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ENVIRONMENTAL INDICATORS FOR SUSTAINABLE DEVELOPMENT AND INTEGRATED COASTAL ZONE MANAGEMENT

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The significance and scale of the global human footprint is not in doubt 42 years after adoption of the idea of sustainability by IUCN. The Earth's capacity to yield products for human consumption, to absorb or sequestrate human wastes and to yield ecosystem services is all limited. This put under question the need of development of new thinking about sustainability (M i l l e n n i u m…, 2005). The European policy toward the coastal regions aims at achieving sustainability by implementation of Integrated Coastal Zone Management (ICZM). This paper provides an analysis of the theoretical basis and interrelations between 1) Sustainability and sustainable development indicators; 2) A conceptual model for developing environmental indicators and indices and 3) The ICZM indicators and the EU policy for sustainable development (SD).

SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT INDICATORS

Sustainable development (SD) definition is under critical analysis since it was proposed in Brundtland Report (1987): "*Sustainable development* meets the needs of the present without compromising the ability of future generation to meet their own needs". However the original term "sustainable development," is a term adopted by the Agenda 21 of the United Nations. Agenda 21 is a comprehensive plan of action to be taken globally, nationally and locally by organizations of the United Nations System, Governments, and Major Groups in every area in which human impacts on the environment. The Commission on Sustainable Development (CSD) was created in December 1992 to ensure effective follow-up of the decisions from the United Nations Conference on Environment and Development (UNCED) held in Rio de Janerio, Brazil, 3 to 14 June 1992. As it is noted in the Millennium Assessment (2005), there is no agreed way defining extend to which sustainability is being achieved or not in any policy program. Sustainable development and sustainability stay ethical concepts, expressing desirable outcomes from economic and social decisions. The term 'sustainable' is therefore applied loosely to policies to express this aspiration, or to imply that the policy is 'greener' than it may be otherwise. Utility plays significant role in the over mentioned definition in terms that utility of the future generation is to be sustained and non-declining instead the physical throughput (H e r m a n, 2001). The concept of throughput forces the recognition of the constraints of physical law on economics and also it forces the recognition that "sustainable" can not mean utility for ever. Or, sustainability is providing for the best for people and the environment both now and in the indefinite future. The following definition of sustainability was proposed: "*Sustainability* is a means of configuring civilization and human activity so that society and its members are able to meet their needs and express their greatest potential in the present while preserving biodiversity and natural ecosystems, and planning and acting for the ability to maintain these ideals indefinitely" (M i l l e n n i u m…, 2005).

As a guiding principle for long-term global development, sustainable development consists of three pillars: *economic development, social development and environmental protection*. It is important to note that these three 'pillars' of sustainability cannot be treated as if equivalent because 'economic development' emerges from 'social development' and the 'environmental protection' is crucial for both social and economic development as a natural capital (the capacity of the ecosystem to yield both a flow of natural resources and a flux of life support natural services) and because environment includes both society and economy. Sustainable development as a concept of throughput requires increasing reliance on the renewable part of the throughput, and willingness to share the non-renewable part over many generations. Research development in field of ecosystem services and innovations in so-called 'green' technologies are basic for the successful implementation of any strategy aiming sustainability nowadays. This understanding was demonstrated also on the United Nations Conference on Sustainable Development Rio+20 which took place on 20-22 June 2012 in Rio de Janeiro, Brazil, aiming to shape a new policies and to promote global prosperity, reduce poverty and advance social equity and environmental protection. Seven areas which need priority attention and actions were recognized during the event: "decent jobs, energy, sustainable cities, food security and sustainable agriculture, water, oceans and disaster readiness" (R i o + 2 0, 2012). The importance of the implementation of the Sustainable Development Indicators (SDI) was underlined as an important system for monitoring of the progress of SD in each particular area.

