual framework can support the policy maker in conceptualising and structuring the decision about alternative possible measures, according to the cause–effect relationships (Fassio et al., 2005).

The components of the DPSIR framework are defined in the following.

Driving Forces. Driving Forces refer to fundamental processes in society which drive activities having a direct impact on the environment. In particolar, they are socio-economic and socio-cultural forces driving human activities, which increase or mitigate pressures on the environment.

Examples are the human demands for agricultural land, for energy, transport and housing. Some examples of driving forces are:

- consumption and production patterns
- population demographics;
- scientific and technological innovation;
- economic demand, markets and trade;
- institutional and social-political frameworks.

Pressures lead to human activities that exert ‘pressures’ on the environment, as a result of production or consumption processes. They can be divided into three main types: (i) excessive use of environmental resources, (ii) changes in land use, and (iii) emissions (of chemicals, waste, radiation, noise) to air, water and soil.

Examples:

- use of resources;
- emissions (direct and indirect) to air, water and soil;
- production of waste;
- production of noise;

- radiation;
- vibration.

States. The 'state of the environment' is the combination of the physical, chemical and biological conditions of the environmental compartments affected by the pressures.

Examples:

- air quality;
- water quality (rivers, lakes, seas, coastal zones, groundwater);
- soil quality;
- ecosystems (biodiversity, vegetation, soil organisms, water organisms).

Impacts. Changes in the state may have environmental or economic 'impacts' on the functioning of ecosystems, their life-supporting abilities, and on human health and on the economic and social performance of society. The changes in the physical, chemical or biological state of the environment determine the quality of ecosystems and the welfare of human beings.

Examples:

- eutrophication;
- contamination;
- siltation;
- coastal erosion;
- nutrient depletion;
- salinization;
- sediment accretion/Erosion.

Responses. A 'response' by society or policy makers is the result of an undesired impact and can affect any part of the chain between driving forces and impacts. A classical example of a response related to driving forces is a policy to change mode of transportation, e.g. from private (cars) to public (trains).

Conclusion Gregory Bateson (1972), stated: "We are not outside the ecology for which we plan – we are always and inevitably becoming part of it". So, ecology and society have to be studied in an integrated way. Anyway, multi-criteria decision theory teaches that a consequence of taking into account various dimensions simultaneously is that it is impossible to optimise all the objectives at the same time (Munda, 2004). What we should learn is to look for ‘‘compromise solutions’’ i.e. the balance between conflicting incommensurable values and dimensions.

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3.12. Productivity from an ecological viewpoint

Environmental policy and productivity. Technological progress and productivity increase play a key role in the solution of environmental problems in the face of these increasingly stringent environmental regulations. Therefore, environmental policy needs to be properly designed to promote technological innovation, and to favor its diffusion (Jaffe et al., 2003). There is a discussion that whether environmental regulations have played a major causal role in impairing the competitiveness of industries. Conventional wisdom tells that environmental regulations impose significant costs to industry and slow productivity growth and impede technological progress (Jaffe et al. 1995). Within this context, the key issue is how to design environmental regulations to attain environmental goals while controlling the adverse impact on industry to the extent feasible, i.e., minimizing productivity loss. Recently, however, revisionist proposes the alternative hypothesis that environmental regulations can have a positive effect on competitiveness in the industry. Environmental regulations pressure firms to innovate and thus enhance growth and competitiveness, named Porter hypothesis (Porter, 1991; Porter and van der Linde, 1995). While there are market failure in technological innovation (e.g., Romer, 1990) that are (1) technological knowledge is a public good – a non-rival and non-excludable good; (2) many beneficiaries (free riders) do not contribute to the cost of technological knowledge; and (3) uncertainty unable to make estimations of technical and commercial returns to innovations, there are situations environmental regulations can lead to long-term benefits to industry (Mohr, 2002).

The notion of the Porter hypothesis is somewhat ambiguous. This study provides the two different interpretations of the hypothesis (see Jaffe *et al.* (1995) for more interpretations). One form of the hypothesis is that, in the long run, environmental regulations are not to worry, because it really will not be all that expensive.

This is so since the regulations encourage innovations and these innovations might, in general, more than fully offset the compliance cost and lead to a net benefit for the regulated firm (Porter and Linde, 1995). Many economist disagree with this hypothesis since addition of constrains on a firm's set of choices cannot be expected to result in an increased level of profits. The other interpretation of the Porter hypothesis is that tougher environmental regulations make firms more internationally competitive than weaker environmental regulations. This interpretation was first advanced as a response to the claim that U.S. firms had become less competitive due to strict environmental regulations. Porter (1991) argues that the critics were wrong and the right form of more stringent regulation could spur competitiveness. I define competitiveness in terms of productivity following literature. This is so because technological change lies at the heart of *long-term* economic growth and social benefit (e.g., Romer 1990).

Depending on how targeted index is measured, the Porter hypothesis may be formulated in different ways (e.g., Jaffe et al., 1995). In a recent study by Managi and Kaneko (2006), they follow the framework presented in Managi *et al* (2004) that measures productivity and tests the causality between environmental regulations and productivities. They examine three versions of the Porter hypothesis. In the standard, or "strong", version, productivity is measured in terms of market outputs only (e.g., crop and livestock productions). In the common, or "weak", version, productivity is measured in terms of environmental outputs only, which is green productivity (i.e., efficient utilization of pollution abatement technologies). The re-cast version of the hypothesis considers joint production model including both market and environmental outputs which environmental outputs are non-market outputs.

Their paper contributes to the literature on productivity change in several ways. First, they apply a distance function approach to a province-level data set tracked from 1987 to 2001 in China to measure various components of total factor productivity (TFP) within a joint-production model of market and environmental outputs. This contributes to our understanding of the various components of total factor productivity change in Chi-

na. In addition, their study contributes to better economic and environmental policy design for sustainable development in China by empirically estimating the role of economic and environmental management on market and non-market (i.e., environmental) productivity.
Their result for market output is consistent with the literature that there has been considerable TFP growth in China, while environmental managements in China have not effectively regulated wastewater, air and solid waste pollutants emissions over our study periods. Over the last two and a half decades, China's economy has recorded an average annual growth rate of close to 9%. As a result of this China's extremely rapid economic growth, the scale and seriousness of environmental problems are no longer in doubt. Whether pollution abatement technologies are utilized more efficiently is crucial in the analysis of environmental management because it influences the cost of alternative production and pollution abatement technologies, at least in part.

Larson et al. (2003) summarizes an assessment of future energy-technology strategies for China. Target in their analysis is find the solution to continue its social and economic development in China while ensuring national energy-supply security and promoting environmental sustainability over the next 50 years. Identification of the technological configuration for an energy system is essential and MARKAL, which is a linear programming model, is used to build a model of China's economic system representing all sectors of the economy and including both energy conversion and end-use technologies.

Their analysis indicates a business-as-usual strategy that relies on coal combustion technologies would not be able to meet all environmental and energy security goals. However, an advanced technology strategy emphasizing (1) coal gasification technologies co-producing electricity and clean liquid and gaseous energy carriers (polygeneration), with below-ground storage of some captured CO_2; (2) expanded use of renewable energy sources (especially wind and modern biomass); and (3) end-use efficiency would enable China to continue social and economic development through at least the next 50 years while ensuring security of energy supply and improved local and global environmental quality.

In the future, more stringent comprehensive pollution control and energy strategies could be obtained by implementing new technologies and more effective management. In addition, it will be crucial for China to rely on private initiatives in order to take major steps in turning current environmental dilemmas around (see Economy, 2004). This is especially so since privately owned firms have less bargaining power in complying policies than state-owned enterprises.

However, China has many challenges in implementing these strategies. First, China is a developing country, and economic development is a primary consideration. Balancing development with environmental protection to realize sustainable development is difficult. Second, the dominance of coal to supply energy cannot be changed in the near future. Also, in general production efficiency is very low, so large investments and long times are needed for improvement. Thus, shift to improved environmental management need to be cost effective.

It is important to understand the environmental performance to realistically estimate the future possibility of pollution reduction. This study analyzes how the performance of environmental management changed over time. Their results find mixed results of environmental productivity using nonparametric productivity indices technique. The productivity increases in overall pollution's case, wastewater, and water uses. However, it decreases in solid waste case. The case for waste gas remains constant relatively in 2003 compared to 1992 although there were some fluctuations.

Managi and Kaneko (2005) provide three interpretations regarding the changes in environmental productivity. Managi and Kaneko (2005) support the interpretation that if the productivity decreases, there is a less efficient utilization of pollution abatement technologies and incompleteness in monitoring and enforcement although China has implemented many environmental policies in the past, and the stringency of these regulations is increasing. As a short-term outlook prevails, investment in waste treatment or new conservation efforts diminish (Economy, 2004). The report by Economy suggests the development of rural areas has contributed to alarming levels of pollution. There is also an evidence for problems in environmental protection management at the local level (Ma and Ortolano, 2000). Ma and Ortolano (2000) show that the administrative rank of the environmental protection bureaus is sometimes lower than that of the enterprises it is intended to oversee (also see Economy, 2004). For example, there are several Environmental Protection Offices where officer was not permitted to monitor wastewater from the paper manufacturing company. This is because the administrative rank of the environmental protection office was lower than that of the company director. Therefore, barriers to effective monitoring and enforcement efforts remain relatively constant, even though the stringency of regulation has increased.

Their results of measuring the market and environmental productivity and connecting it to policies have general implications. These are; there are important factors connecting law, institutions, finance, and growth that are not well understood. A better understanding of how these non-standard mechanisms work to promote growth can shed light on optimal development paths for many other countries. In the next stage, China would need to achieve at least three objectives: first, to set the goal of transition to a market system, second, to establish market-supporting institutions incorporating international best practices, and third, to privatize and restructure state-owned enterprises. For example, the linkages between China and the other countries are assessed by Cheung et al. (2003). They recognize that there are non-negligible restrictions on both physical and financial flows between the China and other economies. Smooth transitions will encourage the transfer of better use of technology and better management.

Detecting the determinants of these factors, they found the "international spillover, FDI" instead of "domestic invention, Patent" is the major factor to increase the market productivity growth. They also found significant negative impacts of pollution abatement and control expenditure (PACE) on market technological progress, although elasticity is small. This PACE, in contrast, positively affects to environmental productivity and technological progress as expected.

While FDI helps economic development by encouraging market productivity improvements, it does not lead to a positive consequence for environmental technologies where FDI does have negative coefficients though they are not significant. Thus, they are able to say that FDI may lead to more environmental damage since firms in advanced countries might avoid stiff environmental regulations.

They find the negative consequence of levy to environmental productivities. Therefore, it seems reasonable to conclude that the levy system needs to be re-considered and they point out several problems of the current system in the following areas: 1). Enforcement of environmental laws is limited and policies and firms' environmental managements are insufficient. For example, the levy rate is less than the average cost of pollution abatement partially because the levy fees are not indexed for inflation, and, for state-owned enterprises, they can be included under costs and later compensated through price increase or tax deductions (Sinkule and Ortolano, 1995). 2). Smaller enterprises tend not to pay levy though they share significant rate of total industrial outputs. 3). The cost of installing pollution abatement facilities is usually not subject to financial assistance from the commercial banks. It should be noted that further studies in developing countries are important since results relies on each country's policy and industry structures among others.

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3.13. Risk optimization approaches to support portfolio-decisions in agriculture: non-parametric versus parametric

Introduction. In agriculture a portfolio-modelling approach is applied in order to balance risk and return of alternative crop-production plans. Therefore, portfolio analysis requires the inclusion of the normal range of risky crop activities. Risks comprise the probability distribution for each crop activity and the stochastic dependencies between crop activities. In practice, the complete stochastic independence may be the exception rather than the rule (Hardaker et al., 2004).

Most decision problems in agriculture, like the crop planning decision problem, involve a number of risky activities. Specifying the joint distribution of crop activities adequately is nearly always a difficult job in portfolio analysis. Capturing the joint distribution inadequately produces results that are significantly in error and perhaps seriously misleading. Another problem of specifying the joint probability distribution is the methodology by which it is built into the portfolio model.

Markowitz (1952; 1991) and Freund (1956) showed that quadratic risk programming (QRP) can be used to maximise the expected income of a risk-averse decision-maker subject to a set of resource and other constraints. The joint distribution is assumed to be appropriately described by the multivariate normal distribution. This is particularly convenient because it only requires a vector with the means and the variance-covariance matrix of the net returns per unit of the possible crop activities. However, normality assumptions of crop-related yields and prices, and thus revenues and net returns, are constantly under debate. In addition, covariance or correlation coefficients measure the overall strength of the association, but give no information about how that varies across the distribution. As an alternative, a non-parametric risk-programming method is free of distribution assumptions and includes the joint distribution by means of so-called “states of nature” (i.e., a finite number of specific combinations and probabilities of possible outcomes). Utility-efficient programming (UEP) (Lambert and McCarl, 1985; Patten et al., 1988) is one of the non-parametric methods applied in farm portfolio analysis (e.g., Pannell and Nordblom, 1998).

Parametric and non-parametric approaches specify the input distribution alternatively and this may affect the decisions supported along the efficiency curve, for example as a result of how the down-side risk is approximated. The goal of this study was to capture the joint stochastic distribution in alternative ways and subsequently to test its impact by means of alternative portfolio modelling approaches. The non-parametric approach (UEP) in this study and was compared with the parametric approach (QRP) by applying the stochastic efficiency with respect to a function method. Risk gradient value (RGV) was applied to compare the potential diversification possibilities within each approach. RGV is defined as the amount of lost gross margin per euro reduction of its standard deviation (Kobzar, 2006). A lower RGV represents a lower expected cost of risk offset with the change in diversification.

Materials and Methods

Data – materials

The application was framed using farm-specific information of a Dutch arable farm, with cultivated area of 40 ha, that produced the following main crops: winter wheat, spring barley, seed potato and sugar beet. Cereal crops (winter wheat and spring barley) were restricted to a maximum of one-third of the cultivated area; tuberous crops (sugar beet and seed potato) were restricted to maximum three-quarters of the cultivated area because of the rotation requirement. Most field operations have to be performed within a certain period of time. To take into account the peaks in labour and machine use, the year was divided into time periods of two weeks

(Kobzar, van Asseldonk and Huirne, 2004). The amount of fixed labour was assumed to be 2.5 labour units (around 300 h/month).

Model optimisation

The non-parametric optimisation is based on a state-contingent programming model with different numbers of iterations (five and hundred). In this approach the joint distribution is defined by the probability distribution of states of nature that are derived from de-trended gross margins of each activity observed in consecutive years. It was assumed that each state of nature has the same probability, so the occurrences were divided by number of observed years per farm. The parametric optimisation was based on a QRP, where the multivariate normal distribution was parameterised with the mean values and variance-covariance matrixes of the de-trended gross margins. Table 3.13.1. depicts the initial assumptions on which the optimisations were based. The main characteristics, for instance, of the non-parametric approach

Table 3.13.1: Descriptive comparison of the inputs of the alternative portfolio approaches

Portfolio approach	
Non-parametric (UEP)	*Parametric (QRP)*
-observed states	-vector of mean values
-probabilities	-variance-covariance matrix
-no assumption about functional form of joint distribution	-joint distribution is assumed to be normal
-stochastic dependency is taken into account by states of nature	-dependency between inputs is specified by variance-covariance matrix
	-stochastic dependency is taken into account by means of correlations, but it does not give any information on how it varies across the distribution
-activities' individual distribution is specified by the observed states	-activities' individual distribution is specified by their means and variances

is that the modelling is based on observed states and the probability values of the states and there is no assumption about the functional form of the joint distribution. The parametric approach, however, is based on a vector of activities' mean values and the variance-covariance matrix, and the joint distribution is assumed to be a multivariate normal.

In the both approaches a negative exponential utility-function was applied in order to include the absolute risk-aversion coefficient (Lien and Hardaker, 2001; Hardaker et al., 2004b, pp. 102-114). It is difficult to quantify the degree of risk-aversion of a decision-maker and to specify a person's utility function. There is no good method of eliciting values specifying such an individual's utility function, including the risk-aversion coefficient (Hardaker et al., 2004, pp. 100-104, 113-118). The major problem is the inadequate introspective and mental capacity of individuals to quantify their degree of risk-aversion. An alternative is to make some assumptions about the nature of the utility function, thereby avoiding the need to elicit a specific function. Some straightforward assumptions have to be made about the risk aversion value used for each individual farm (Pratt, 1964). Following this approach we defined the values of expected utilities within the range of different risk-aversion levels. For the calculation we considered a range of risk aversion from the lowest value representing a farmer who is approximately risk neutral, to the highest value for the most risk-averse farmer considered.

Results

Table 3.13.2. contains the main results of non-parametric and parametric optimisation approaches of the farm (the detail optimal-plan results of each approach are not presented due to the space limitations). Non-parametric optimisation is presented by three different numbers of states: number of states observed in the farm data, 5 iteration and 100 iterations. Parametric approach is based on the parameters in the farm data observed (mean, standard deviation and covariance matrix). Each optimisation includes the utility function on the different risk-aversion levels. In the table the expected gross margins of the minimum (least risk-averse

Table 3.13.2: Default results from the farm

Model	Non-parametric						Parametric	
	number of states observed		5 iterations		100 iteration			
Risk aversion	Min	Max	Min	Max	Min	Max	Min	Max
Gross margin (000'€)	95	80	82	74	94	79	95	80
Standard deviation (000'€)	124	62	160	81	124	62	111	56
Risk gradient value	0.25		0.11		0.24		0.27	

farmer) and maximum (most risk-averse farmer) risk aversion levels are presented. Standard deviations are presented on the each risk-aversion level. The risk gradient value shows that the lowest cost of risk offset with the change in diversification is expected in the non-parametric approach with 5 iterations.

Conclusions

This paper compares two different approaches (non-parametric and parametric) of whole-farm portfolio optimisation using individual farm data. The impact of this study is that it clarifies two problems of portfolio analysis. The first is the specification of joint probability distribution in portfolio analysis. The second problem is the inclusion of joint probability distribution in the portfolio analysis.

The main conclusions that can be derived from this study are:

- *In terms of response to change of risk-aversion level:* the expected results of optimisation exhibit smoother change in the non-parametric method (changing at each point of the Ra-interval), while they change only step-wise and at a limited number of Ra-levels in the parametric method. This can be explained by the fact that the variance-covariance matrix is a simplification of real the stochastic relationships. Since this matrix embodies a farm-specific joint distribution, it is essential to have genuine values in parametric programming. Consequently, in such a way all unrealistic results of this method can be resolved by the matrix.

- *In terms of the extreme points of the risk-aversion level:* the parametric method responds essentially to the data with high values of standard error in variance, and that is why, depending on the input data, it may produce some extreme results ("drops" or "jumps"). On the whole, the parametric method produces extraordinary results especially at extreme values of *Ra* (minimum or maximum), while the non-parametric always gives a result more or less attached to the average values of activities.
- *In terms of the optimal plan:* the non-parametric method often includes a crop with the highest mean values, while the parametric method may include a crop with a lower variance at the maximum possible rotation level, unless the crop has the lowest mean value; therefore the certainty equivalent and expected gross margin can be lower than at the non-parametric equivalent

It is not justified to state unambiguously which method is better. One's personal belief (preferably based on the partial multivariate normal assumptions test described), experience with data-relevancy and with accuracy of assumptions determine the choice of model. If the decision-maker is sure that the given information is relevant and all states are specified correctly, then the non-parametric method is better to be applied. Non-parametric is also a better choice in the case of a data-set that is highly non-normally distributed. Otherwise, if the assumptions about normal distribution and the correlations between activities are specified correctly, then the parametric method is a good alternative.

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3.14. Enhancement of Eco-efficiency as a main direction of sustainable development

Assessment of production cycles has two main aspect: on the one hand, the integral costs of the whole production and consumption cycle (including environmental protection) should be calculated, on the other hand, aggregate human activities including negative environmental impact should be considered. Eco-efficiency indicators are most useful in this respect.

To estimate eco-efficiency two equitable indicators – the ratio *produced goods over environmental impact* and the *environmental impact over the produced goods* can be used. These are called the reverse indicators.

An increase in eco-efficiency refers to an increase of economic value at unchanged (or decreased) environmental impact. As indicated in table 3.14.1, four variants of increased eco-efficiency indicators (environmental versus economic result) can be defined.

- *An increase in eco-productivity* (i.e. efficiency of environmen-

Table 3.14.1: Four types of eco-efficiency

Ratio	Goal	
	Productivity increase	Environmental state improvement
Economic versus environmental indicators	Total production per unit of aggregate environmental impact costs or *environmental productivity*	Sum of costs incurred per unit of environmental state improvement indicator (averted damage)or costs of environmental state improvement
Environmental versus economic indicators	Environmental impact indicators (ecological-economic damage) per unit of production or *environmental intensity*	Improvement of environmental state per unit of costs or *environmental cost-effectiveness*

tal impact);

- *A decrease of nature intensity* (i.e. a decrease of costs of natural factors);
- *An increase in the efficiency of environmental costs* (i.e. better state of the environment per unit of environmental cost);
- *A decrease in environmental specific costs* (i.e. costs per unit of environmental state improvement).

The increase in efficiency is one of the key success components in business. Enterprises constantly seek ways to improve their efficiency.

Figure 3.14.1. summarises the main instruments, which are effectively used in the framework of modern environmental and economic policy to increase the eco-efficiency (Ekins, 2005).

Eco-efficiency (*EE*) refers the idea to realise more goods and services using less resources. EE is defined as:

$$EE = P_e / B_{n,} \qquad (3.14.1.)$$

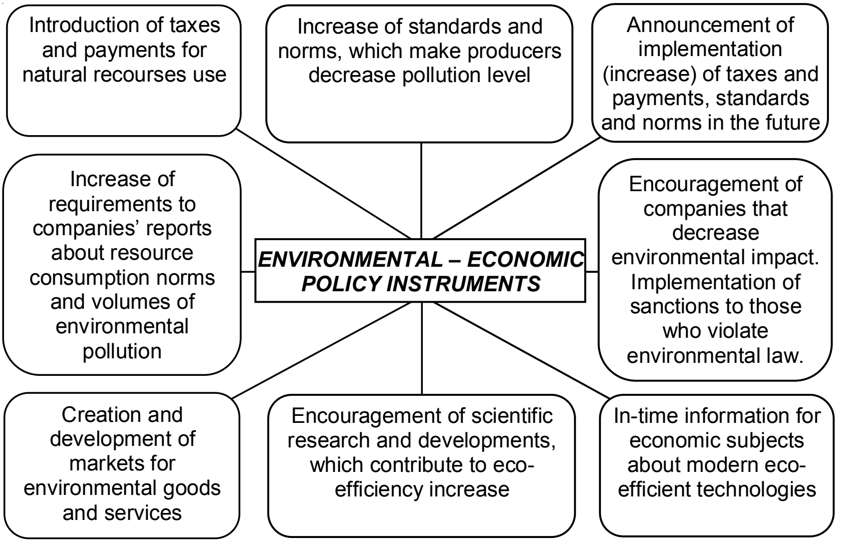

Figure 3.14.1: Instruments for Environmental – Economic Policy

where

P_e is the economic result (the additional value of produced net goods, additional profit etc.);

B_n - an estimation of the environmental impact (in particular, the amount of consumed natural goods and their monetary value, economic environmental damage).

The basis to evaluate eco-efficiency is the integral material intensity indicator *(M_u)*

$$M_u = \frac{\sum M_i}{\sum S_i} \qquad (3.14.2.)$$

where

$\sum M_i$ is the input of material costs (natural raw materials) in the production process or production chain; and $\sum S_i$ is the quantity of services provided (produced goods). The inverse ratio $\sum M_i / \sum S_i$ is the conditional equation for *natural-resource efficiency* or *eco-efficiency*.

The integral material intensity analysis (or M_u – analysis) allows to identify more effectiveness of goods: in other words *dematerialization* of the economy. This allows to address environmentally dangerous *outputs* (emissions, discharges, wastes etc. at the end of production process or consumption) in relation to the flow *inputs*.

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3.15. State regulation of business development within sustainable development framework

Entrepreneurial structures are market institutions that secure economic growth and ensure meeting the goals social development goals. At the same time, activities of entrepreneurial structures cause misbalance in the internal relationships of the "human being – nature" system that lead to global environmental crisis. That

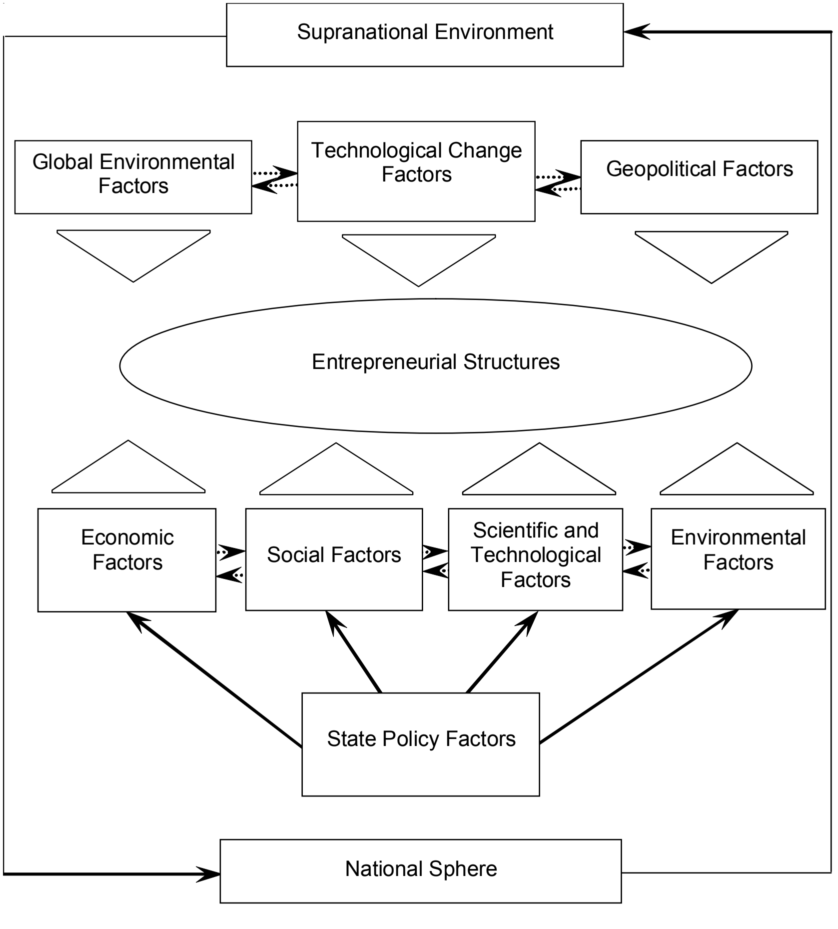


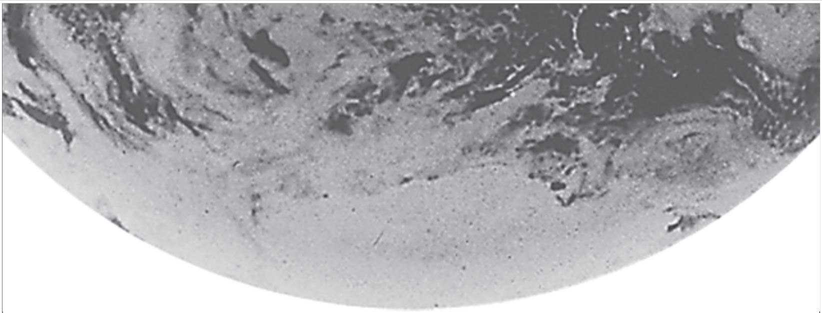
Figure 3.15.1: Relationships within "Environment – Entrepreneurs" system

is why regulation of economic activity is a priority task for sustainable development provision.
Entrepreneurial structures function in the environment formed by the two groups of factors: supranational and national (Fig. 3.15.1).

International (global) processes that impact the biosphere, global scientific and technological changes, world economic development, international relations, cultural component of the global society, etc. belong to ***supranational factors***.

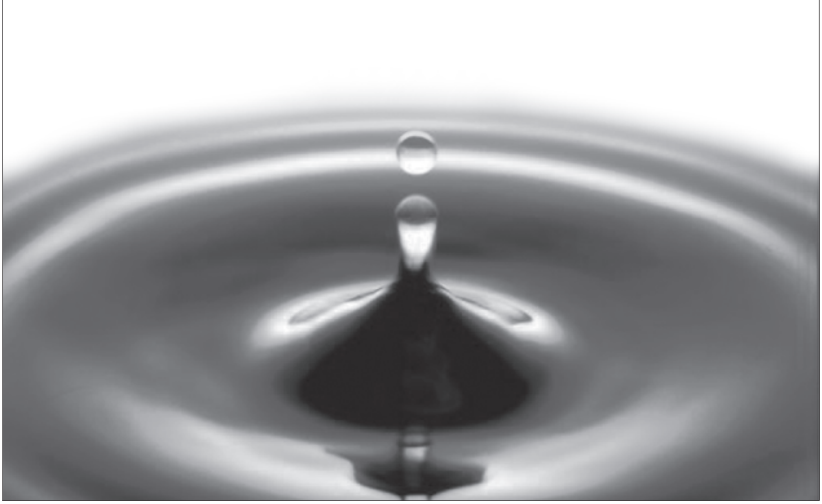
Processes that form entrepreneurial environment inside a country belong to ***national factors***. The key processes among those are economic, social, environmental, scientific and technological. Most of them are determined by the state policy.

Adoption of sustainable development concept in a country is made by the government via adapting and changing the social and economic environment where entrepreneurial structures function, setting rules, norms and standards, as well as guarding the interests of market players, etc.



PART IV

ECONOMIC DIMENSION OF SUSTAINABLE DEVELOPMENT (ISSUES OF ECONOMIC TRANSFORMATION)



4.1. Reproduction mechanism of sustainable oriented transformation of economy

Success in sustainable management of human civilization development greatly depends on human ability to effectively transform economic systems towards their permanent perfection and a decrease of nature intensity of conditional production needed for human life-support. From now on, this process of economic transformation for sustainable development will be called *ecologization ("greening")*. This process is a form of an integral system that stipulates permanent reproduction of basic factors of production factors including material basis, hardware and people, as well as managerial methods.

Transition of post-soviet countries to market economies necessitates the need to treat ecologization issue of public production, and to analyze all complication and variety of communications of complete production cycle and public consumption in a new way. In market systems, people's needs are the major incentive for social development in general and production in particular. In "supply – demand" framework, is a demand side that determines a long chain of supply.

In industrial technological society, that has reached climax, the productive sphere is considered to be the main point in public life. It is this sector that determines current political, economic, and social processes. Human beings work with this in mind frequently forgetting that economy is only a means. Frequently, motivation of economic activity is not based on physiological needs or social interests. Very often, this damages human health, as well as, spiritual development and personal happiness. Transformation of the countries of the former-socialist block looks at the problem of "greening" of social production in a different way. They analyze the complexity and variety of the relationships through production cycle and public consumption. In market systems, people's needs are the main driving force of social development and production. The "structure" in the so called "demand-consumption market structure", is considered to be a powerful engine, which propels the long chain of decisions.

The "greening" of the national economy implies a targeted process of economic transformation aimed at reduction of the integral ecological impact of the processes of production and consumption of goods and services on the environment. "Greening" is realized through a system of organized measures, innovations, restructuring of sectors of production and consumption, technological conversion, rationalization of the use of nature, and transformation of environmental protection activities at both – macro- and micro-levels.

Greening of Industry and Commerce might be considered as a function of a system which continuously reproduces interaction of the system's elements (figure 4.1.1.):

(1) the reproduction of green needs;
(2) the reproduction of green technological basis;
(3) the reproduction of green labour factors;
(4) the reproduction of motives for "greening" production and trade.

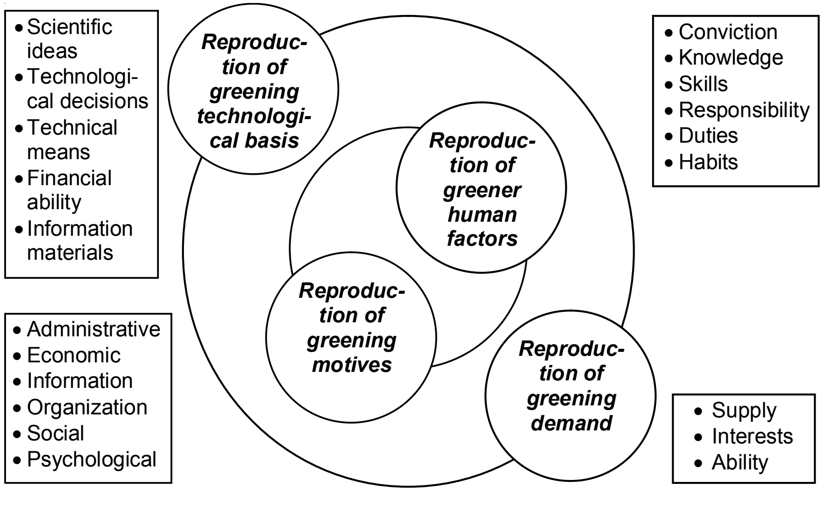


Figure 4.1.1: Mechanism of reproduction of greening economy

“Greening” of demand. Reproduction of sustainable (“green”) demand is defined as permanent process of shaping the needs for sustainable goods, as well, as formation of financial possibilities for realization of identified needs. Sustainable goods are considered to be products and services that contribute to mitigation of integral ecological impact per unit of aggregate public product.

Furthermore, when speaking about reproduction of ecological needs we have to formulate the required economic conditions for “greening” of the national economy.

Firstly, the reduction of the material-energy flows of consumed goods must not lead to the lower quality of service from a standpoint of person’s vital needs. Otherwise, unpredictable compensational flow of goods and services for patching up the “breaches” in consumption standards can occur. Production of these goods can lead to minimum ecological successes.

Secondly, refusal from the use of ecologically non-friendly products must be compensated by increase in the use of more ecologically friendly goods. It is necessary to meet the condition – total volume of sold goods and services (in monetary terms) as well as their production must not be reduced. It is very important because production is only one side of human activity in modern world. Even a small decrease in numerous inter-connections can lead to considerable social-economic consequences, including a decline in living conditions and an increase in unemployment. In addition, a decrease in national income can weaken the technical-scientific potential, reduce the budget of different sectors and, can worsen ecological problems. So, the demand for reproduction of the sustainable commodities is the leading link of “greening” the economy.

Finally, demand for sustainable goods must result from three interconnected economic elements: needs, elements, and possibilities. *Needs* are motives for consumption of goods that have been realized by people and communities. *Needs* are transformed into *interests*. *Demand* is undermined by financial capability, and the ability to pay for goods and services.

It is possible to identify four stages of development of sustainable needs.

1. The first stage is associated with the means of control of environmental destruction («the end of pipe»).
2. The second stage is related to environmental improvement of technology («wasteless technology»).
3. The third stage is associated with substitution of undesirable goods and service by "greener" ones («more efficient goods»).
4. The fourth stage is associated with production and consumption of goods for sustainable development («sustainable life style»).

Evolution of greening cycles of production and consumption of various products can be divided in two possible stages of development.

(1) Greening of individual components of production-consumption cycle: production, packaging, communication, storage, trade, consumption, waste disposal.
(2) Transition of economic systems from production of individual (separate) material benefits and services to formation of life-prosperity.

The "life-beneficent complex" is regarded as a destiny for human life, and as an aggregate system of material objects, cultural values, information, and natural ecosystems which ensure prosperity, as well as physical and spiritual development of people.

"Greening" of supply. Reproduction of a sustainable production is considered as generation of scientific ideas and information as well as formation of technical means which are needed for the development of green production. Social, economic, and technological causes for "greening" should and can be formulated. Social causes emerge when social interests, cultural values, and private interests of people facilitate the development of ecological needs. Economic causes are set in motion when economic conditions and organizational mechanisms make the supply of "green" goods and services profitable. Technological causes arise when there exist sufficient technical means for realization of ecological needs in production.

"Greening" people and motivational instruments. *Formation of sustainablly oriented people* is considered as a continuous process of training, education and experience that provide the required information, knowledge, skills, and desire for "green" production and consumption.

"Greening" of production includes the following:

- Selection of employees with certain qualities.
- Personnel education and training.
- Ecological training and retraining.
- Development of legal standards.
- Activity regulation.
- Development of a system of rewards and penalties.
- Information.
- Control.

Motivational instruments for "greening" imply permanent facilitation of organizational, social and economic conditions, which promote the desire to achieve goals of the economy's "greening". Motivational instruments involve a system of administrative, ecological and social-physiological factors. The following are some motivational instruments in well-developed countries.

The policy and strategy of "greening". Specification of "greening" allows us to formulate local objectives for transformation of the national economy as follows:

- Restructuring of the economy.
- Restructuring of enterprises.
- Removal of needs with respect to not environmentally friendly products or services.
- Change of ecologically non-friendly technological processes.
- Lowering of the resource capacity of the products.

The principles that must be used in the process of "greening" the economy include:

- Integral approach – it stipulates the necessity to take into account all effects within the cycle of production and consumption of goods.

- Orientation according to the causes – it addresses the causes, not the consequences.
- Division of responsibility – it identifies the impact and the degree of eco-destructive activity.
- Formulation of motivational instruments under given conditions.
- Systems approach – it identifies direct and indirect influence on all objects and subjects of "greening" the economy.
- Maximum efficiency – it stipulates achievement of the goals of "greening" with minimum expenses and maximum return.

Consideration of the above mentioned principles along with the analysis of criteria of eco-destructive influence of the production-consumption cycle allows formulation of the main directions for the "greening" of the national economy (figure 4.1.2).

Evidently one can foresee the following main stages of the evolution of ecological needs. The first stage is associated with the development of the means of environmental protection from the processes of its destruction (pollution). At the second stage, priorities will be given to a substitution of ecologically non-friendly goods and services by ecologically friendly ones. There are three main strategies of "greening" the economy.

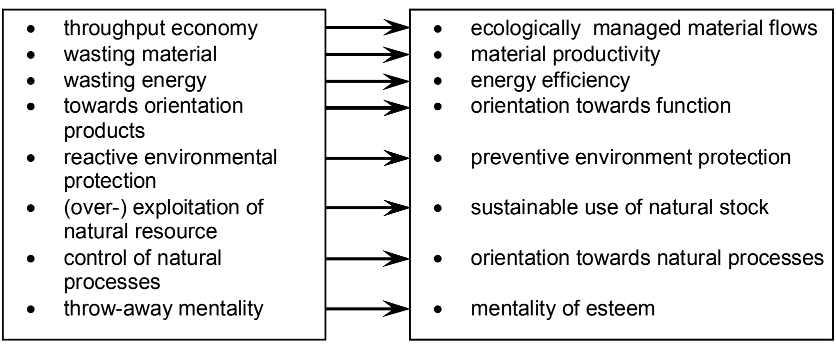


Figure 4.1.2: Conceptual directions of the development of environmental tasks (Oosterhuis, 1996)

- Influence on supply, "pull-strategy" the "production-consumption train". Influencing the supply, one can pull the links of "greening" production. The essence of this strategy lies in the necessity to convince a consumer psychologically and economically to use ecologically friendly products.
- Influence on demand, called "push-strategy". The essence of this strategy is to create a system of motivational influence (ecological standards, economic instruments, information supply) which will push the producer to manufacture "green" products.
- Influence upon the communication between producers and consumers, called "interface-strategy" (as in figure 4.1.3).