The first set of SDI was adopted by the EU Sustainable Development Commission in 2005 and further reviewed in 2007 in order to be adjusted to the Sustainable Development Strategy (SDS), (2006). SDI are used to monitor the EU SDS in a report to be published by Eurostat every 2 years. The SDI framework is based on ten themes, reflecting the seven key challenges of the strategy, as well as the key objective of economic prosperity, and guiding principles related to good governance. The themes follow a general gradient from the economic, to the social, and then to the environmental and institutional dimensions. They are further divided into sub-themes to organise the set in a way that reflects the operational objectives and actions of the sustainable development strategy. In order to facilitate communication, the indicator set is built as a three-level pyramid. This distinction between the three levels of indicators reflects the structure of the renewed strategy (overall objectives, operational objectives, actions) and also responds to different kinds of user needs, with the headline indicators having the highest communication value. The three-levels are complemented with contextual indicators, which provide valuable background information but which do not monitor directly the strategy's objectives. The typology indicators, proposed by the European Environmental Agency (EEA) are divided in four types:

Type A: *descriptive indicators* of what is happening to the environment or human health eg emissions and concentrations of pollutants (nearly 60 of this type);

Type B: *performance indicators* linked to a reference value or policy target, illustrating how far the indicator is from a desired level (over 40 of this type);

Type C: *efficiency indicators* illustrating the efficiency of production and consumption processes, eg energy consumption per unit of output (only 8 individual indicators);

Type D: *total welfare indicators/indices* which aggregate together economic, social and environmental dimensions to illustrate whether, overall, welfare is increasing (no one).

The remaining indicators are either contextual indicators or those 'to be developed' in the future (N i k o l o v a, 2011).

The scientific basis on which SDI are build needs to be regionally tested and relevant to the specific environmental features of a given territory, like coastal or urban regions.

A CONCEPTUAL MODEL FOR DEVELOPING SUSTAINABLE DEVELOPMENT INDICATORS AND INDICES (CMDEII)

The term "*indicator*" traces back to the Latin verb "*indicare*", meaning to disclose or point out, to announce or make publicly known, or to estimate or put a price on. Indicators communicate information about progress toward social goals such as sustainable development. The indicators are *models of a more complex reality*, and so are systems of indicators.

Successful indicators have two defining characteristics and few additional characteristics. Defining characteristics requires to: 1) *Quantify* information so its significance is more readily apparent and 2) *Simplify* information about complex phenomena to improve communication. The additional characteristics are: 1) To reflect the goals a society seeks to achieve (*User-driven)*; 2) To be pertinent to policy concerns (*Policy-relevant)* and 3) The final indices must be few in number although the indicators may have many components *(Highly-aggregated)*.

Developing an indicator we need to: Identify societal values (e.g. clean water, rear species etc.); Identify key issues for each value because issues may apply to more than one value (loss of habitats); Develop pertinent assessment questions to help identification of what we need to measure (area at risk etc.); Select attributes that describe or measure the assessment questions (as changes of water quality); Evaluate attributes using 10 selection criteria: functional relevance, application relevance, sensitivity to change, standard method used, applies across space and time, low error in measure, reliable data, interpretable data, validated data, intelligible to end user; Select indicator using compliance with selection criteria (e.g. clear land in an affected area); Apply indicators and interpret maps.

Ideally choice and scaling of indicators would take into consideration regional variations in climate, land form, different land development patterns and environmental issues. To describe the environmental conditions we need indicators for water, land and biota conditions and all of them are expected to pass the selection criteria. The more criteria they pass, the more reliable they are. Each individual environmental indicator contains the following information: assessment question, indicator description, measure and units, impacts on what, source of information and data, scale and map. For example an individual indicator for the biota conditions is "native vegetation fragmentation". To assess this indicator we first have to formulate an *assessment question*: "What is the resilience and quality of areas of native vegetation?", than to *describe the indicator* as "native vegetation fragmentation" and to define it's *measure and units* as "native vegetation patches of > 50 ha as a percentage of the given area". This indicator provides information about the *impact* on the wildlife mobility and populations, invasion by weeds, biodiversity, connectivity etc.