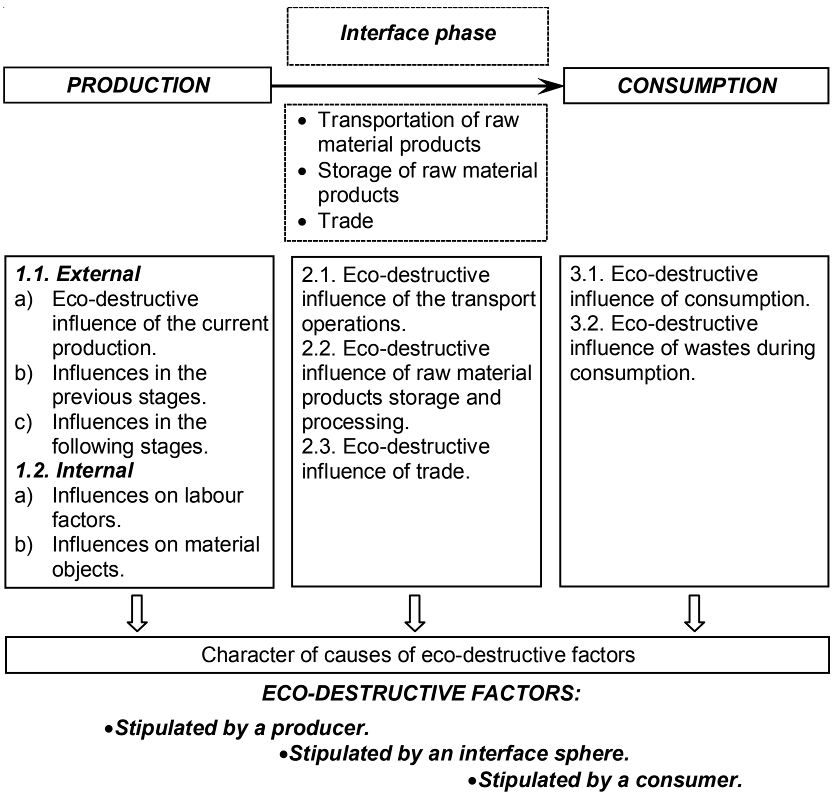


Figure 4.1.3: Formation of the eco-destructive factors in the main phases of the production-consumption cycle

In “greening” the economy the intermediate links are the producers and consumers. The following are the ways of this strategy realization: the use of influential communication, mechanism for “green” trade and marketing research, and development of information systems. The use of this strategy has given an opportunity to some countries to solve very important environmental problems. The embargo on trade of rare animals and goods saved wildlife in a number of African countries. Japan managed to clean its streets and towns by introducing strict non-tariff barriers (ecological standards) on imported means of transport. Ukraine also has a list of toxic and dangerous wastes, import and transit of which are forbidden. Any country that uses these three strategies has a good chance of real success in “greening its economy”. Although, a great number of economic categories have been mentioned, nonetheless basic content of different sides of the production-consumption cycle is a common factor for all these categories. Man is considered to be within this factor. Speaking about the “greening” of supply, demand, trade, and communication, means the “greening” of the relations between people. The “greening” of production and consumption can only be realized through people, labour, skills, and desires.

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4.2. Environmental effects of economic decisions

Economic efficiency, is one of the keys to sustainable development.

Evaluation criteria of intervention in natural production address the three primary goals of sustainable development:

1) Preservation of *ecosystems* including *different* taxonomic levels, gene pools and ecological webs.
2) Maintenance of favorable social conditions *for human life* and the surrounding biological species.
3) Preservation and (if possible) extension *of the nature-resource potential*.

These criteria are mainly targeted using standards. Standards are mainly formulated at three levels:

The first level is about ***nature protection***. These standards regulate thresholds of human impact on health and nature. These standards target dangerous changes in humans and ecosystems.

The second level of *standards* is about ***environmental-technical and environmental-technological standards***. These standards are about impacts on ecosystems and on best available technology. Examples of this second level are: a) maximum permissible emissions or discharges.

The third level is about ***environmental-economic and socio- economic standards***. *These are the* preconditions to meet the standards of the previous levels. This level is about standards related to the environment-economics interaction (payments, taxes, duties), and bans and restrictions at work.

Territorial division according to environmental capacity allowed the Council for utilization of Productive Resources of the National Academy of Sciences to perform an integral evaluation of relative potential of natural assimilation of Ukrainian economic regions (Tab. 4.2.1).

Table 4.2.1: Index of Regeneration of Natural Landscapes of Ukrainian Regions

Regions	J	Regions	J
Vinnitsa	0,62	Chernigov	0,59
Ternopol	0,65	Odessa	0,41
Khmelnitskiy	0,61	Nikolaev	0,31
Kiev	0,59	Kherson	0,23
Cherkassk	0,63	Poltava	0,71
Kirovograd	0,49	Sumy	0,71
Chernovtsy	0,63	Kharkov	0,54
Zakarpatye	0,78	Donetsk	0,39
Ivano-Frankovsk	0,73	Lugansk	0,38
Lvov	0,62	Dnepropetrovsk	0,31
Volynsk	0,52	Zaporozhye	0,29
Rovno	0,52	The Crimea	0,38
Zhitomir	0,50		

Ability of natural environment ability to reproduce and regenerate makes a certain economic sense. Therefore, allocation of production and its waste disposal increases general efficiency of spending, if it is done according to environmental capacity of a territory. Environmental capacity is associated with assimilative properties landscapes, which define a degree of wastes utilization as well as reproduction functions of landscapes. Therefore, the ability of natural and anthropogenous landscapes to assimilate different types of technogenic compounds determines environmental and economic capacity of a territory through an opportuto allocate different types of economic activities and their wastes under condition of certain state of nature limited by environmental standards.

4.3. The Belgian experience in "greening" urban economy

The complex of actions currently carried out in the city of Geraardsbergen (Belgium) can serve as an example of "greening" urban economy. All implemented actions here are divided into 7 basic directions (clusters), according to the following activities.

The first cluster is conditionally called "General questions". It has organizational character and involves broad public to implement simple and accessible actions in order to decrease contamination level of the environment by household waste products. The goal of such actions is an increase in knowledge and ecological literacy of the population, as well as environmentally motivated behaviour with respect to their everyday life and nature. It also promotes the re-use of basic municipal wastes such as paper, glass and others.

The second cluster is associated with a system of management of the so-called conditionally solid wastes, pesticides, etc. It includes wastes collection and sorting. Each household is notified in advance by means of a schedule when and what kinds of wastes will be picked up.

The third cluster is "energy saving" and includes a complex of actions associated with energy saving. In particular, the use of insulating materials in construction, energy saving windows and lamps are promoted.

Among implemented economic tools, it is possible to mention payments to owners of houses for energy saving activities; 2 euros per 1 m^2 of the total area of energy saving windows (due to a decrease of heat emission below standard level); reduction in tax payment, if a house owner invests in heat insulating house (for example, if 1000 euros are invested, the tax decreases by 40%). If a group of houses jointly save energy, they can receive a gift from municipal authorities (for example, a sport ground, a children's playground etc.), in terms of extra infrastructure.

The fourth cluster is "water consumption". It involves water saving and pollution prevention activities. Since, water is a source of life for all living creatures, formation of skills and habits of water-saving as well as keeping it clean is very important. This is the reason for promotion of simple and accessible ways of economical and rational water use.

The fifth cluster is "physical impact". It includes education of public with respect to importance of light, noise pollution, radiation and vibration. Since a human being receives 90 % of information through eyes, the appropriate use of light is of great importance.

The sixth cluster is "a healthy lifestyle". It promotes mobile lifestyle. The so-called healthy lifestyle groups are being formed. These groups are engaged in walking, jogging and exercising, which is also rewarded. A person, who walks for 5 kilometers per day, is paid 15 cents per every kilometer.

The seventh cluster is called "greening of the environment». It is aimed at the maximal greening of streets, decorating of balconies and house roofs with flowers, planting of bushes and trees in gardens and parks, and also building of fountains that use rain fall.

Belgium not only declares, but also actively participates in solving resource-ecological problems, investing in environmental protection programs to achieve sustainable development and environmental safety. It is one of the cleanest European countries. All its 39 beaches completely comply with the EU standards. In Belgium capital, the city of Brussels, fuel station with environmentally clean fuel, bioethanol A85 was opened. This fuel is a mixture of 15 % of gasoline and 85 % of biomass made of beet or cereals.

4.4. Economic instruments for preservation and restoration of biodiversity

Economic instruments of environmental policy aim to financially motivate individual or group behaviour that is considered in public interest[1]. Economic instruments may stimulate ***negatively***, so that individuals and organizations abstain from doing something (for ex.: fees for discharging polluted water into the river). On the other hand, economic instruments may also motivate ***positively***, so that individuals and organizations carry out some beneficial activity (for ex.: subsidies for restoration of natural elements). The use of economic instruments should be ***economically more efficient*** than the use of legal instruments. In this chapter, we consider economic instruments that have influence on biodiversity.

Economic Instruments of Environmental Policy with Indirect Positive Influence on Biodiversity. Some economic instruments of environmental policy aim to protect air, water or soil. These instruments have also an indirect positive influence on biodiversity. Among these instruments are included: fees for discharge of polluted water, fees for discharge of air pollution, transferable rights (of pollution, of construction development), fees for construction development on forest and agricultural land, various public expense programs and ecological tax reform[2]. The indirect positive influence on biodiversity is mediated through improvement of habitats (for ex.: river, in case of water pollution fees). Or, these instruments discourage elimination of habitats (for ex.: forests, in case of fees for appropriation of forest land for construction).

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[1] The people in transitional economies in East and Central Europe may consider the term «public interest» rather suspicious, since it brings up memories of «societal interests», a concept that was seriously abused by the former political regimes. However, because of existence of «public goods and services» in free-market societies, it seems rational that there exists also «public interest» in their optimal use. Biodiversity is considered largely «public goods» in most of theoretical works, since it is difficult to assign property rights to it.
[2] A complex instrument whose main principle is the shift of tax burden from taxing labour to taxing pollution and use of non-renewable resources.

Perverse Subsidies: Economic Instruments with Harmful Effects on Biodiversity. The term *perverse subsidies* describes economic instruments that work against the goal of sustainable development. In some cases, governments subsidize activities that damage the environment. At the same time, governments develop programs to remove or reduce these damages. Originally, certainly, all is financed by the tax-paying citizens and companies. Most of the perverse subsidies are in the sectors of energy, transportation and agriculture. Identification and elimination of perverse subsidies should accompany an efficient introduction of economic instruments for conservation and restoration of biodiversity.

Expense Programs Directly Related to Biodiversity Conservation and Restoration. Among *economic instruments that are directly related to biodiversity conservation and restoration*, we can list the following *public expense programs:*

- Compensation for Damages Caused by Selected Species of Animals
- Rescue Programs and Specie Management Programs for Plants and Animals
- Landscape Management Programs (some parts)
- Agri-environmental and Forest-environmental Programs (some parts)

Compensation for Damages Caused by Selected Species of Animals. Some countries employ this economic instrument in order to protect selected species of animals. A compensation is given to the farmer, fish pond owner, forester or another subject that proves that the damage to his property has been caused by a particular specie of a wild animal. This measure supports conservation policies in the countryside, and in some cases, it helps to limit illegal killings of wild animals. The selected wild species may vary among different countries. However, carnivores such as medium-size beasts (lynx, wolf) and large-size beasts (bear), as well as animals problematic from the fish pond production viewpoint (otter, cormorant) may be included in this measure, as well as beaver and elk. Certainly, this measure is usually rather expensive for the public budget, therefore only animals that are critically endangered in the given country are included.

Rescue Programs and Species Management Programs for Plants and Animals. ***Rescue programs*** may be often incorrectly identified with nature conservation in general, even though they form only a small part of nature conservation efforts. The focus of modern nature conservation has shifted from ***species' conservation*** to ***natural areas' conservation***. It makes no sense to declare legal protection for a specie if the specie has no area to live in. Simple prohibitions of killing of animals are not sufficient to avoid extinction if the animal has no suitable biotope where it can feed, take shelter and raise offspring. Moreover, area conservation takes care also of variety organisms about which the scientists have insufficient knowledge. This is important especially for many invertebrates and less conspicuous species. Therefore, area-oriented (land-based) conservation is the basis of modern nature conservation efforts[3]. However, protection of individual species supports me effort of area-based conservation. The species-oriented conservation uses both legal and economic instruments. The legal protection of a specie is sometimes supported by an economic instrument called "rescue program". This program usually provides for financing and implementation of various measures that are focused on individual specie. Among these measures may be: artificial reintroduction of a specie to an area from which it has previously disappeared, artificial breeding of animals in captivity for the purpose of reintroduction, artificial growing of plants in sheltered conditions for the purpose of reintroduction,, conservation-oriented research, educational activities directed at the public, etc. Sometimes, these programs are targeted at species that need special kind of measures which cannot be provided in area-oriented conservation. While rescue programs are often funded and managed by governments, non-governmental institutions and private donors may be involved as well.

We need to distinguish ***rescue programs*** from ***species management programs***. Rescue programs are usually targeted at species that are at risk of extinction in a particular country, or region. On the other hand, *specie management programs* may be tar-

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[3] Declaration of *protected areas* (national parks, natural reserves, etc.) are the usual start of *area-oriented (land based) conservation.*

geted at species that are beyond risk of extinction, on contrary, their numbers may be on increase. The peregrine falcon and the lynx are examples of species that had their *rescue program* in several European countries. The European beaver is an example of a specie whose numbers are on increase, and who is a *subject of species management program* in some countries.

Landscape Management Programs. Important economic instruments that we call ***landscape management programs*** exist in various countries under different names. Landscape management programs are oriented on the whole biotopes, not on individual species. Landscape management provide for financing of regeneration and revitalisation of natural places and processes. An example may be ***creation of natural landscape features*** (planting of alleys of native trees, natural field hedges, restoration of species-rich wet grasslands or heazlands. Another example may be ***revitalization of water streams*** (rivers, brooks) in the open landscape that got changed by human involvement. River revitalization means bringing the river closer to its original natural state, both in its channel and in its floodplain. Stream revitalization measures include recreating meanders, removing artificial concrete and stone reinforcement of banks, recreating of side channels and floodplain wetlands, replanting of native vegetation, etc. Obviously, opportunities for stream revitalization are much more limited in urbanized landscape as opposed to open landscape, however, even there some measures are possible. Significant projects in river revitalization were carried out in Europe and in the U.S.A. River revitalization programs should be coordinated with ***flood protection programs***, as well as by regular everyday ***river channel management***. Otherwise, there may be counterproductive efforts.

The landscape management programs are usually selective (the governmental nature conservation authority chooses from various projects), and the tasks may be quite complex. These programs are targeted usually at landowners, land managers, or possibly at river management public organizations. The claimant has usually no legal right to obtain this public subsidy; the nature conservation authority chooses the best project according to a set of publicly known criteria. The landscape management programs have the ***increase of biodiversity*** and the creation of habitats as one of its goals only. The other goals may be s***oil erosion reduction, water protection,*** etc.

Agri- and Forest-Environmental Programs. These important economic instruments related to agriculture and forestry are important especially in the countries of the European Union. There they form a part of the Common Agricultural Policy. However, we may find similar programs also in some non-EU countries as well (Switzerland, Canada). ***Agri- and forest-environmental programs*** relate often only indirectly to the issue of biodiversity conservation, and focus on soil and water protection. However, certain subsidy titles may be targeted directly at some animal specie or a biotope that is important from the point of nature conservation. Unlike landscape management programs, agri- and forest-environmental measures are usually relatively simple measures that can be applied widely. Another usual difference from the landscape management programs is the non-selective nature of the agri- or forest-environmental subsidy. Any farmer or forester who meets certain conditions has the legal right to receive the subsidy. Agriculture authorities usually manage the agri- and forest-environmental programs, unlike in the case of landscape management programs, which are usually a domain of specialised nature conservation authorities.

In all public expense programs, clear goals have to be set at the beginning, as well as a ***transparent method of controlling and monitoring*** the program. An independent evaluation of impacts is critical. Otherwise, inefficiency and misuse may result.

Private Expense Instruments for Nature Conservation and Landscape Protection. All the above mentioned instruments were ***public expense programs***. However, we could consider other ones. In some countries, there are some non-government initiatives that ***buy out*** land by money collected from private donations. For instance, in Great Britain, NGO initiatives succeeded in buying out large parts of land for the purpose of nature conservation and landscape protection. Also, there might be a ***buy-out*** of private land by the government and its ***hand-over*** into the management of private nature conservation organisations. However, limiting of biodiversity conservation to selected areas only cannot solve the whole issue. Some animals, like birds, are very mobile. They change places often by large distance (sometimes migrate between the continents of Earth). Attributing *ownership rights* to biodiversity presents a serious problem, therefore market-based approaches are difficult to develop in nature conservation and restoration. **Income Instruments for Nature Conservation and Landscape Protection.** The above described economic instruments belonged to the group of ***expense instruments***. However, we should consider another group of economic instruments as well – the ***income instruments***. Among income instruments let us mention the ***income fees***. Among the income fees there could be entry fees to attractive natural areas (national parks, private reserves), film and photography fees, income fees from guided tours, etc.

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4.5. Technological innovations as the basis of economic transformations

Effective transformation is possible only when it is based on the use of a complex set of drivers of progress. A key role is reserved for science, new knowledge and technology. Scientific and technological knowledge is the capital of innovation.

Concepts as “Factor Four” (Weizeker et al., 2000), point to the possibility of impressive economic growth (while respecting the environment) using technical efficiency. Improving efficiency has for some even magic aspects: Pal Pilzer calls this mystery “alchemy” (Pilzer, 1999).

The mysterious “substance”, which is beyond the modern “alchemy” that drives efficiency, and offers an opportunity to deal with the environmental problems, is *information*.

The essence of the message is that wealth is the product not only of natural resources, but of *technology* as well. Among these two, technology is the most important one.

Mathematically this can be expressed by the equation:

$$W=PT^n \qquad (4.5.1)$$

In which W is means wealth; P – natural resources, such as land, working force, minerals, etc.; T – technology, and n – the degree of technological changes that influence technology. Technology is self implicative, as each technical achievement entails the basis for the next one (Pilzer, 1999).

The key factors that relate economic transformation with sustainable development are innovations. Innovations create the prerequisites for the decrease in demand of a resource or for the substitution of one resource by another, which is more effective from an economic or from an ecological point of view. In this context economy can increase along a number of pathways:

1) An increase in the efficiency of production or consumption without the substitution of key resources (in this case the efficiency of the production process increases, the use of raw materials and the demand for energy decreases).
2) The substitution of less effective resources by more effective ones.
3) Less effective resources are substituted by more effective in social demand.

The notion “a more effective resource” is associated with the following:

- the decrease of resources, used during the product life cycle;
- the decrease of environmental quality (negative influence on the environment) during the life cycle of a product.

Functional substitution of resources. Resources substitution entails also the substitution of capital. This type of substitution relates to the fact that identical functions (in production or consumption), can be fulfilled by different resources.

Information as a resource. One of the most universal and effective resource substitutes is *information*. Technological progress can decrease the relative demand for any resource.

Structural resource substitution. This increase in efficiency is relative in character. The substitution of one resource by another doesnot happens to fulfill a concrete function, but charges the structure of the consumption of economic resource. By this new demand for resources appears and increases, and the need for the previously used resource decreases or disappears. For example, one hundred years ago there was no need for bauxite, silicon, uranium, but there was a need for ivory and rubber.

Science and technology can solve almost all global problems: birth rate, food production, resource saving, and nature protection.

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4.6. The role of information and communication technologies in achieving sustainable development

The technological evolution and information and communication technologies (ICT) have aroused much interest among policy makers, and industry, business, the media, and the academic world in the industrialised countries. ICT has transformed the lives of many, but has also left untouched the lives of many others. As result, a large segment of the world population is missing the tremendous political, social, economic, educational and career opportunities created by the digital revolution.

Communication may be defined as the sharing of ideas and feelings in a way that ensures mutual understanding. It is the process of creating, transmitting and interpreting ideas, facts, opinions and feelings.

ICT has been identified as the most sustainable tool for bridging the gap between the information-rich knowledge-based and technology driven economies of the industrialised countries (IT-encyclopaedia, 2004). ICT is a generic term used to express the convergence of information technology (IT), communications and broadcasting. Information technology encompasses all forms of technology used to create, store, exchange and use information in its various forms (networks, data, voice, still images, multimedia presentations, human resources, messages and other forms, including those not yet conceived).

As can be seen from table 4.6.1, these two characteristics of ICT support each other and create opportunities for development.

The role of ICT in SD can be described in two ways: ICT as an enabler of the production sector and ICT as an enabler of socio-economic development (UNDP, 2001). Economically speaking, ICT production and application can contribute to increase productivity, generate economic growth, create jobs, new services, markets and businesses, and promote poverty reduction. The development and deployment of ICT generate economic benefits and social sustainability through governance, education, health care, preservation and

Table 4.6.1: The Uniqueness of ICT development opportunities (Adapted from Accenture, Markle Foundation and UNDP, 2001)

ICT - pervasive & cross-cutting	Multifunctional and flexible uses for tailored solutions to meet diverse needs based on personalization and localization
ICT - key enabler to create networks	Exponential increases in benefits return as usage increases for those access
ICT - disseminating information and knowledge	Allowing remote communities to become integrated into global network and making information, knowledge and culture accessible to any one (in theory)
ICT – declining marginal costs and transaction costs	Replication of content is virtually free regardless its volume. Marginal costs for distribution and communication are near zero
ICT - efficiency gains in production, distribution	Based on capacity to store, retrieve, sort, filter, distribute and share information. Streamlining supply and production chains
ICT - new and innovative	Creating new products, services and distribution channels and innovative business models Lowering barriers and increasing competition
ICT - facilitating disintermediation	Users acquire products and services directly from original providers, reducing the need for intermediaries
ICT - global	Transcending cultural and linguistic barriers by providing ability to live and work anywhere relying on networks Integrating local communities into global network economy without nationality

exchange of cultural values, empowerment and participation. ICT applications also result in cleaner production systems, environmental protection and effective management of natural resources, disaster prevention and effective environmental education.

Table 4.6.2 presents a summary of economic impacts and opportunities created by ICT in three orders: physical existence of ICT (first order); on-going use and application of ICT (second order); and accumulative effects (third order).

Figure 4.6.1 indicates the correlation between ICT represented by Networked Readiness Index (NRI) of 2003–2004 and GDP per

Table 4.6.2: Economic impacts and opportunities created by ICT (WEF & INSEAD, 2004)

First Order Effects	***Second Order Effects***	***Third Order Effects***
Growth of the ICT market - Size of sector and numbers of employments	***Application of ICT within businesses*** - ICT creates opportunities for new efficiencies in business - ICT enables new financial markets and wider participation	***ICT and the "new economy": a new paradigm of growth?*** - Changes for a more beneficial environmental for S.D.
Ongoing investment in ICT - Investment in ICT within companies continues to grow - New types of business	***New opportunities for SMEs*** - New markets and products for SMEs	***Comparative advantages*** in ICT in different regions may create inequality in sharing economic benefits
	The relationship between business and the market - Consumers are empowered - Companies act ethically	

capita. The analysis also reveals that ICT is one of the key reasons for the European countries lag behind the United States in growth performance in recent years.

Figure 4.6.2 depicts the correlation between the percentage of internet users population and the Gross National Product (GNP) per capita. According to these studies, those countries with a big ICT producing sector and revenue from the production of ICT manufactured goods and services such as Finland, Ireland and Sweden have experienced a big contribution to GDP growth.

Figure 4.6.3 presents the contribution of ICT to labour productivity growth in the developed countries over the periods 1990–1995 and 1996–2002. The trend depicted in this figure seems more or less to correlate with the Internet presentation in figure 4.6.2.

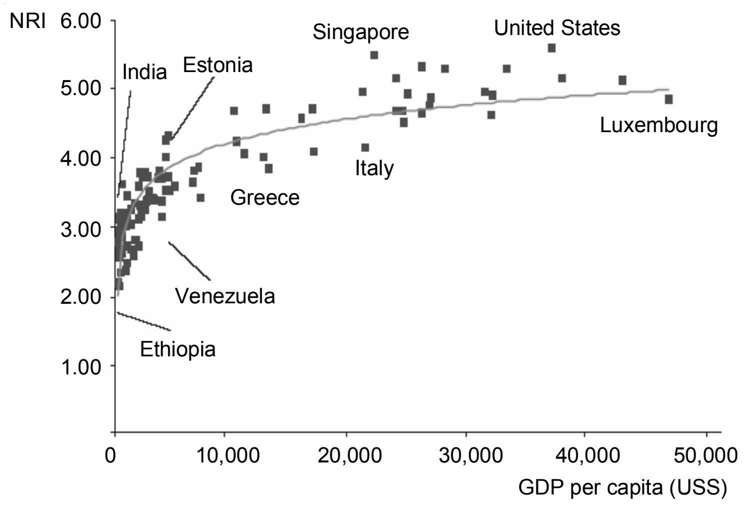

Figure 4.6.1: Networked Readiness Index 2003-2004 vs. GDP per capita, partial log regression (WEF and INSEAD, 2004)

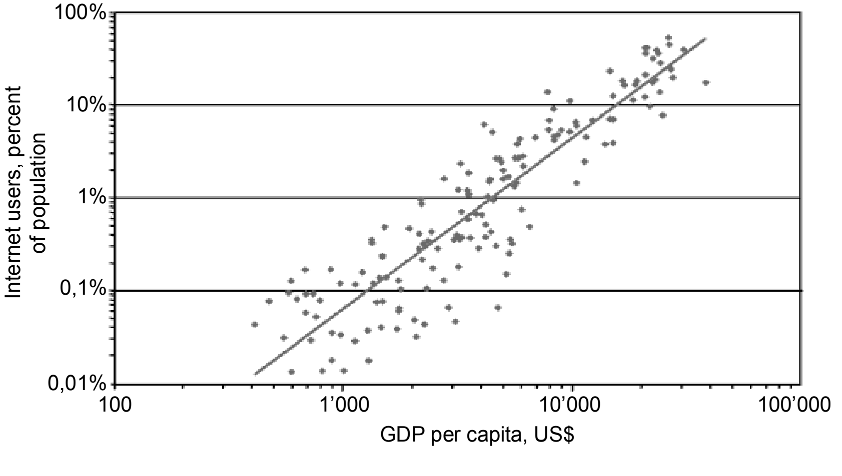

Figure 4.6.2: Internet penetration and GNP per capita (Accenture, Markle and UNDP, 2001)

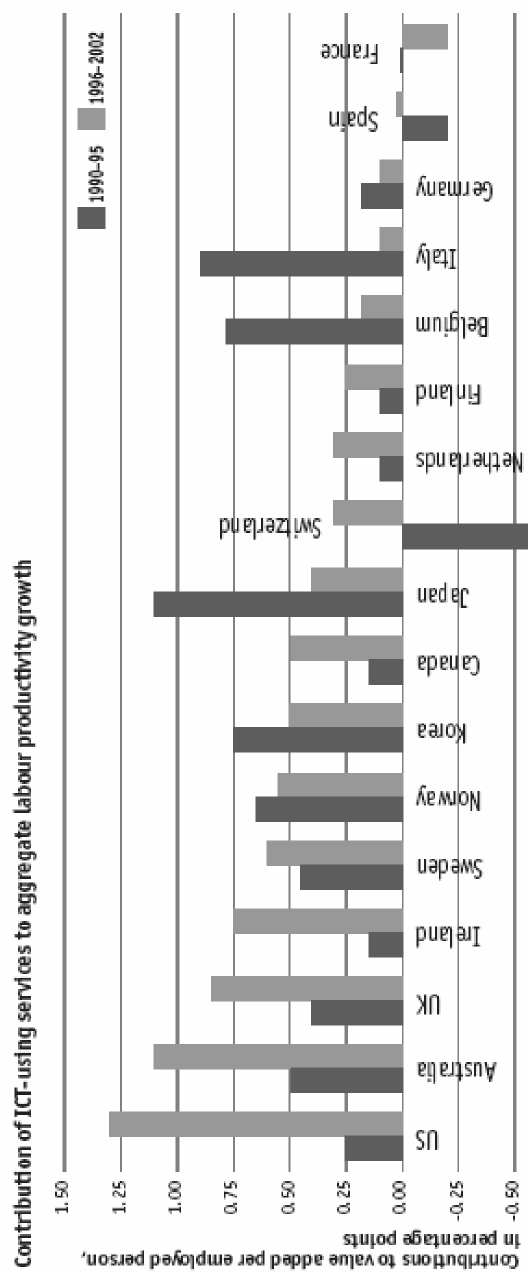

Figure 4.6.3: Contribution of ICT-using services to aggregate labour productivity growth (EITO, 2002)

Many studies indicate that SD and ICT share many characteristics in the drive by the nations of the world to change into modern economies. Both SD and ICT require people to rethink the nature of goods and services and the capacity to transform the relationship between governments, companies, citizens and consumers.

For example, promoting ICT applications for rural development and poverty reduction, the USAID introduced the Agricultural Knowledge System (AKS) approach, an ICT based framework consisting of the organizations, sources of knowledge, methods of communication, and behaviours surrounding an agricultural process in order to meet the needs of small farming households (Winrock International, 2003). The model of the AKS framework is depicted in figure 4.6.4. The model demonstrates how different ICT tools such as the web/t Internet, email, TV / radio, CD-Rom, and phone are used to help farmers to approach various institutions at different levels to access information and services on a wide range of issues related to land use, market organization, credit, education, health care, etc.

The World Summit on Information Society (WSIS) which was launched in December 2003 (phase 1) in Geneva (Switzerland) may be regarded as the first international event relating to engaging ICT and SD. Bringing national leaders to discuss "Building the Information Society: a Global Challenge in the New Millennium", the WSIS produced a good Declaration of Principles.

This Declaration confirms that the WSIS is working in conjunction with or is following up on the commitment to achieving SD. It agreed to development goals defined in the Johannesburg Declaration and Plan of Implementation (POI). The Declaration also stresses the exploitation of ICT potential to achieve the eight Millennium Development Goals (MDGs) of the Millennium Declaration. These include the eradication of extreme poverty and hunger; achievement of universal primary education; promotion of gender equality and empowerment of women; reduction of child mortality; improvement of maternal health; to combat HIV/AIDS, malaria and other diseases; ensuring environmental sustainability; and development of global partnerships for development. With regard to sectoral impacts, the WSIS Declaration recognises that

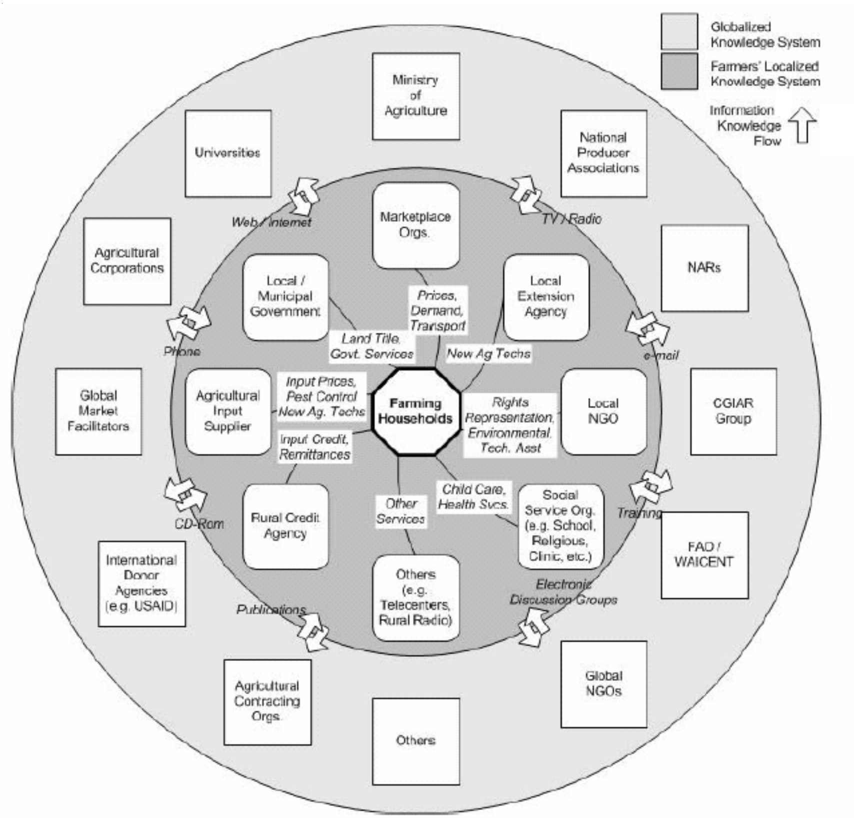

Figure 4.6.4: Globalised and localised agriculture knowledge system surrounding a typical farming household (Winrock International, 2003)

ICT applications can support SD in the fields of public administration, business, education and training, health, employment, environment, agriculture and science within the framework of national e-strategies.

Conclusion

The ICT industry in the world has experienced tremendous developments in over the past few decades and has influenced all aspects of human life. The emerging information society and knowledge economy are developments that reflect the progress and impacts of ICT on economic growth and social change. In various fields like agriculture, health, education, human resources, transport, business development and environmental management, ICT can be a key enabler and a catalyst to the development process of the world and Africa in particular.

However, it should be understood that ICT is not a panacea to progress in Africa its development policies and processes are flawed, deficient or absent. The existing social divide and the emerging digital divide between the developed and developing countries are major constraints preventing Africa from fully seizing the opportunities offered by the ICT revolution. Clearly, the current pace and direction of industrial development and economic growth in the developed world cannot be sustained without addressing the social and digital divides, poverty and environmental degradation of the rest of the world and Africa in particular. The worry about the divides is justified because the ICT revolution will continue to accelerate for many years to come.

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4.7. Management of innovative development as means of providing sustainable development of economic system

For the national economy proper innovations and innovative development are the driving forces that will establish economic independence of Ukraine and close the gap with the economically developed countries on the basis of the principle to "outstrip, not overtaking". Naturally, it is necessary to handle this process purposefully and effectively, and not only to rely upon actions of market regulators.

Management conception of innovative development of enterprises. Two types of market strategies of economic subjects are considered in general case (Economics, 2002):

1) stabilization – preserving the achieved level of production, market share, etc.;
2) development – expansion of production and market share, income increase, etc.

However, as practice shows the first one can bring temporal success, but fails to provide the long-term survival of enterprises at the market.

Development of economic subject activity and, in general, development of the national economy can be achieved in different ways (Table 4.7.1):

1) *the extensive way of development* foresees expansion of production volumes and product sales. It takes place in the conditions of the unsaturated market in absence of keen competition and relative stability of economic environment and is connected with the increasing of resources expanses;
2) *the intensive scientific and technological way of development* foresees the use of achievements of science and technology for the improvement of production technology of traditional products (modernization) with the purpose to decrease production costs and increase the product quality, and, in general, to increase the competitiveness;

Table 4.7.1: Correlation of economic growth factors for different types of economic development

Factors of the economic growth	Extensive development	Intensive development	Innovative development
Growth in production volumes	+++	+++	++
Development of productive forces	+	+++	+++
Growth of technology and product quality		++	+++
Capital growth	+++	++	++
Growth of investment	+++	+++	++
Acceleration of scientific and technological progress		++	+++
Renewal of fixed assets	+	++	+++
Economical use of natural resources		+	++
Improvement of financial indexes		++	+++
Improvement of economic activity indicators on the foreign markets		++	+++
Increase of efficiency of economic activity		++	+++
Progressiveness of management structure		++	+++
Growth of consumption share		++	+++
Thrift of production		++	+++
Improvement of social sphere		++	+++

+++ - the factor plays an important role;
++ - the factor plays a considerable role;
+ - the factor plays an insignificant role.

3) *the innovative scientific and technological way of development* foresees the uninterrupted modification of products assortments and technologies of its production as well as the improvement of the production management and sales.

Example. The modern level of scientific and technological development allows creating electric heating devices that are twice more energy-saving, than the existing ones. There is the surplus of electric power production in Ukraine and the absence of sufficient volumes of own gas and oil reserves that makes their use too expensive. The use of coal is connected with considerable eco-destructive load on the environment. The idea is that the heating devices are turned on at night, when the electric power is cheap, and are only periodically turned on during the day to support a required temperature. Production of such devices is inexpensive and economically expedient. Their deployment is advantageous for the users as it allows for large cost savings on the apartments heating.

Thus, *innovative development* is a management process which is based on the continuous search and use of new methodologies and opportunities for the enterprise in the conditions of changing external environment and in the context of mission selection and activity motivation. It is connected with modification of existing and formation of new markets (Illyashenko, 2005).

Methods of innovative development management on a macro-level. The management of innovative development is carried out at a number of levels: state, region and enterprise. The first two represent the macro-level of management, and the last one – micro-level. The macro-level of management contains the elements of regulation mechanisms: governmental regulations of market processes, legal adjustments of entrepreneurial activity, social adjustments, political adjustments, etc.

Structure of methods which are used on the macro-level of innovative management of economic development (that embraces the mechanisms of adjustment) is presented on Figure 4.7.1 (Illyashenko, 1999).

Planning	***Economic stimulation***	***Legal***	***Social regulation***	***Political regulation***
Forming of government orders	System of taxes	Legal regulation	Public motions	Political rights and guarantees
Restructuring of economy	Encouragement of scientific and technological development	Administr ative sanctions	Democratic institutes	
Planning of territory development	Ecological adjustment	System of standards		
	Encouragement of investments and innovations			
	System of crediting			

Figure 4.7.1: Methods of management of innovative development of enterprises (macro-level)

Example. The methods of economic stimulation can be used for ecological payments which compel many enterprises-polluters to reduce their emissions and, in consequence, lead to installing the controlling equipment of clearing the harmful wastes. It means that the market possibilities of development (mostly innovative) for the enterprises-producers of this equipment are created.

Functions of innovative development management on a micro-level. Management *functions* of innovative development on a micro-level are following ones (Illyashenko, 2005).

1) analysis of external environment and forecasting of its development;

Example. The aluminum sulfate is the product which was developed based on the forecasted needs and requests of customers in combination with the analysis of scientific and technological achievements (it is produced, among others, by JSC "Sumykhimprom"). This chemical product is widely used for cleaning of sewer and muddy wastes in water (in the communal economy, chemical industry, producing of electric power, pulp-and-paper industry, construction industry, etc.). Sharp growth of expenses of industrial enterprises on the environmental protection led to the product success in the market due to the necessity for a relatively cheap and effective reagent suitable for the stated aims.

2) analysis of internal environment of enterprise;

3) forming the target market for implementation of innovative development projects;

Note. For forming the target market in relation to one of the most perspective directions of innovative activity – development of ecological commodities (ecologically safe and economically effective in the process of their production, consumption and utilization) – it is needed to analyze ecological problems (modern conditions and tendencies). For example, the idea of necessities in such ecological services as utilization and processing of wastes is given by modern statistical data published in annual regional reports about the state of environment (e.g., National reports about state of environment in Ukraine and other editions). From such reports it is also possible to get the data about the current state and tendencies in solving regional problems on other types of contaminations.

4) analysis and quantitative estimation of risk at all stages of innovative development;

5) selection of priority directions for the activity;

6) forming the organizational structure of innovative development management;

7) planning of production, sales and financial activity according to the selected priority directions;

8) control of implementation of the measures directed on realization of innovative development potential;

9) preparation of decisions for the well-timed priorities change and search of new directions of innovative activity.

Management of the choice of innovative development directions. ***Essence and stages of choice of innovative development directions.*** *Direction of innovative development of* enterprise is a motion based on introduction and implementation of innovations, which provide the improvement of quantitative and qualitative characteristics of enterprise activity, strengthening of its market positions and creation of conditions for progressive development (Bilovodska, 2004).

Choice of innovative development directions (CIDD) is one of the major stages of acceptance by the housekeeping based on the economic (foremost administrative) decisions. It includes the choice of one over the alternative scenarios of innovative development on the basis of its optimal criteria (Bilovodska, 2004).

The stages of choice of innovative development directions of enterprise are (Bilovodska, 2004):

1. Analysis of interrelations between the internal possibilities of development and the external ones as well as determination of possible ways of their matching.
2. Criterion estimation and pre-selection of perspective directions of innovative development.
3. Economic ground of choice of development directions.
4. Final choice and working out the details of the innovative project (projects).

"Planes" of choice of alternative directions of innovative development. Forming of criterion base for the CIDD optimization must represent the specific features of stage-by-stage decision-making and also take into account the "planes" of choice of alternative directions of innovative development (Problemi, 2005):

1) for homogeneous variants (if it is necessary to define the priority variant of innovative development from the several single-typed ones, for example, alternative single-typed production directions);
2) for different spheres of application (for example, if an enterprise chooses between organizational-administrative direction and market one);
3) within the limits of one classification group.