The process of creation of the SDI is known as "Indicators Information Pyramid" (Fig. 1). The indices are aggregated from a set of primary environmental indicators, many of which are themselves aggregations of a number of similar data series, compressing a lot of information in a simple message. They are very useful tool for implementation of the SDS from decision makers on different levels of governance.

A number of models have been proposed for developing indicators, and illustrating the links between issues, particularly for environmental indicators. These models were developed primarily to help in understanding the interactions between the economy and the environment so they are not entirely appropriate for dealing with sustainable development. The best known of these is the "pressure, state, response" model developed originally by O E C D (1998). This model is also the basis of the United Nations Commission for Sustainable Development (UNCSD) framework of sustainable development indicators. It has been adapted by the European

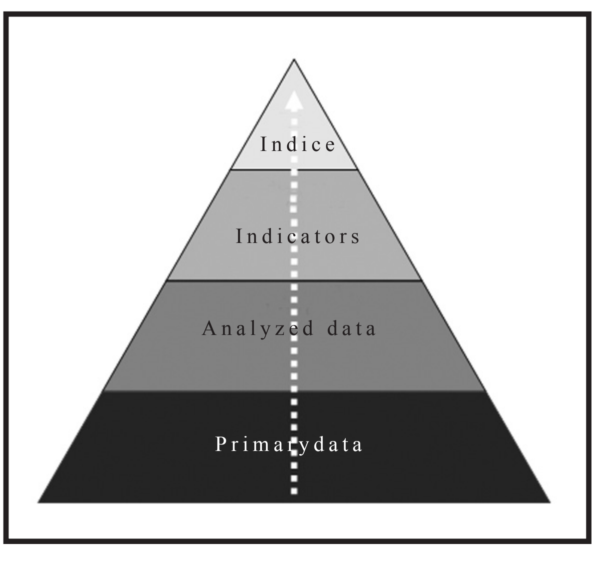

Fig. 1. Indicators Information Pyramid (B r e t o n e t a l., 2006)

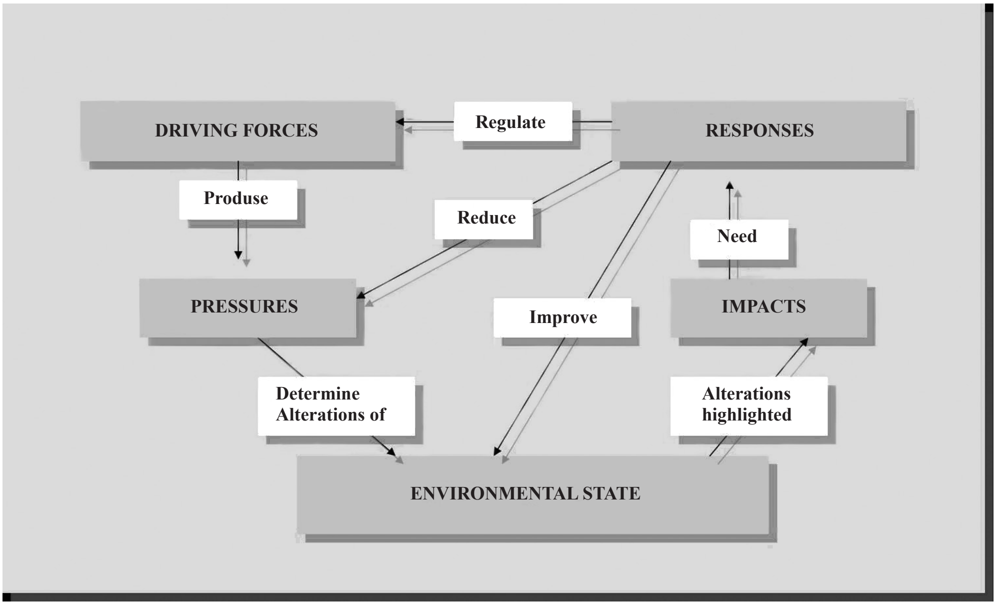

Fig. 2. DPSIR Model (after EU, 1999)

Environment Agency into the "DPSIR" model – Driving forces, Pressures, State, Impact, Responses.