Methodological approach to pre-selection of directions of innovative development of enterprise in one classification group. The choice of directions of innovative development takes place on the basis of their compliance to the certain factors (to the criteria). The important ones among those are:

1) aims and innovative reference points of enterprises;
2) sufficiency of resource base (integral estimation of sufficiency of financial means, material resources, personnel, information);
3) level of competitiveness;
4) decision maker attitude toward risk.

On the basis of the selected criteria the methodological approach to pre-selection of directions of innovative development is represented on the Table 4.7.2 (for more details see Bilovodska, 2004).

Criteria of stage-by-stage acceptance of decisions and justification of choice in the planes of homogeneous variants and different areas of application. We will define the criteria of stage-by-stage acceptance of decisions and justification of choice for homogeneous variants and different areas of application (Bilovodska, 2004; Problemi, 2005).

On *the first stage* for CIDD from alternative for these planes of choice the criteria of estimation there is maximization of accordance the internal terms of development external ones, based on the method of SWOT-analysis.

On *the second stage* the criterion of estimation of possible innovative development directions are: indexes of efficiency of innovative development direction (directions from positions of enterprise are estimated) and consumer attractiveness (from positions of user innovations) (for more details see Socio-economic, 2007), and also indexes of risk estimation (expected value of result, absolute size of risk, relative size of risk (Illyashenko, 2004; Syllabus, 2003).

On *the third stage* for the choice of the most acceptable direction of innovative development the criteria of estimation is optimization of average-weighted probabilities of different scenarios of events development (at least: pessimistic, normal, optimistic) of such indexes: net present value (NPV), profitability index (PI), pay-off-period (PP) and inner rate of revenue (IRR).

Table 4.7.2: Sequence of pre-selection of directions of innovative development in the plane of one classification group (fragment)

Aims	Innovative reference points	Sufficiency of resources	Level of competitiveness	Attitude toward risk	Recommended directions: classification signs	Recommended directions: directions
Market	Corresponding to the aims of enterprise	Surplus	High	Inclined	strategic orientation	protecting
						...
						coming
					scales	global
						local
Organization-management		Norm	Middle	Neutral	level of analysis	strategic
						operative
					functional activity	production
						...
						administrative
					realization term	long-term
						medium-term
						short-term
					sphere of application	production
						...
						resource
					marketing positions	working out and realization of new commodity
						...
						diversification of production and sale
...		Lack	Low	Opponent	incentive motives	comprehensive advantages
production						...
						effect of image

The formed criterion base for decisions acceptance on different CIDD stages is described in Table 4.7.3.

Table 4.7.3: Criteria of choice of innovative development directions of enterprise

Stages of decisions acceptance		Criteria of decisions acceptance	Method of estimation
name	essence		
Analysis of interrelations between the internal possibilities of development and the external ones, and determination of possible ways of their matching	Determination of possible directions of innovative development. There are internal and external conditions of development for implementation of those.	Comparison of market possibilities and threats with the strong and weak positions of enterprise activity and selection of directions for which the internal possibilities of development maximally match the external ones (taking into account the choice in the system: aims – innovative reference points – sufficient of resource base – level of competitiveness –attitude toward risk)	See (Ilyashenko, 1999; Problemi, 2005), p. 1.2
Criterion estimation and pre-selection of promising directions of innovative development	Computing the correspondence of possible directions of innovative development to the criteria of optimum (taking risk into account)	Maximum value of efficiency index of innovative development direction and consumer attractiveness (for estimation of product direction) taking into account quantitative (probabilistic approach) and qualitative estimations of risk for every direction	See (Ilyashenko, 1999; Illyashenko, 2004), p. 1.2 is higher
Economic justification of development directions choice	Conducting the economic estimation of innovative projects for the choice of the most acceptable product direction. Making the marketing programs and draft projects	Optimization of average-weighted probabilities of different scenarios of events development (at least: pessimistic, normal, optimistic) of such indexes: net present value (NPV), profitability index (PI), pay-off-period (PP) and inner rate of revenue (IRR)	See (Illyashenko, 2004; Robocha, 2006)

Thus, this chapter is directed toward exposing the reader to conceptual management bases of innovative development at different levels as well as to theoretical, methodological and practical approaches describing how to apply the tools for the choice of innovative development directions. Those set the basis for sustainable development.

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4.8. Consumer motivation in achieving sustainable development

Consumer motivation controls consumers' behaviour. It is driven by both internal and external motivation that determines a choice for a production commodity.

The conduct behaviour of the consumer is related to his internal (disposition) and external (situation) motivation.

For a psychologist a user aggregates a number of subpersons, each with a different motivation. Consumption is therefore the result of different reasons (figure 4.8.1). Financial limitations are the most limiting factor to consumption.

Buying a product is also the result of the internal motivation of a user, although internal motivation does not explain everything.

For a consumption psychologist every commodity is an aggregate *of different attributes* – which correspond to the different needs of the consumer.

Guiding the demand means to take into account the attributes in a context of sustainable development (figure 4.8.4).

To guide *consumers towards sustainable development* it is necessary to understand which aspects of sustainable development the consumer values as meaningful.

Which aspects of SD does a consumer consider as meaningful? The direct aims related to sustainable development are important as is the satisfaction (for example, the choice for ecological commodities – see the figure 4.8.2).

Consumption targeted to sustainable development is characterizes by 3 main parameters: the charges/taxes on the product, its advantage and uniqueness and the values or moral motivation be-

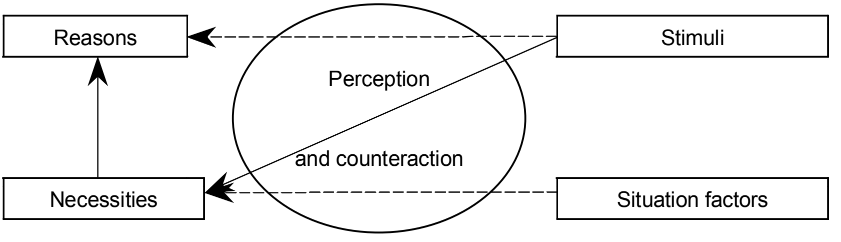


Figure 4.8.1: Factors influencing the internal consumer motivation

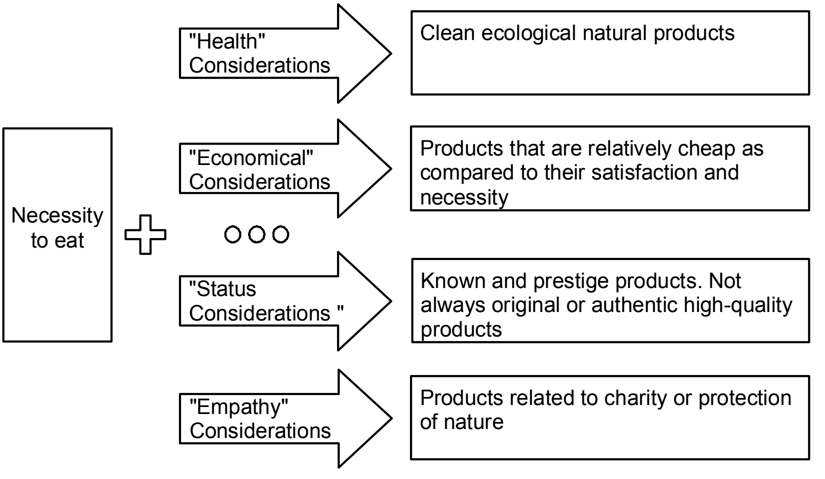


Figure 4.8.2: Determinants of consumer choices

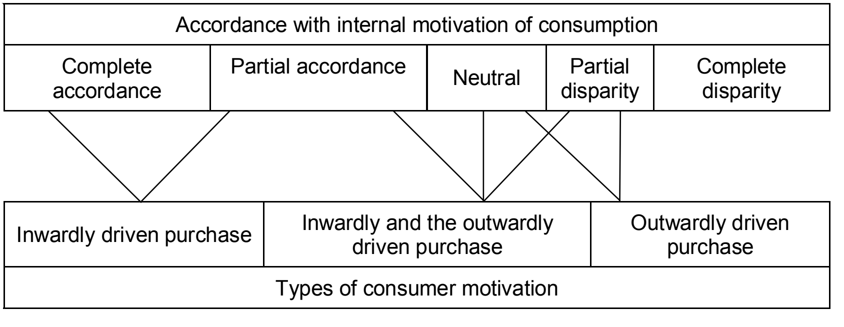


Figure 4.8.3: Consumer choices in relation to the motivation

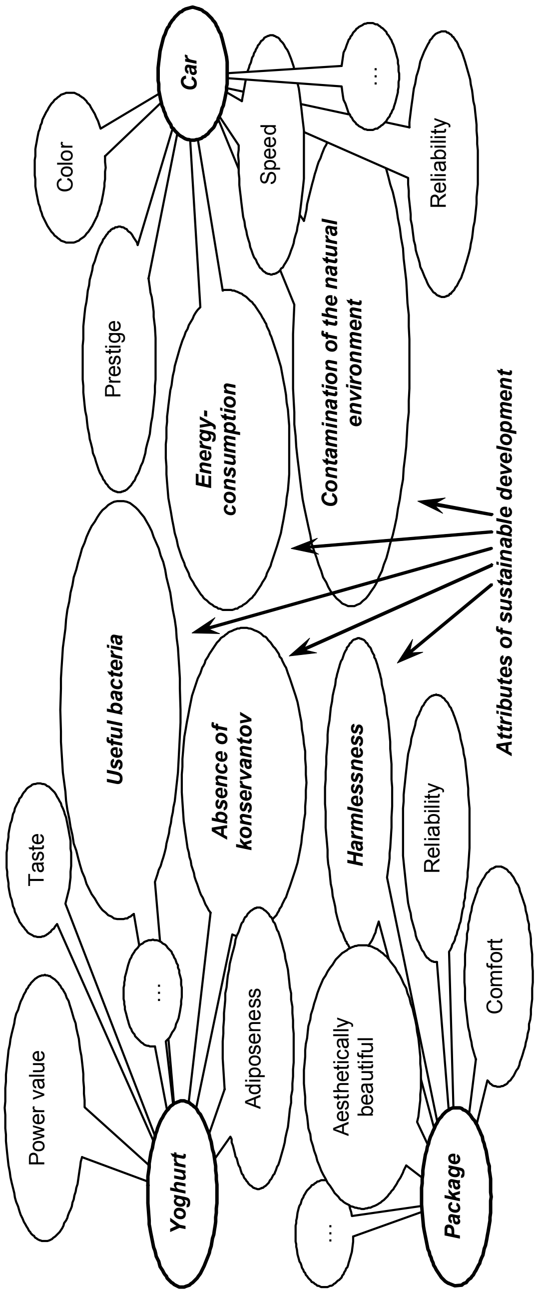


Figure 4.8.4: Selection of attributes of commodities proper to the aims of sustainable development

Table 4.8.1: Elements that drive motivation

Charges Consumption product	Commodity and sustainable development	
	individual	public meaningful
Lower than at similar regular commodities	Rational, emotional	Rational, moral
More than at similar regular commodities	Emotional, rational	Moral

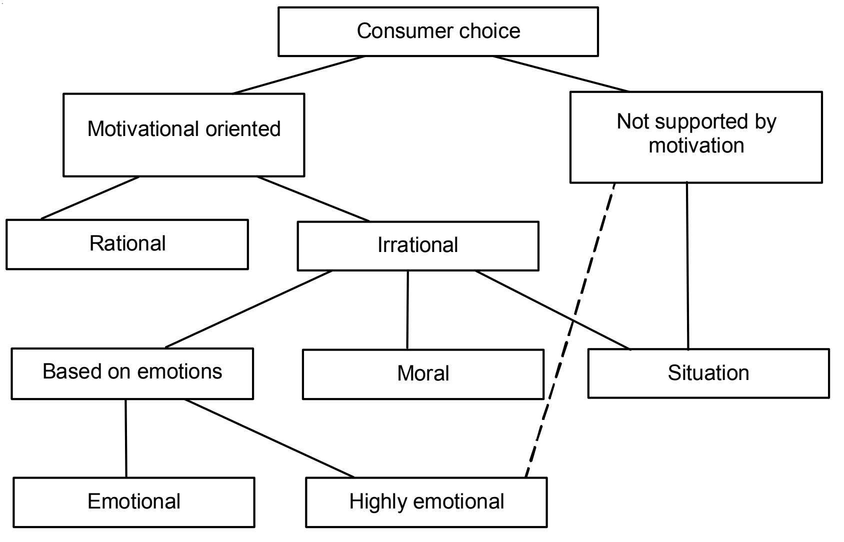


Figure 4.8.5: Consumer choices in relation to motivation

hind it (table 4.8.1) To promote products that fit in sustainable development, psychological instruments can be used. A classification of the options is summarized in figure 4.8.5.

4.9. Ecologically clean products: an assessment of consumers′ preferences

In the Donetsk region 80% of the people who participated in a survey are concerned with healthy food. More than 70% of the respondents indicated that they are ready to pay more for ecologically clean products (ECP). The majority of respondents answered the question “What is understood by you by an ECP as *lack of harmful additives and preservatives, use of natural raw materials, recycled packaging, and an environmentally friendly product?*”

To answer the question “*What is the proof of ecological cleanness of the products you like to buy?*” the majority of population of different age categories and social status said that they would give preference to:

- reputation of the product or TM – 29% ;
- opinions of friend, relatives, colleagues, i.e. purchasing verified products – 19% ;
- expert’s recommendations – 16% ;
- outcome of the state control bodies and special marking – 9% ;
- ECP labeling – 8% ;
- they are ready to respond to the outcome of an express analysis of immediate control during the purchase – 7% ;
- trust the data on the packaging – 3% .

Table 4.9.1: Readiness to purchase ECPs in Donetsk

ECP prices' increase, %	Ratio of the population that indicates to purchase ECPs (% of total number of participants: 200 persons)
Up 10	22
10-30	46
31-50	25
51-100	4
More than 100	3
Total	***100***

Notwithstanding high prices, the people from Donetsk are ready to buy ECP (table 4.9.1).

According to this survey, a most significant part of the people are ready to purchase ECPs provided that the price would be only 10–50% higher than those of products produced using traditional technologies.

4.10. Resource saving in maintaining sustainable development

Resource saving refers to an activity (organizational, economic, technical, scientific, practical, information), methods and processes, that accompany all stages of an objects' life cycle and are directed towards the rational use and an economical expenditure of resources.

The main elements of resource saving entail: 1) qualitative changes in industrial resources dynamics; 2) change in rates of growth of an end-product versus expenses of work; 3) reduction of resource intensity; 4) more resource saving as a result of the application of new and technologies; 5) transformation of nature protection expenses in factor of economic growth; 6) replacement of primary materials and resources by secondary ones, which is part of waste processing.

Figure 4.10.1 overviews the activities that contribute to saving resources.

Different aspects of saving resources are summarized in table 4.10.1.

The most important stakeholders involved in the wise use of resources are summarized in figure 4.10.2.

Table 4.10.2 summarizes the economic mechanisms that allow to promote resource saving.

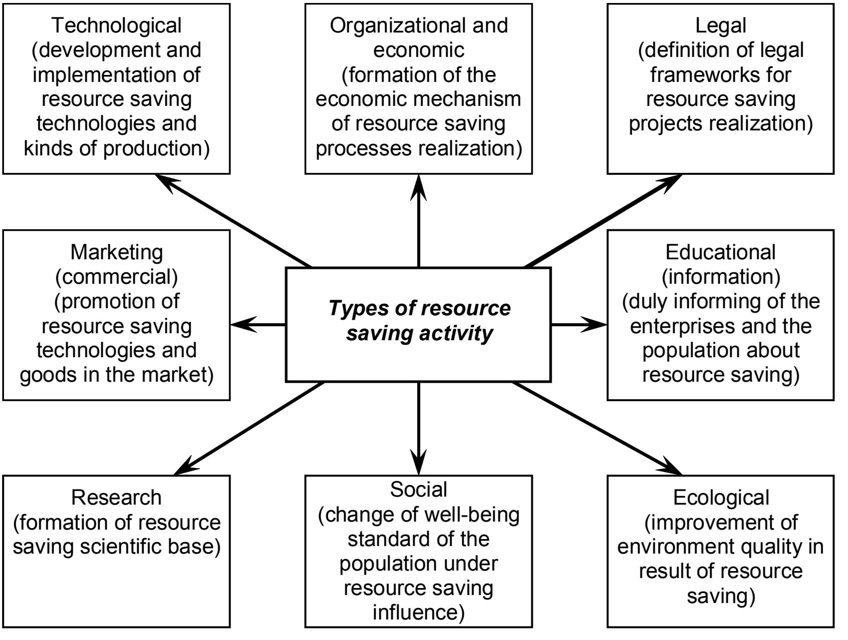


Figure 4.10.1: Activities contributing to saving resources

Table 4.10.1: Ways to save resources

Classification	Resource saving direction
Aspects of saving resources	– material saving
	– water saving
	– energy saving
	– labour saving
	– stock saving
Processes	– rational use of resources
	– conservation of resources (direct and indirect, structural)
Opportunity of realization	– potential (theoretical, technically possible and economically expedient)
	– actual

Classification	Resource saving direction
Scale of processes	– global
	– national
	– regional
	– sectoral (functional)
	– local (enterprise level)
Life cycle stage to save resources	– extractions of raw material (feedstock)
	– processing the raw material
	– production
	– consumption
	– transportation
	– storing
	– use
Stages of that product life cycle that allow to save resources	– exploratory design
	– industrial design
	– manufacturing and testing of the product
	– manufacturing the end-product
	– consumption (explotation)
	– use
Scale of financial needs	– large-scale
	– small-scale

Table 4.10.2: Economic mechanisms to promote resource saving

Mechanism	Characteristics
Property rights	on possession, use of natural resources, entrepreneurial rights
Market rights	the right on emissions, limits of natural resources use, obligations / pledges
Fiscal instruments	taxes on emissions, on used resources (including ecological taxes), on production; differentiation of taxes, tax privileges for investments in resource saving technology, the accelerated amortization of resource saving equipment
System of payments	the payment for natural resources use and for environmental pollution, administrative payments, sanctions, penalties
Financial instruments	grants, loans, subsidies, credits, government work, ecological insurance, creation of special funds of resource saving actions financing, leasing
Price instruments	introduction of discounts and extra charges to the price of resource-efficient and resource-insentive production, programmes on demand management of resources

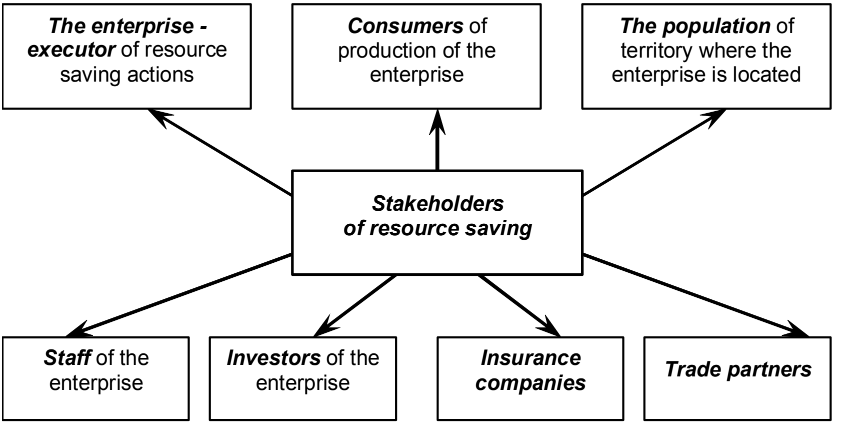
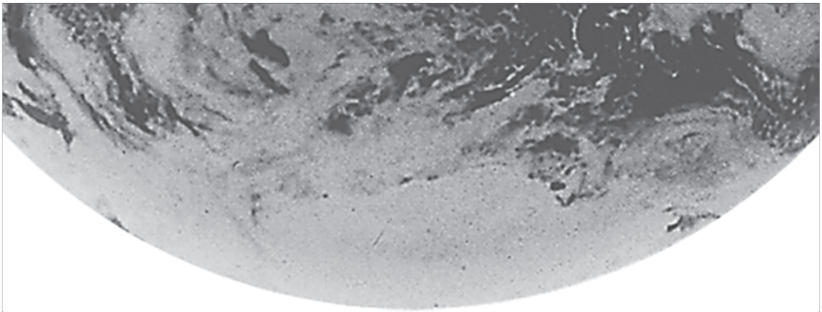
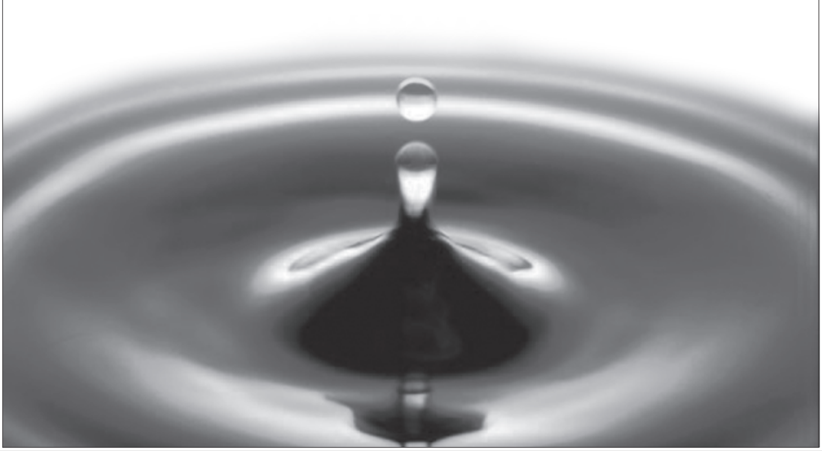


Figure 4.10.2: Stakeholders



PART V

SOCIAL DIMENSION OF SUSTAINABLE DEVELOPMENT



5.1. Human health and environment

People's wellbeing and health have always been depended on the quality of environment, but the last decade the environmental situation has become so complicated and insecure that these issues became very urgent and attract very serious attention.