According DPSIR terminology human developments (drivers, D) exert pressures (P) on the environment and, as a consequence, the state (S) of the environment changes (changes of ecosystems). This has impacts (I) on humans and the society (by less or changed provision of ecosystems services), which may elicit a societal response (R). This response may either target the drivers, the pressures, the state or the impacts on society via various mitigation, adaptation or curative actions (Fig. 2) (O d e r m a t t, 2004).

The CMDEII describes four interactions between human activity and the environment:

• Source - Driver: From the environment people derive natural resources for the economic activity, thus potentially depleting these resources or degrading the biological systems on which their continued production depends.

• Sink – Pressure: The natural resources are transformed by industrial activity into products and energy, thus creating pollution and wastes that flows back into the environment.

• Life support – State: The Earth's ecosystems provide essential life-support services ranging from decomposition of organic wastes to nutrient recycling to oxygen production and to the maintenance of biodiversity.

• Human welfare – Impact: Polluted air and water and contaminated food affect human health and welfare directly.

The Environmental index, Pressure index, State index and Response index track four broad types of human interaction with the environment (Table 1). The four indices are aggregated from more than 20 primary environmental indicators, many of which are themselves aggregations of a number of similar data series, compressing a lot of information in a simple message. They provide a comprehensive basis for national reporting and sustainability policy evaluation and can easily be communicated to the policy makers and the public.

A given conceptual model for development of environmental indicators does not represent the only way to organize the environmental information for this purpose. It does matter what is the scale of the observed territory and it's place in an administrative and political management structure. Environmental indicators can be developed for global, regional or national levels and also for a particular administrative unit or river basin or for coastal zones according to the particular political goals.

T a b l e 1

Matrix of Environmental Indicators – CMDEII

Issues	Pressure	State	Responce
I. Source indicators			
1. Agriculture – land quality – others	Value added/Cross output Human – induced soil degradation	Cropland as % of wealth Climatic classes & soil constrains	Rural/Urban terms of trade
2. Forest	Land use changes EDP	Area, volume, distribution	In/output ratio, main users
3. Marine resources	Contaminants, Demand for fish and Food Intensity of use	Value of forest Stock of marine species	Recyc. Rates % coverage of Int'l. Protocols/Conventions
4. Water		Accessibility to prop (weighted % of total)	Water efficiency measures
5. Sub-soils assets – fossil fuels – metals and minerals	Rate of extraction (s) Rate of extraction (s) Rate of extraction (s)	Sub-soil assets % wealth Proven Reserves Proven Reserves	Material balances NNP Reverse Energy subsidies In/Output ratio/ main usera
II. Sink or pollution indicators 1. Climate change – G – HG – Stratospheric ozone 2. Acidification	Emissions of CO_2 Apparent consumption of CFC's Emissions of CO_x and NO_x Use of Phosphates (P)	Atmospheric concentrations of GHG Atmospheric concentrations of CFCs pH and concentr. of SOx and NOx in precipitations	Energy efficiency of NNP % coverage of Int'l. Protocols/Conventions Expenditures on pollution Abatement % Pop. w/waste treatment

3. Eutrophication 4. Toxification	Nitrates (N) generation of hazardous waste load	Biological Oxigen demand, P,N in rivers Concentration of Pb, Cd etc. in rivers	% petrol unleaded
III. Life Support Indicators 1. Biodiversity 2. Oceans 3. Special Lands – wetlands	Land Use Change Threatened/ extinct species % of total	Habitat NR	Protected areas as % Threatened
IV. Human Impact Indicators 1.Health – water quality – air quality – exposures 2. Food security and quality 3. Housing/Urban 4. Waste 5. Natural Disasters	Burden of Disease (DALYs/ Persons) Energy demand Population density p/km^2 Generation of industrial/municipal waste	Life expectancy at birth Dissolved oxygen, faecal coli form Concentration of particulates, SO_2 etc. Accumulation to date	 % NNP spent on housing Exp. On collect and treatment Recyc. rates