When we speak about health we imagine an ordinary, typical state of functioning of an organism or a system. When we say "healthy person" we mean a concrete person who doesn't have any diversions in physiological and psychological spheres. When we say "healthy nation" we presuppose that indicators of health of every representative of this nation in total have quite a satisfactory level. When we say "healthy economy" we mean that we speak about a typical economic system that is developed according to ordinary rules and which doesn't seem to cause any worries about its unpredictability in the future. In the latter case the notion of "health" acquires a bit different meaning as it goes beyond medical meaning. But whenever we use the notion of health we mean the normality of development of anything we talk about.

So, health is a state of an organism (or in a wider sense of a system) when all its organs (system components) are able to function according to the normal processes.

Human health is an integral notion and is characterised by parameters which are related to its physical, psychological and social essence.

Numerous observations and special research demonstrate that human health is very much dependant on lots of factors of natural development (figure 5.1.1).

All known factors of the environment can influence the state and development of the organisms and that is why at the end of the day they predetermine qualitative characteristics of populations. The majority of the factors are necessary for the development of living organisms; though, there are also such factors that have a destructive influence on them. In the table below we demonstrate the examples of the influence of some environmental factors on human health.

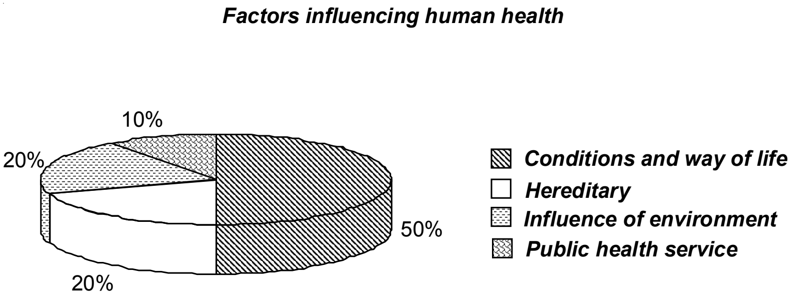


Figure 5.1.1: Conditions influencing human health

It is a given general principle of the influence of ecological factors on human's and animal's organisms that the effect or intensiveness of its influence depends on the nature of the factor itself and on its quantity (for chemical factors) or dose (for physical factors). Those dependencies of the influence of concentration or dose of the certain ecological factor on this or that vital indicator (in the long run it could be the quantity of population) are non monotonous and are generalised on the figure 5.1.2.

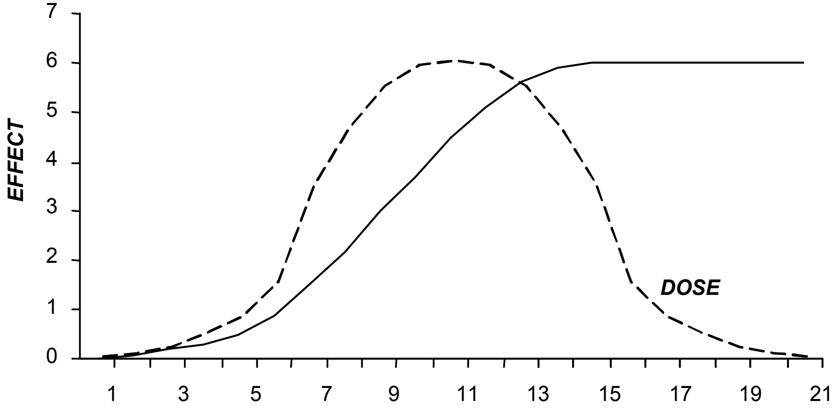


Figure 5.1.2: Graphic demonstration of generalised dependence of intensive influence of ecological factors (dose, conventional units) on vital indicators of the organism or population (effect, conventional units)

Table 5.1.1: Iinfluence of external environmental factors on human health

№	Environmental factors	Influence on human organism
1	Thermal field, temperature of the environment	Under deviation from optimal temperature (20–22 °C) to the increase or decrease metabolism is changing, organ's and system's biorhythms are disrupted and inflammatory and allergic reactions are aggravated. It is believed that thermal regime of the environment influences morphometric and anatomic indicators of the human's organism.
2	Atmospheric pressure	Change of atmospheric pressure causes disruption of metabolic processes and can initiate hyper and hypotonic crises, headaches and decrease ability to work and increase intensification of chronic diseases.
3	Humidity	Excessive humidity facilitates activation of respiratory and inflammatory processes and assists in formation of the centres of epidemic diseases.
4	Chemical components of the environment	They have a wide range of influence on the human body – from stimulation of some functions of growth and development to suppression and death.
5	Gravitation	Change of intensity of gravitation (under artificial conditions or, for example, at different Moon phases) influences at least on irritability of nervous system and other functions of the organism.
6	Magnetic and electromagnetic fields (magnetic storm, local magnetic fields of domestic appliances and so on)	Change of intensity and frequency of vibrations of electromagnetic and magnetic fields cause hypertonic and hypotonic crises, facilitate stenocardia, disrupt heart rhythm, increase the quantity of heart attacks and diseases, increase capillary pressure, change nervous, endocrine and immune system, as well as influence red-ox processes at cellular and sub-cellular level. Other deviations are also possible.
7	Noise and vibrations	They decrease level of attention, deteriorate general condition, increase the quantity of mistakes, cause stress and oppress central neural system, provoke change of pulse and breath level, disrupt metabolism and facilitate hypertension and heart diseases.
9	Ionising radiation	It could provoke radiation sickness, malignant tumour, leucosis, and induce intensification of hereditary diseases. Marrow, small intestine and central nervous system are most sensitive to ionising radiation.

Interrelation between the state of the environment and people's health has become unique and indisputable. High quality of the environment does not guarantee 100% health of the population but its influence would not become aggravating for the people's health. At the same time deterioration of the environment resulting from human activity inevitably increases risks for human health. It should be known and remembered, at the least. At the most, people's life strategies should be designed in such a way so that it minimises negative impact on the environment, the environment, which we are living in.

5.2. Modeling of development of a society on the basis of socio-ecopolis

Nowadays many countries foresee their development via sustainable economic growth, evolution of a society based on knowledge, information and innovations, accession of a country into common scientific and technological European as well as world space. Sustainable development of a country can be achieved, if sustainable development of its regions is provided. With this goal in mind various technopolises, innovation centers, incubators of new ideas and socioecopolises are being created.

Ukrainian scientists have proposed a macro project "Socioecopolis", which includes seven components. Each of these components coincides with relatively independent projects, designed to manage development of one out of seven components of socioecopolis. Table 5.2.1 lists these components.

This concept found its first implementation in the city of Reni (Odessa Region, Ukraine). It is expected to implement the concept in other cities of Ukraine as well as in Moldova. Such components of sustainable development as technologies for harmonized environment should be developed in the framework of the whole Socioecopolises and their associations. In these settlements intellectual factor should play a leading role. That is why a system of technologies for continuous development of intellect must be activated in Socioecopolis.

Table 5.2.1. Main components of sopcioecopolis

№	Subproject	Content
1	«Minirepublic»	The development of technologies to upgrade the democratic components in management of territorial community
2	«Municipal territorial community»	The development of technologies to achieve economic self-sufficiency and competitiveness in global economy by territorial community.
3	«Ecopolis»	The development of technologies to promote ecologically harmonized environment for life within sociopolicises and their associations.
4	«Intellectual city» (noograd)	The formation of a system's technologies to promote continuous development of intellect – logical, emotional and dynamic – beginning from pre-birth period and until death.
5	«City of health»	The formation of a system of technologies to decrease illness and to improve health of inhabitants.
6	«Spiritual community»	The design and enhancement of a socio-corporative potential of a community via development of cultural traditions, ethics, spirituality, psychological methods of communication.
7	«Digital city (infopolis)»	The implementation of modern information technologies in all spheres of social life with the aim to radically increase efficiency.

5.3. Strategic environmental assessment of social and economic development

Nowadays we are not only talking about sustainable development, but also about its spatial understanding. Nevertheless, traditional theories of spatial development basically study it in *a two-dimensional* (i.e. territorial) sense.

In general, a system's stability or sustainability is an index, which measures the system's ability to preserve motion (motion as ability to change) along certain trajectory, despite the influence of various disturbances.

There are the following three forms of sustainability (Hrodzinskiy, 1993) (fig. 5.3.1):

1) *Inertness* – a system's ability not to leave a feasible set z_0 during time "*t* under influence of factor *f*;
2) *Recoverability* – the ability of a system to return to feasible set z_0 in time "*t* after being outside the set under influence of factor *f*;
3) *Plasticity* – the existence of several states of a system's feasible sets (z_0) within the limits of variant *Z* as well as the ability of the system to move from one set to another under influence of factor *f*, not leaving the invariant area *Z* during time "*t*.

Thus, a ***system's spatial sustainability*** is the system's ability to remain or return into original feasible set due to inertness and recoverability, or to migrate due to plasticity from one set to another and not leaving the invariant area under the influence of external factors in a given period of time.

Spatial sustainable development is possible, under conditions that each element possesses the following ***properties***:

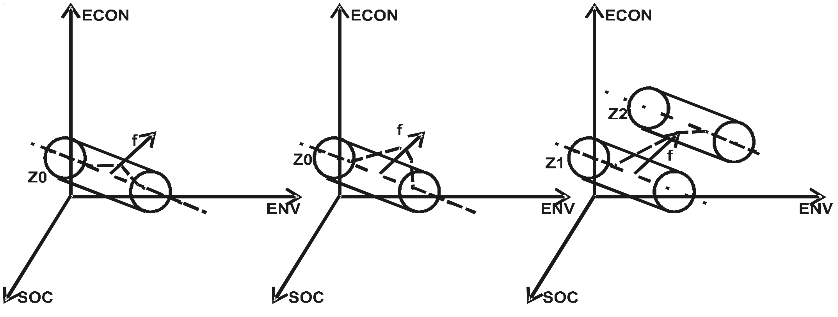


Figure 5.3.1: Dimensions of sustainability (ECON - an economic component of development, ENV - environmental, SOC - social)

1) Ability to interaction.
2) Orderliness and structuredness of relationships, i.e. existence of exact mechanisms of interaction.
3) Integrity, uniqueness and independence of each element.
4) Existence of three fundamental groups of factors underling spatial development: "input", "output" and the relationship between them.

Spatial management is defined as an activity to specify spatial strategy of balanced socio-economic and ecological development, to develop priorities and forms for a relevant spatial system (Pavlikha, 2001). The objective of spatial management is a simultaneous provision of increasing standards of life, rational utilization of a territory, and natural resources as well as environmental protection.

The key principles of spatial management are:

1) Achievement of a territorial integrity via balanced socio-economic development of regions and improvement of their competitiveness.
2) Perspective development via urban means and improvement of a relationship between urban and rural areas.
3) Development of equal conditions for special accessibility (transportation networks).
4) Improvement of access to information and knowledge.
5) Reduction of environmental damage (coordination of local industrial programs and decisions).
6) Development and protection of natural resources and natural heritage.
7) Enhancement of cultural heritage as a factor of development.
8) Development of energy resources under maintenance of safety.
9) Limitation of impacts of natural disasters.

Realization of conceptual ideas of sustainable development, regardless of a hierarchical structure of space, should be carried out through *legal, organizational, financial and economic, scientifically-educational and information* components of the mechanism.

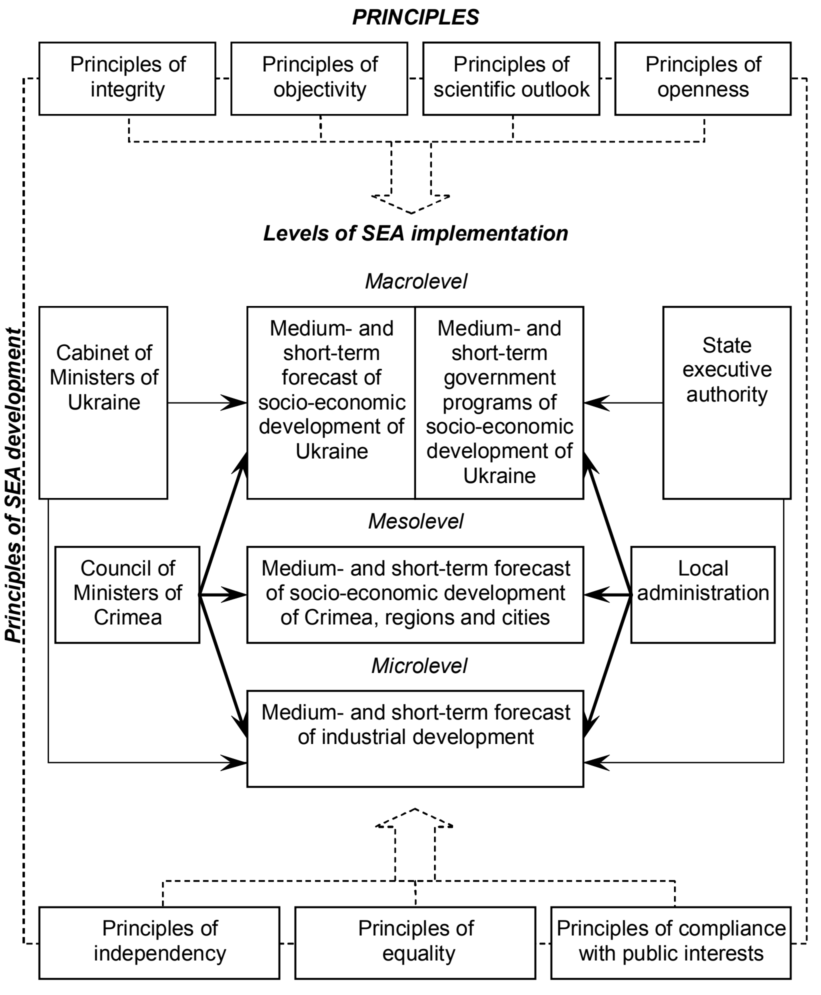


Figure 5.3.2: The authorized executives, principles and levels of the SEA implementation for planning and forecasting of social and economic development

We consider that ***the strategic environmental assessment (SEA)*** is such a unifying element of the general mechanism of spatial sustainable development that meets modern requirements, world tendencies and obligations of Ukraine, and also has a sufficient basis for implementation in the country.

The conceptual scheme of SEA implementation for the state planning and forecasting of social and economic development is presented in fig. 5.3.2.

Sustainable development is being implemented gradually, and the system of coordinated and agreed upon procedures is one of primary factors of its implementation in economy and in efficiency of productive labour. Therefore, the SEA implementation is a decisive factor for the design of up-to-date administrative mechanisms to achieve steady social and economic growth, as well as to transform economic relations and systems.

References

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5.4. Social factors of ecology-oriented economic development

The subject of national economy activity and his motivations which determine the conditions of organizational forms of national economy management come out to be major factors in maintaining stable development of social economy systems. Internal problems of this subject lie in formation an idea and image reflecting the essential basis and targets of human vital activity. External problems are connected with nature of relationship between the subjects of national economy activity. Thus, the character of such relations is in fact modeled by these subjects.

In contemporary world there have been formed three basic types of national economy activity: financial, economic and ecological. To tell the truth, the last one has only been declared.

The schemes represented on fig. 5.4.1 show, that the principle of the type of national economy activity formation is determined by the people itself depending on the targets of its development. And in this case the worldviews play the first role.

Finance-oriented type of national economy activity (fig. 5.4.1 a), as it is known, functions under the influence of hypertrophied financial factor which in its final stage subordinates all the other factors and functions under conditions of reproduction. This type of activity will surely be resource-intensive.

Economy-oriented type of national economy activity (fig. 5.4.1 b), as it is seen, presents traditional, classical type of economy oriented on commodity production. In fact, such a system is rather human. It presupposes creation and development of artificial environment. In this case national economy activity may be balanced as far as ecology is concerned (or in ecological sense). To achieve this it is necessary that the so called "people " should limit the use of natural resources for economic needs. Otherwise it will lead to ruining (destruction of) natural resources and provoke the gap between the nature cycles and their reproduction. At present time we witness the results of ignoring the limitation control over ecological resources.

Ecology-oriented type of national economy activity (fig. 5.4.1 c) presupposes priority of ecology targets over economic ones. Such type of activity is ensured not by competitive objectives but by vital needs, by the necessity of people's survival as a unique human community with high level of self-consciousness. This type of activity envisages that everything must be subordinated to the idea of forming special environmental surrounding where all the strengths are directed to support the natural cycles that ensure not only reproduction of a specific processes of nature (geobiocenosis), but also the peoples who constitute wholeness with Nature. It is such a type of national economy activity that is more than other ones oriented on the realization of the targets of stable

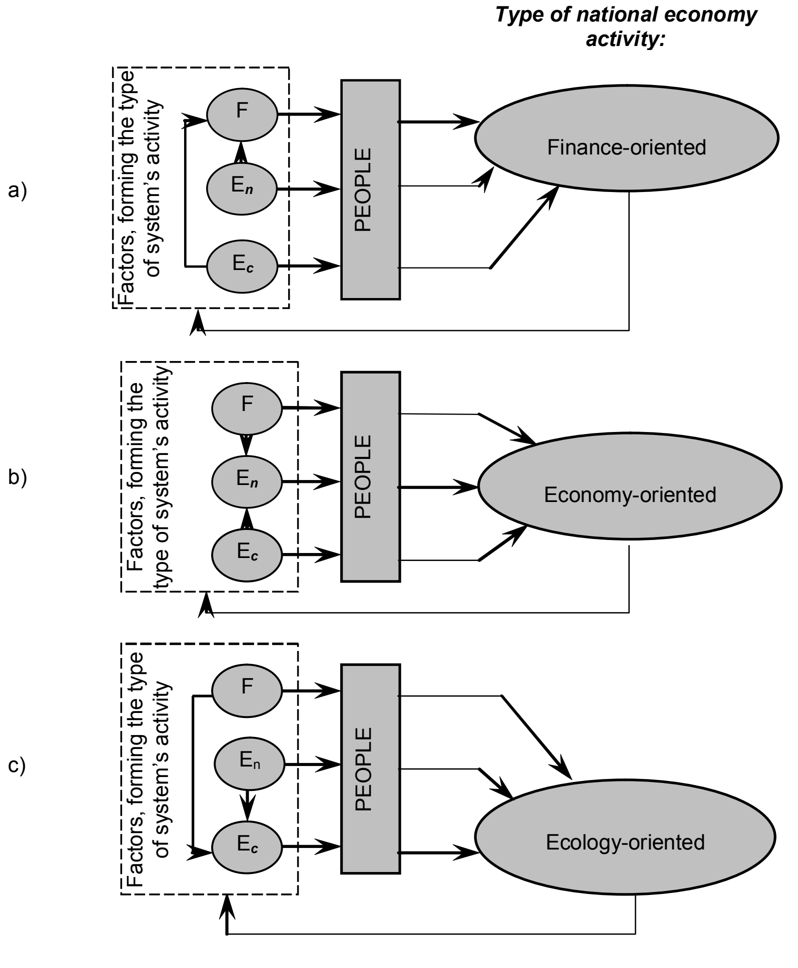

Figure 5.4.1: Scheme of national economy activity formation (F – financial factor; E_n – economic factor; E_c – ecological factor)

and sustainable national economy development.Type of national economy activity

Factors, forming the type of activity system

PEOPLE
Finance-oriented
Economy-oriented
Ecology-oriented
Fig. 5.4.1 Scheme of National Economy Activity Formation
(F – financial factor;
E – economic factor
E – ecological factor).

5.5. Social and human capital as key factors for the sustainable development strategy

Transformations in XXI century (from the society promoting consumption to the society promoting intellect) require new approaches to be developed with account to rethinking of socio-economic values. Studies on social and human capital, being a basic societal resource together with physical and financial capital, gained force in Europe at the end of XX century.

Human capital encompasses all knowledge and skills of a human, which he/she is capable to put together, to resolve problems in all walks of life. Human capital can be divided into the two components: intellect and skills. What is usually meant by economists as the human capital is, in fact, the intellectual capital, that is, formal education, diplomas and certificates. The capital related with qualifications and skills of a human encompasses professional skills, competencies and working experiences. That is, skills as a component of the human capital are involved rather than the intellect.

Social capital encompasses human relations as a medium for resources and information transfer (communication). Social capital is not merely an individual's characteristic, but rather depict relations between humans, in which a given individual is involved. Therefore, the strength of links between individuals involved in network communications and the diversity of these individuals and communications should be accounted for, to measure the social capital.

The concept of social capital is used to study the social structure of a society, covering institutes, relations and legal rules behind the quality and the scope of social communications within a society. The meaning of social capital is interpreted in varying ways in the modern scientific literature.

According to J. Coleman, while physical capital is tangible, being embodied in clear material forms, *human capital* is less tangible. It reveals itself in skills and knowledge acquired by an individual. Whereas s*ocial capital* is even less tangible, because it only exists in human relations. Like physical and human capital, social capital eases production activities. Thus, a group wherein there's absolute trust would be capable to do much more than a group devoid of these values. A vivid example is team sport games (football, hockey) or musical orchestras.

Social capital enhances cohered action and cooperation. Full understanding of the social capital implies the socio-political environment that predetermines the social structure of a society and makes it possible to change (revise) legal rules existing in this society.

Example

An example can be changed (increased) permissible norms for radioactive emission in Kiev after the Chernobyl catastrophe, allowing one to say about the normal radioactive situation in Kiev.

Scientists have learnt to measure and evaluate human capital, as well as its other types. As regards social capital, commonly recognized methods and indicators for its measurement have not been elaborated by now, although approaches to its measurement do exist. Thus, quantitative estimates can be made on what economic damage would be incurred to an organization (a country) due to the shortage of social capital in it, entailing inner conflicts and suspicious atmosphere, distrust to managers by subordinates and vice versa.

Social capital, like human one, has several parameters measured by market value (price). Apart from this, social capital, as any other one, has a property such as growth and devaluation, e.g. it increases or decreases depending on its position within social and market relations of humans. This is embodied in the synergetic effect that can have either positive or negative implications for the situation.

Many researchers study the relation between economic progress and its social (positive and negative) consequences. To have a high and sustainable level of welfare, it's important to understand the implications of decision-making for not only the physical environment, but for the social one.

5.6. Social and economic evaluation of ecological conflicts in achieving sustainable development

Questions and problems associated with fundamentals of sustainable development (SD) are an essential part of the "Millennium Development Goals" (World, 2002). Strategic goals of development can be formulated as follows:

1) priority of environmental measures in policy making and national programs;
2) reduction in depletion of ecological resources;
3) improved access to ecological services.

Resource conflicts in SD system. Ecological consequences of globalization such as trans-boundary pollution, solid and liquid wastes, ozone layer depletion, negative ecological aspects of international trade, resource depletion and ocean pollution require adequate approaches and mechanisms. Extensive use of ecosystems in modern technological processes is one of the major sources of potential ecological conflicts (EC)(or the so-called "resource conflicts") which have already become visible at a regional level and very soon can become a global phenomenon (McNeely, 2000; Understanding, 2004; Climate, 2002).

Ecological conflict is defined as confrontation caused by incompatible or opposing interests of one or more parties and their struggle for the right of possession, use (distribution) of nature resources or their control frequently accompanied by the force to achieve the desired goal.

In general, any conflict including ecological consists of various stages. It is dynamic in nature, and it develops within certain boundaries (see figure 5.6.1.). Resource conflicts can be subdi-

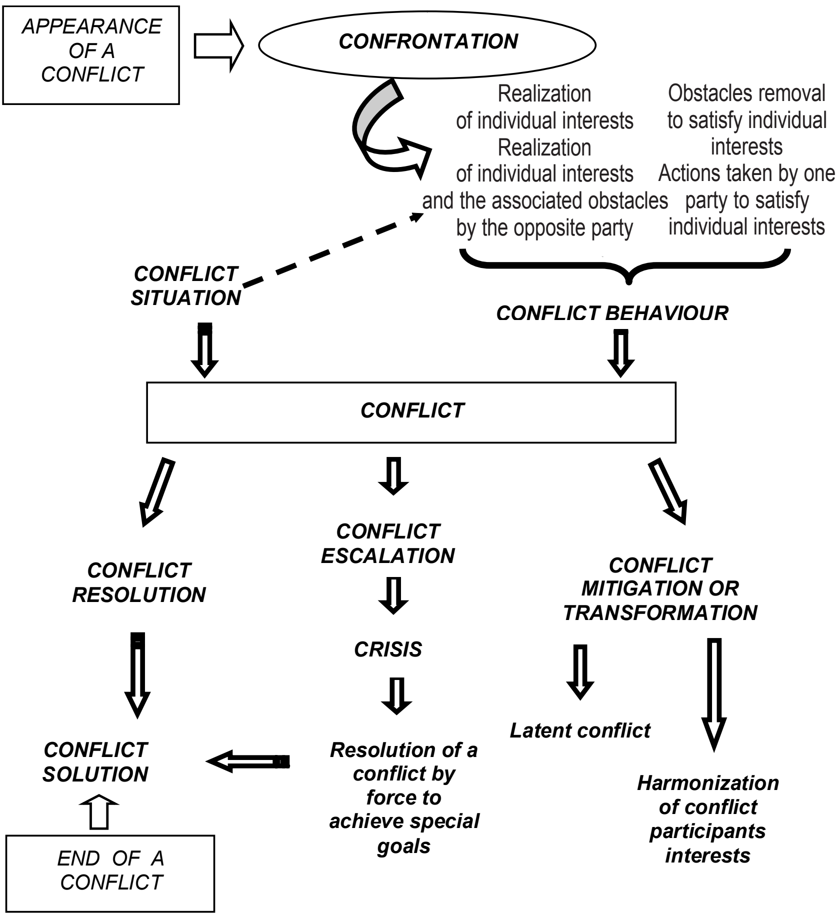

Figure 5.6.1: Development and resolution of conflicts

Table 5.6.1: Brief description of resource conflicts

№	*Conflict type*	*Conflict causes*	*Conflict content*	*Examples*	*Conflict resolution*
1	2	3	4	5	6
1	***«Land conflict»***	▪ Issues related to the property rights ▪ Unresolved questions related to territorial frontiers ▪ Imperfect legislation ▪ Property rights associated with exhaustible resources as a consequence of territorial issues ▪ Population growth, poverty, aggressiveness	Conflict over possession/control over certain territory and/or natural resources which can bring direct or indirect profits	1. Conflict between Ukraine and Romania over the Island Zmeinyy (Ukraine has found considerable oil reserves in the adjacent shelf). 2. Conflict between Japan and Russia over the Kurily Islands (Japan considers the islands to be their territory)	Political, institutional, civil, technological, cultural, market methods of conflict resolution
2	***«Water conflict»***	▪ Issues related to the property rights ▪ Intensive use of water resource by one party ▪ Trans-boundary water pollution ▪ Restricted access to water resources	Conflict over possession/control over water resources which can bring direct or indirect profit: financial, technological, social, territorial profits	1. Permanent conflicts between Ukraine and Romania over trans-boundary pollution of river Siret by Romanian mines. 2. Trans-boundary pollution of the river Pripyat (Ukraine – Byelorussia).	Political, institutional, market methods of conflict resolution
3	***«Forest conflict»***	▪ Issues related to the property rights ▪ Ecological and social consequences of deforestation ▪ Distribution of profits from sale of timber ▪ Imperfect legislation	Conflict over possession/control over forest resources which, as a rule, can bring financial, social profits and advantages in armed conflicts	1. Timber as a source of financing national and regional conflicts (Burma, Congo, Liberia, Cot D'Ivuar, Cambodia). 2. Forest as ecosystem and natural habitat for local population (Mexico, Brazil, Venezuela, Indonesia, India, Nepal)	Civil, institutional, technological, and market methods of conflict resolution

1	2	3	4	5	6
4	***«Mineral conflict»***	▪ Access to, control over and trade of mineral resources. ▪ Mineral resources ownership as a factor of financial influence ▪ Conflict of interests between mining companies and local population ▪ Macroeconomic dependence on mineral resources, an increase in social and economic vulnerability ▪ Corruption and obstacles to economic development caused by availability of mineral resources and poor control	Conflict over possession/control over mineral resources which as a rule can bring financial and social profits	1. Most of armed conflicts in Western Africa, (Congo, Angola, Rwanda, Sierra Leone, Liberia – diamonds, gold; Togo – phosphates), Papua New Guinea, Tanzania, South Africa, Zimbabwe, Peru - ore. 2. Armed conflicts in the Middle East (Kuwait, Iraq – oil)	Political, institutional, civil, technological, cultural, market methods of conflict resolution
5	***«Food conflict»***	▪ Scarcity of land resources (arable land, pastures etc.) ▪ Closed economic systems ▪ Lack of appropriate technologies for land cultivation ▪ Lack of harvesting ▪ Poor climatic, weather conditions ▪ Low living standards	Conflict over possession of necessary resources, technologies which as a rule can bring financial and social profits	1. Catastrophic shortage of food in the countries of Central Africa (Somali, Chad, Sudan), South-eastern Asia (Northern Korea). 2. Permanent food crisis caused by ecological disasters (countries of Africa, South-eastern Asia). 3. Trade embargo caused by the armed conflicts (Afghanistan, Iraq)	Political, institutional, civil, technological, cultural, market methods of conflict resolution
6	***«Assimila-tion conflict»***	▪ Ecosystem assimilation capacity ▪ Imperfect legislation related to trans-boundary pollution ▪ Failure to apply tradable pollution permits	Conflict over possession of necessary resources, technologies which as a rule can bring financial and social profits	1. Greenhouse effect. 2. Trans-boundary pollution caused by the man-made disasters (Chernobyl catastrophe, Bhopal) 3. Uncontrolled deforestation (Transcarpathian forests, Brazilian rainforests)	Political, institutional, civil, technological, cultural, market methods of conflict resolution

vided into 7 groups as follows: 1) «land conflicts»; 2) «water conflicts»; 3) «forest conflicts»; 4) «mineral conflicts»; 5) «food conflicts»; 6) «assimilation conflicts»; 7) complex conflicts (brief description of this classification is presented in table 38.1; for details, see: Sabadash, 2004; Sabadash, 2006 a; Sabadash, 2006.

Ecological conflicts remain rather urgent for industrially developed countries as well since their geopolitical and economic interests include cooperation with developing countries. Further development will cause an increase and intensification of economic interests, correlation and penetration of production and capital including new forms and subject matter. That is why international cooperation can and must prevent and/or resolve ecological conflicts with the goal of restoring ecological and economic balance on the basis of sustainable development.

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5.7. Ethics and sustainable development

The moral aspects have been the objects of investigation for centuries. Nowadays these are turning into a necessary condition for the survival of the whole mankind. At this time when two millenniums meet the human civilization is turning into an informational society. According to the neat expression of Sergey Lazarev “ethic was a luxury yesterday, it is a necessity today and the only condition of surviving tomorrow”.

The moral way of management turns out to be more effective in the perspective even with the account of only the primary results of the activity of the concrete economic subject.

The economic advantages of moral norms of management will be much more significant with secondary effects (use of social benefits, the perspectives of profitable work for all members of a family within the limits of other economic subjects) and far-distant effects (possibility of welfare for children and grandchildren).

It is easy to recognize that moral norms have to be included in decision-making process and tactics and strategy goal setting and achievement. Several reasons can be given as evidence.

The immoral attitude of the state towards its citizens is a blow on the nearest and distant future of the national economics:

- delays in delivering salary and pension block the demand of economic cycles of the nearest future;
- violent or deceitful extraction of savings blocks the internal loans for many years.

The immoral generation relations reduce the future economic potential of a society. In particular:

- immoral attitude to young generation brings down the information-economic potential for the nearest future;
- immoral attitude to the older generation provokes its fear of the homeostasis change and the tendency to be an obstacle in the way of youth coming to power (progressive transformations blocking).

From the first steps of economics learning we face the answering three fundamental questions: "What is it needed to be produced? How have it be produced? Whom have it be produced for?"

From the first viewpoint these three questions can be observed only in an economic plane. But it is needed to study them in ethical plane too taking connection between economy and ethics into account (they are united by a man). Such observing creates preconditions of development and regulation of sustainable economy (Figure 5.7.1).

Technology orientation. Many people consider nowadays that production technologies define society changing. According to I. Barbour ideas "technology depends on a society". Technological projects are realized by concrete managers and organizations. Governments, transnational corporations own a great economic and political power, thus it is possible to take everybody's opinion into account through democratic forms of impact (election, court requests, society committees, ecological organizations). Producer has a right to create medicine items or military facilities and his option has to bring a maximum utility for a society.

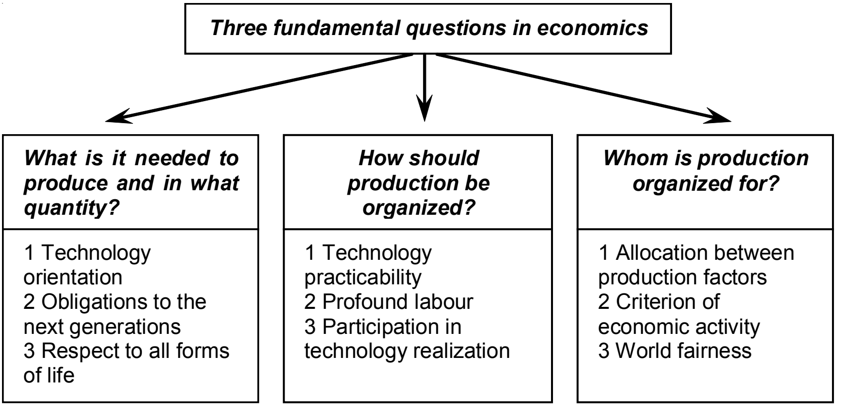

Figure 5.7.1: Three fundamental questions in economics including ethical component

Obligations to the next generations. Many technologies make impacts for a longtime period and will influence on life of our descendants. If we talk about renewable resources we should intent to gain maximally sustainable output. When we exceed this limit, productivity of the natural wealth starts declining rapidly (hewing too many forests, fishing too much).

If we talk about nonrenewable resources the fairness between generations can exist only under the following condition: we can exhaust a resource base not as fast as we extend it with an aid of a technology (Figure 5.7.2).

Respect to all forms of life. Ethics boundaries were defined by a human community, but nowadays we can talk about ethics evolution, the next stage of which is extending of the boundaries to the whole Earth community, where every member is equal. Ecosystem integrity is important because it makes possible a well-being of interrelated individuals – men and other beings. Any being

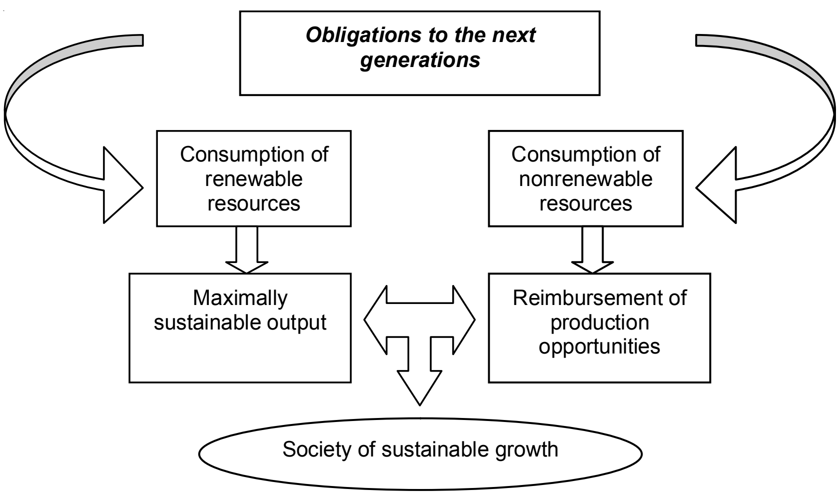

Figure 5.7.2: Obligations to the next generations as premises of formation of sustainable growth society

owns unique information, which has to preserve life of the whole Earth community including men.

Technology practicability. There are two main tendencies concerning technology's directions – intermediate and advisable. The first one came from the developing countries and had its own characteristics (middle scale, labour content, relative simplicity, local management). Such features were connected with industrialization of the developing countries and problems of poverty and unemployment.

In its turn, western countries launched advisable technology, which was formed in other conditions. The main problems were overgrowth of economy, person's self-realization, profound labour and environmental protection.

Profound labour. One of the labour incentives is our necessity to earn money satisfying our needs. Thus the prime aims are employment guarantee, sufficient salary and safety labour conditions. And we also have to intent to self-realize our individual abilities during our labour activities in the best way.

Participation in technology realization. Ethics of technological management demands today to larger community's participation and more democratic power allocation during technological decision-making process. Such participation is easier to realize in intermediately scaled technologies then in larch scaled ones. For example, nuclear energy needs huge investing and is connected with a big risk, thus it needs to be regulated by a government. While many other intermediate technologies (solar energy) are decentralized – it can be served with local facilities. In this case local needs and values would be priority on local community behalf.

Allocation between production factors. We use several fundamental production factors to produce goods and commodities (labour, land, capital, entrepreneurial abilities). Who has to capitalize from production activity in a result? One of the major criteria is a labour factor. It is characterized with a multitude of professions and qualifications, performing a wide range of specialties. From one side, the more random a specialty is, the bigger demand for it is (it is paid higher). From another side, each person has a right to satisfy all his basic natural and cultural needs. But such approach can lead to a weakening of successful work.

Criteria of economic activity. Any man, who takes participation in a productive activity, has a right to gain a benefit. But there are people, who can't fully participate in this process – they are minors, aged, jobless and disabled. Government has to care of these categories of nationals and provide them with minimum social protection. It requires formation and financing of relevant social programs.

World fairness. There is an incisive disproportion between development levels of developed and developing countries. According to A. Rich opinion, there are two major strategies of this problem solving. The first strategy is export extending of developing countries, which will allow avoiding unilateral exchange of items between countries. Another strategy is orientation to own economy, which presumes nonparticipation in a world trade.

Nowadays actual changers of the social-economic system require social and economic claiming for ethical norms based on the principles of Christian morals.