Source: World Bank

THE ICZM INDICATORS AND THE EU POLICY FOR SUSTAINABLE DEVELOPMENT

The 6th Environment Action Plan (Parliament and Council Decision 1600/2002/EC) set out the objective for the EU to promote sustainable use of the seas and conservation of marine ecosystems, including coastal areas, and to encourage and promote effective and sustainable use and management of land and sea. The promotion of Integrated Coastal Zone Management was identified among the priority actions to achieve these objectives in 2002, (Implementation of Integrated Coastal Zone Management in Europe (2002/413/EC).

In 2003, the European ICZM expert group, set by the EC (DG ENV) recognized the importance of defining a group of indicators to assess the progress on the implementation of the ICZM process, and therefore created the "Working Group on Indicators and Data" (WG-ID). The WG-ID proposed that member States should use two sets of indicators: 1) Progress indicators: to measure the progress of implementation of ICZM and 2) Sustainability indicators: to measure sustainable development of the coastal zone.

In 2004, in order to further develop these objectives, the WD-IG launched the DEDUCE project (2004-2007). This transnational project, funded in the framework of INTERREG IIIC-South, had the purpose of evaluating “the utility of Indicators for an optimal decision-making at the coast, following the principles and criteria established by the EU Recommendation on ICZM“ 34. The project resulted in the definition of a set of 27 indicators. The indicators are divided into seven groups according to the seven goals of the EU ICZM Recommendation (Table 2). Taken together, the indicators in each group will help the European Commission, Member States and coastal partnerships to monitor progress towards achieving the goals for coastal sustainability set out in the EU Recommendation. The role of the present EU sustainability indicators for coastal zones is still subject for further research and dialogue. Present challenges are to:

- Investigate data-model integration possibilities in order to develop a set of sustainability indicators suitable for outlook reports.
- Link to priority issues at regional and local level through stakeholders meetings.
- Integrate with evaluation criteria of European legislation like Water Framework Directive and the Birds and Habitats Directives and coming EU regulations.
- Use innovative studies on coastal science-policy processes to define next steps.

T a b l e 2

Indicators of Sustainable Development of the Coastal Zone, proposed by the WG-ID.

GOALS	INDICATORS
To control, as appropriate, further development of the undeveloped coast.	1. Demand for property on the coast 2. Area of built-up land 3. Rate of development of previously undeveloped land 4. Demand for road travel on the coast 5. Pressure for coastal and marine recreation 6. Land taken up by intensive agriculture
To protect, enhance and celebrate, natural and cultural diversity.	7. Amount of semi-natural habitat 8. Area of land and sea protected by statutory designations 9. Effective management of designated sites 10. Change in significance coastal and marine habitats and species
To promote and support a dynamic and sustainable coastal economy	11. Loss of cultural distinctiveness 12. Patterns of sectoral employment 13. Volume of port traffic 14. Intensity of tourism 15. Sustainable tourism

To ensure that beaches are clean and the coastal waters are unpolluted.	16. Quality of bathing water 17. Amount of coastal, estuarine and marine litter 18. Concentration of nutrients in coastal waters 19. Amount of oil pollution
To reduce social exclusion and promote social cohesion in coastal communities.	20. Degree of social cohesion 21. Relative household prosperity 22. Second and holiday homes
To use natural resources wisely.	23. Fish stocks and fish landings 24. Water consumption
To recognise the threat to coastal zones posed by climate change and to ensure appropriate and ecologically responsible coastal protection.	25. Sea level rise and extreme weather conditions 26. Coastal erosion and accretion 27. Natural, human and economic assets at risk

Source: DEDUCE Project – Indicators Guidelines (2007).

The main challenge of implementation of the SD and CZIM indicators is availability of relevant and reliable data. That is why EU Maritime policy during the period 2007-2012 focuses on the data, information and knowledge exchange as priority action. The prototype European Marine Observation and Data Network (EMODnet) start to operate and provide data access through thematic portals (raw data, metadata and derived data products). It is a EU marine data infrastructure for delivering marine knowledge, assembling marine data, metadata and data products and facilitating their access and re-use. The prototype internet portals of EMODnet facilitating access to the collected data which are processed into'derived products'- contiguous data layers over the whole sea basin (M e i n e r, 2012). All data and map layers are freely available through six portals developed in 2010-2011:

• *Hydrography* – bathymetry (water depth) and topography, coastlines, underwater features (wrecks etc);

• *Geology* – seabed substrata, strata, coastal erosion, geological hazards;

• *Physics* – temperature, salinity, waves, currents, sea-level, water clarity (light penetration);

• *Chemistry* – concentrations of chemicals (nutrients and contaminants) in water, sediments and biota;

• *Biology* – distribution and abundance of living species;

• *Physical habitats* – classification of seabed habitats, based on physical parameters (water depth, light penetration, sediments etc.).

EMODnet is a Shared Environmental Information System (SEIS) which aims to create a decentralized but integrated and web-enabled, Europe-wide environmental information system. There is an official implementation plan for SEIS developed from the European Commission. It is about shifting the approach from individual countries or regions reporting data to specific international organizations and online systems with 'services' that make information available for multiple users (people *and* machines).

The integration of *space* monitoring data with corresponding *in situ* monitoring of water, biodiversity and physical-chemical parameters is provided by the European initiative for Global Monitoring for Environment and Security (GEMS). Additional support to the formation of EU knowledge base is provided from the European Monitoring and Data Network (EMODNET), the Water Information System for Europe (WISE-Marine), INSPIRE EU geoportal, the European Atlas of the Seas and other information systems and networks.

CONCLUSIONS

Sustainable development of the coastal areas in Europe is a matter of an integrated approach towards a systemic understanding of the marine and coastal ecosystems in a common maritime space under integrated monitoring and assessment. The coastal zone management needs ecosystem-based approach and integration of the marine regions and river basins. The maritime spatial planning and ICZM, including adaptation to climate change impacts and holistic management approach for all sea-related activities.

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ИНДИКАТОРИ ЗА УСТОЙЧИВО РАЗВИТИЕ И ИНТЕГРИРАНО УПРАВЛЕНИЕ НА КРАЙБРЕЖНИТЕ ЗОНИ

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(Р е з ю м е)

През 2005 г. беше публикувана оценката за състоянието на екосистемите на планетата (Millennium Ecosystem Assessment) и резултатите от тази оценка ясно показват, че екосистемите на планетата са променени в много голяма степен под влияние на човешката дейност. Капацитетът им да предоставят ресурси и блага и да абсорбират и преработват отпадъците е ограничен и това поставя в нова светлина необходимостта от преосмисляне на концепцията за устойчиво развитие. В статията е направен анализ на връзките между Стратегията за устойчиво развитие в Европейския съюз и Интегрираното управление на крайбрежните зони в контекста на теоретичния модел за анализ на състоянието на околната среда, известен като DPSIR: Drivers (Движещи сили) – Pressure (Натиск) – State (Състояние) – Impact (Въздействие) – Response (Ответна реакция). Посочена е ролята му като концептуален модел за създаването на индикатори и индекси за оценка както на устойчивото развитие, така и за оценка на нтегрираното управление на крайбрежните зони. Индикаторите и индексите са ключови инструменти в политиката на Европейския съюз за прилагане на стратегиите за устойчиво развитие и за

интегрираното управление на крайбрежните зони. Познаването на механизма, по който те са свързани помежду си, е важно условие за изграждането на необходимите бази данни, с които те оперират. Засега напредъкът на България в прилагането на тези индикатори и индекси, както и в изграждането на съответните бази данни е доста скромен. За да се промени това, партньорството между системите за управление на околната среда и научната общност е абсолютно необходимо.