5.8. Policy and management for sustainable development

Governance for sustainable development. The term governance deals with the processes and systems by which an organization or society operates. The World Bank defines governance as the traditions and institutions by which authority in a country is exercised. This includes the process by which governments are selected, monitored and replaced, the capacity of the government to effectively formulate and implement sound policies and the respect of citizens and the state for the institutions that govern economic and social interactions among them. (Kaufmann *et al.*, 1999) In other words, governance is the use of institutions, structures of authority and even collaboration to allocate resources and coordinate or control activity in society or the economy.

Planning. When steering a society towards sustainability, planning is a common instrument.

A useful tool when planning for SD is the "planning cycle".

Details

The planning cycle contains six steps (Tellus Consultants Ltd., 2006):

1. Gathering information to identify the needs of all people and organizations of the country and the needs of the plants, animals and essential resources.
2. Exploring possible ways to meet the needs that are not currently satisfied.
3. Selecting the best way to proceed and making this the current policy.
4. Implementing the policy with an action plan.
5. Monitoring the effect of the action plan.
6. Revising the plan and the policy as needed.

For Belgium, the sustainable development policy has been concentrated in the Federal Plan for Sustainable Development. So far, two plans for SD have been published: a first plan covers the period 2000–2004 and a second one relates to the period 2004–2008. The content of the present Federal Plan for Sustainable Development (2004–2008) is shown below.

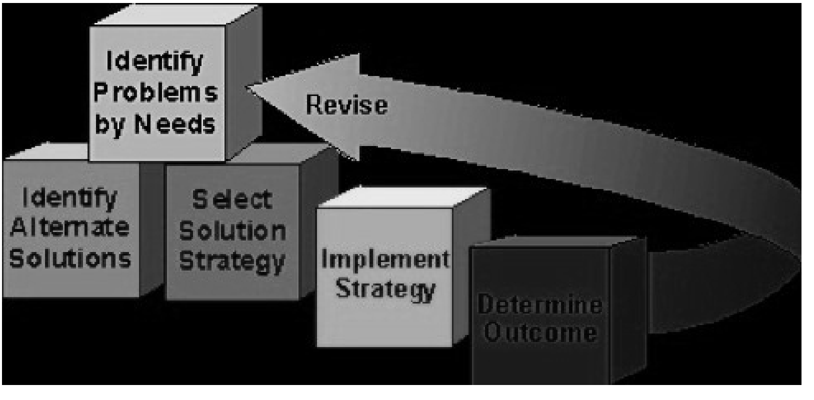

Figure 5.8.1: The "planning cycle"

1. A plan for SD
   - 1.1 Challenges
   - 1.2 Policy solutions based on coherence and continuity
   - 1.2.1 Sustainable development
   - 1.2.2 National and federal strategies
   - 1.3 Between global and local administration
   - 1.3.1 International cooperation
   - 1.3.2 European cooperation
   - 1.3.3 National cooperation

2. Strategic framework of the Plan for SD
   - 2.1 Choice of terms
   - 2.2 Combating poverty and social exclusion
   - 2.3 Dealing with the implications of an ageing society
   - 2.4 Addressing threats to public health
   - 2.5 Managing natural resources more responsibly
   - 2.6 Limiting climate change and increasing the use of clean energy
   - 2.7 Improving the transport system

3. Actions for SD
   - Action 1: Integrating the objectives of social inclusion as a part of SD
   - Action 2: Consumer protection
   - Action 3: Decent and affordable housing
   - Action 4: Quality of employment
   - Action 5: Entrepreneurs and the agricultural world
   - Action 6: Working beyond the age of 55
   - Action 7: Developing community services
   - Action 8: Ethically sound investments
   - Action 9: Making family care possible
   - Action 10: Improving overall relief
   - Action 11: Providing better information and making health care more accessible
   - Action 12: Quality of food
   - Action 13: Preventing violence
   - Action 14: Striving for better health worldwide
   - Action 15: Restricting use of natural resources
   - Action 16: A strategy for sustainable products
   - Action 17: The government’s exemplary role

Action 18: Protecting biodiversity
Action 19: Sustainable forest management: the fight against illegal logging
Action 20: Integrated management of the North Sea
Action 21: A sustainable energy policy
Action 22: The right price
Action 23: Energy-conserving buildings
Action 24: More solidarity: the use of flexibility mechanisms
Action 25: A global approach to the energy issue
Action 26: Steering the demand for mobility
Action 27: Alternative ways of traveling
Action 28: Improving the supply of public transport
Action 29: Improving expertise and information regarding mobility
Action 30: Less polluting vehicles
Action 31: The need for corporate social responsibility

4. The Plan's follow-up
   4.1 Viewing the policy as a learning process
   4.2 Taking precautions against risks
   4.3 Actively involving the population
   4.4 Collaboration with other governments
   4.5 Connecting tools and targets

Impact assessment. An EIA is a policy and management tool for both planning and decision-making. EIA assists to identify, predict and evaluate the foreseeable environmental consequences of proposed development projects, plans and policies. The outcome of an EIA study assists the decision maker and the general public to determine whether a project should be implemented and in what form. EIA does not make decisions, but it is essential for those who do (Modak and Biswas, 1999).

Strategic Environmental Assessment (SEA) is a system that allows to incorporate environmental considerations in policies, plans and programmes.

Details

The structure of SEA under Directive 2001/42/EC is based on the following phases (EU, 2001):

1. Screening: investigation of whether the plan or program falls under the SEA legislation.
2. Scoping: defining the boundaries of investigation, assessment and assumptions required.
3. Documentation of the state of the environment: effectively a baseline on which to base judgments.
4. Determination of the likely (non-marginal) environmental impacts: usually in terms of 'direction of change' than firm figures.
5. Informing and consulting the public.
6. Influencing decision taking based on the assessment.
7. Monitoring of the effects of plans and programs after their implementation.

The Sustainability Impact Assessment (SIA) offers a more recent methodology to assess projects, plans, programmes, agreements and policies on their impacts for sustainable development.

Details

The SIA follows a four-step methodology:

Screening: to determine if a project, plan, programme, agreement or policy should be subjected to the procedure.

Scoping: to determine the terms of reference. Which components should be assessed? Which appraisal methods and consultation procedures should be used?

Preliminary assessment: to determine the impacts associated with each measure and with the intended development as a whole. How significant will each of them be?

Flanking measures (mitigation and enhancement analysis): to determine types of flanking measures which may reduce significant negative impacts that result from trade opening measures and enhance positive impacts on sustainable development. This is particularly important for developing countries and least developed countries (European Commission, 2006a).

Management of and reporting on sustainable development. The most important management system related to sustainable development is the Environmental Management System (EMS).

An EMS is a continual cycle of planning, implementing, reviewing and improving the processes and actions that an organization undertakes to meet its business and environmental goals. Most EMS are built on the 'Plan, Do, Check, Act'-model (Figure 5.8.2):

Figure 5.8.2: The “Plan, Do, Check, Act”-model

Sustainable development labels. A label is a distinctive trademark to identify a product. Three different types of sustainable development labels currently exist: environmental labels, ethical labels and social labels. Up till now, a SD-label doesn’t exist, but the next step will probably be one (SD-) label replacing the three preceding labels. The FSC- and PEFC-label are a step in the direction towards a SD-label.

The European Eco-label is a voluntary scheme designed to encourage businesses to market products and services that are less impacting on the environment and for European consumers (including public and private purchasers) to easily identify them (European Commission, 2006b). It emerged from different national initiatives such as ‘Der blaue Engel’ (Germany), ‘Milieukeur’ (The Netherlands) or the ‘White Swann’ (Scandinavian countries).

The Natureplus-label is an independent international label (Figure 5.8.3) for construction materials and home furnishings. Products with this label comply with the highest environmental and health requirements (Natureplus, 2006).

Figure 5.8.3: The Natureplus-label

The Forest Stewardship Council (FSC)-label (Figure 5.8.4) is an international and independent label for ecological and social sensible forest management.

Figure 5.8.4: The FSC-label (FSC, 2003)

The Programmme for the Endorsement of Forest Certification schemes (PEFC)-label (Figure 5.8.5) is an independent, non-profit, non-governmental organization, which promotes sustainable managed forests through independent third party certification (PEFC, 2007a).

Figure 5.8.5: The PEFC-label (PEFC, 2007a)

Ethical labels. Fairtrade labeling is a product certification system designed to allow consumers to identify products (especially agricultural products) which meet agreed environmental and social standards.

Figure 5.8.6: The Fairtrade-label. (Fairtrade, 2006)

Social labels. An international social label doesn't exist yet. Therefore the example of the Belgian Social Label, is addressed (Figure 5.8.7).

Figure 5.8.7: The Belgian Social Label (POD з SPP, 2005)

Conclusions

The planning for sustainable development, the impact assessment and the management for and reporting of sustainable development were introduced recently and are mainly based on environmental instruments.

5.9. Freedom of will and responsibility as components of sustainable development

Personality as a goal and means of sustainable development. Personal development is a key goal of human civilization. It is equally one of the leading elements of sustainable development. However personality development is not only a goal, but also a mean to ensure sustainable development. Only mature personalities make complex decisions, which define the welfare of human civilization.

Freedom as a necessary condition of personalities. Freedom of will is a fundamental law worldwide. In practice, freedom of will provides meaning and dedication to a human life, it offers opportunities for creativity. This huge gift of nature, also brings significant which is the basis for moral values.

Creative (good) or destructive (evil) aspects of freedom are determined by personal, inner, deep choices, of humans. Choices of the past determined the values of today and choices of today determine the future.

Dialectic unity of freedom and responsibility. Freedom is linked with responsibility. There is no freedom without responsibility.

The claim that responsibility restricts freedom is false. In reality, responsibility doe not restrict freedom, but *determines its quality*. These days the feeling of responsibility should be acute, because human power and the possibility to influence global processes have significantly increased. Mistakes are most costly. Sustainable development as a movement that aims to prevent global catastrophes is based on moral values. These values can to some extent be compared to physical laws. An adapt of sustainable development feels and is responsible for life on the Earth in all its aspects.

Culture as experience of generations. Personalities, people, and nations are closely related to the scope, and the space of the underlying *culture*. Culture is the memory of the historical successes of humanity. Therefore it offers a basis to take fundamentally right decisions. Also beneficial pathway for contemporary people be determined by culture. Culture outlines the contours and goals of development. Culture is the experience of generations; it is primarily a moral experience.

Science as an instrument of transition to future. Creative labour is part of culture. *From this point of view, science* is one of the most important cultural aspects.

Science is also the most visible part of culture. Its attractively is in the quantitative criteria and the objective ways to describe the surrounding world. Science is about systematized knowledge, carriers of knowledge (scientists), systems of knowledge (education) and *morality, which determines the application of knowledge.*

Responsibility of science is mandatory for sustainable development. Morality is an integral aspect of science. Moral values are related to the use and the dissemination of knowledge. The development of values that regulate the use of scientific results, and their dissemination is in the core of sustainable development in particular when the knowledge threatens life and the ecosystem.

It is imperative to develop global *international agreements*, that apply in all countries and which would determine the use and spread of knowledge in the benefit of humans.

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5.10. Theoretical foundations of marketing methods in the framework of reproduction of socio-economic ideology

Transition from a science and technology driven society to sustainable development, which next to technology includes social and environmental aspects, supposes changing priorities, in particular, social worldview. Social, ecological and technological concept displaces aims in this system. Therefore, it is a necessity to realize new priorities. Equity and sound relationships between humans and their environment are among them.

Sustainable development (SD) concept is about the integration of the biosphere, economy and social aspects. Solving the problem of managing social and economic development of a society depends on reorganization of social system.

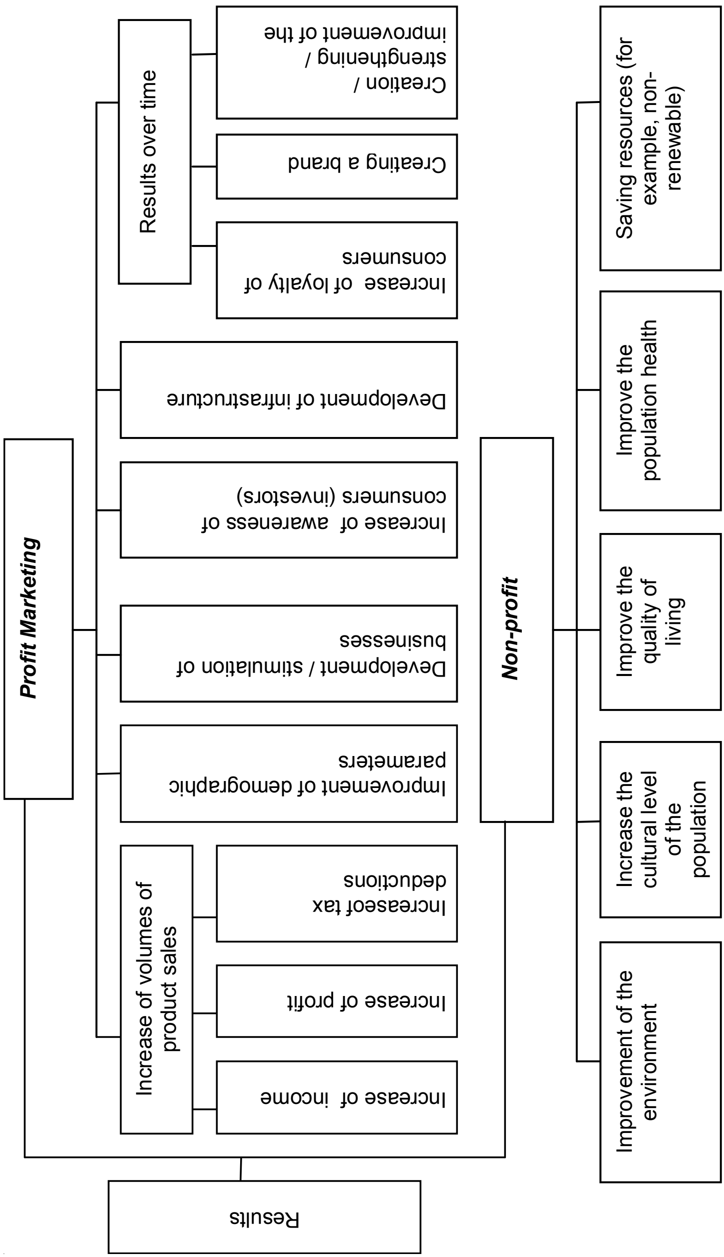

Figure 5.10.1: Results of commercial and non-commercial marketing

Influencing social aspects can be done both at the conscious and at the subconscious levels. Modern marketing uses exactly these ways to influence people. Therefore, changing the social worldview can make use of that are common in the non-profit marketing methods.

Non-profit marketing should not be judged on the income it generates. Moreover, non-profit marketing has commercial and non-commercial aspects (Figure 5.10.1).

Table 5.10.1: Direct and indirect results of sustainable development, realized particularly by commercial and non-commercial marketing

Results	The levels			
	National	Regional	Municipal	Enterprise's
Commercial	Increase in national income	Increase in sales of products		
	Development of infrastructure			Increase in income
	Increase in tax payments			Increase in profit
	Increase in appeal for investors			
	Development of towns and regions			Branding
				Customer's loyalty
	Increase in investor awareness			Customer's awareness
	Development/stimulation of different business			
	Creation/reinforcement/improvement of a positive image			
Non-commercial	Savings of certain types of recourses (e.g., non-renewable)			
	Improvement of environment			-
	Formation of a stimulating intellectual atmosphere			
	Increase in quality of life			
	Increase in the standard of culture			
	Improvement of demography			
	Preservation of historic heritage			

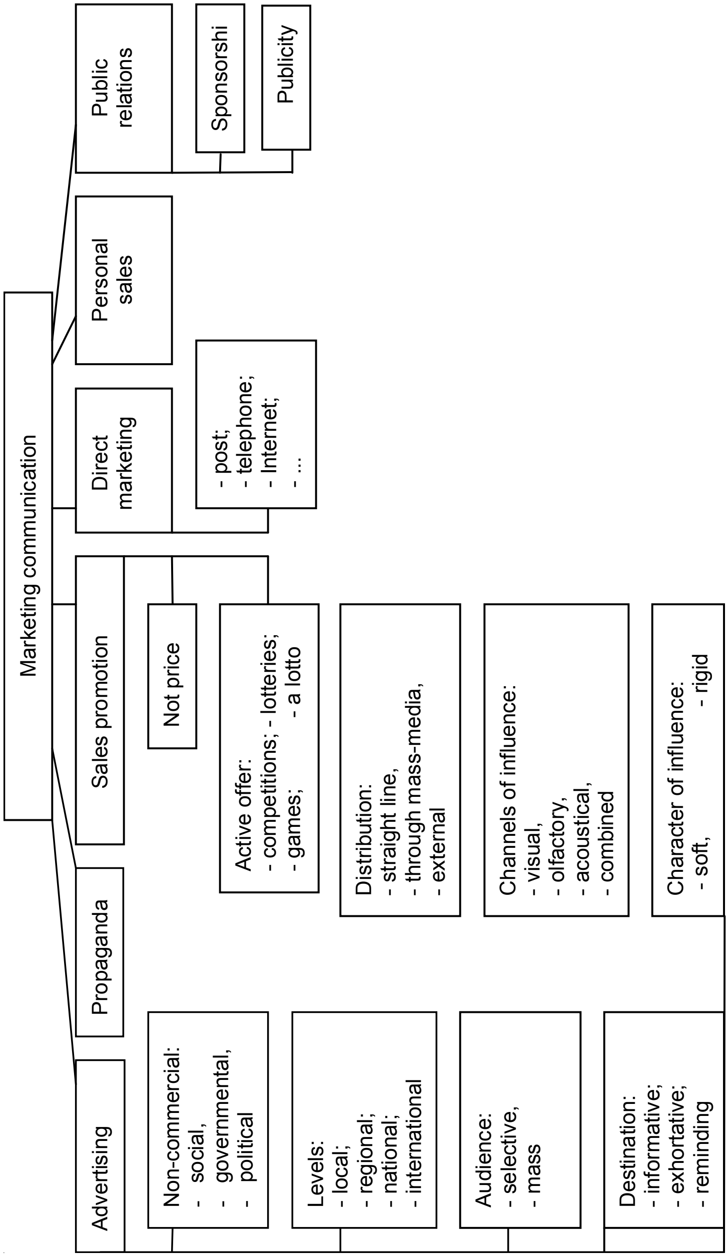

Figure 5.10.2: Marketing communication instruments used in non-profit marketing

As shown in table 5.10.1, sustainable development relates to scales.

Marketing instruments used include: advertising, personal sales, sales promotion, propaganda, public relations and direct marketing. Some of these instruments can be used to promote sustainable development (Figure 5.10.2). Each marketing instrument has its own characteristics. Moreover, different marketing instruments complement each other (Table 5.10.2).

In conclusion:

- to promote social and ecological worldview it is possible to use instruments of non-commercial marketing;

Table 5.10.2: Comparison of marketing communication instruments

Criteria	Marketing communication instruments					
	Sale promotion	Advertising	Direct marketing	Propaganda	Public relations	Personal selling
Influence period (T_{infl})	Short-term	Short-medium-term	Long-term	Short-term	Long-term	Short-, medium- and long-term
Receiving effect time (T_{ef})	$T_{infl} = T_{ef}$	$T_{infl} << T_{ef}$	$T_{infl} = T_{ef}$	$T_{infl} < T_{ef}$	$T_{infl} < T_{ef}$	$T_{infl} = T_{ef}$
Main idea	Selling	Information, attitude, image, selling	Information attitude, image, selling	Image	Attitude, image	Selling
Main stimulus	Emotional, rational	Emotional	Emotional, rational	Emotional	Emotional	Rational
Cost-efficiency	high	average	high	low	low	high

- sustainable development is a matter of scale (regional, national and international) and saving recourses;
- instruments for marketing can be used to promote sustainable development;
- scientific data can strengthen the marketing approach.

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[1] Abbreviations: SumSU – Sumy State University; CSPF – Council for Study of Productive Forces of Ukraine of NASU; NASU – National Academy of Sciences of Ukraine; MESU – Ministry of Education and Science of Ukraine; RAS – Russian Academy of Scienses; MSU – Moscow State University; APS – Academy of Pedagogical Sciences; DrE – Dr. of Economics; CES - Candidate of Economic Sciences; SR - senior researcher; pgs – post graduate student; Scs – sciences.

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