Scientific Survey (WP8)

ICT for Environmental Sustainability concerning Key Area: “ICT for Sustainable Use of Natural Resources"

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1) Scope: Definition and Analysis of Key Area ICT for Sustainable Use of Natural Resources"

a) Overview of sub-categories included in the observed key area:

Considering ICT for sustainable use of natural resources such as sustainable land use for water, energy, food production the following subcategories can be identified:

- Functional analysis of catchments with respect to land- and water management,
- the collection and processing of hydrological and meteorological high resolution data with the aim of revealing mean- and distribution patterns.
- Evaluating the irreversible functions of the various landscapes as are irreversible material losses from the catchments from the topsoils to the sea with the water courses determining in part the sustainability of management and landscapes cover change
- Evaluating of damping properties and distribution patterns of the landscape including the vegetation with respect to temperature and evapotranspiration.
- Providing a dynamic regional basis for the evaluation of management cycles quality, control tools, and feedback information for transfer payments to achieve sustainable conditions in land management.

b) Analysis of key area concerning:

The most relevant key process for the sustainable development of the landscapes function is the energy dissipative water cycle on the earths surface and its contact to the various phase boundaries such as atmosphere, geological substrates and biological membranes and matter. Therefore an integrative holistic approach concerning all subsistence functions is chosen. On the one hand natural resources are reduced to the resources of daily needed subsistence. The basic resources for all societies are landscapes area, renewable energy (natural energy flow) and human intelligence providing the local production and maintenance processes. The distribution and coupling of these processes is determining the efficiency of the environmental-societal assemblage. All subsistence requirements are interlinked and subsumed under landscape-space, naturally provided energy, water, food, soil-fertility, atmosphere and climate (daily needs for everyone).

- The main problem of ecosystem stability (sustainability) is the degradation of harmonic functions in nature which is the opening of closed cyclic processes: Analysing system boundaries and cyclic processes in relation to system-immanent sources of randomness and irreversible losses "from the landscape to the sea". This can be achieved by the determination of space and time boundaries with minimized openness with respect to irreversible matter losses. Determining the courses of losses and loss preventing feedback loops and improving the integrity of cyclic processes.

- Priorities in management must therefore be taken for enhancing of permanent evapotranspiration by tree-vegetation achieving maximum evenness of cooling (temperature damping) and thereby minimizing seepage and ground water flow. Finding the bottlenecks of process control and delineating a process for relevant monitoring and management of the key parameters. These are determining the efficiency of the landscapes functions with respect to irreversible matter losses and cyclic metabolism.

2) Relevance

a) General importance of sustainability research in this key area

Sustainability research should deal with 1.) the function of the “physical hardware process nature”. In the natural production system of subsistence products (energy, water, food atmosphere, climate and soil fertility) linked to the 2.) socioeconomic “Software”of a market system carrying the human population (societal structures). Research on allocation mechanisms, recycling patterns and irreversible loss functions.

b) Scientific interest of ICT in the analysed key area

building up a monitoring-system in feedback to the natural production systems performance as a basis for:
an integrated management feedback loop providing a worldwide sustainable development despite of the local production needs of the daily requirements for the human population such as water, energy, food, atmosphere, climate (subsistency products).

c) Economic importance of ICT in the analysed key area:

Adjusting a regionalized management system with the aim of internalized subsistence functions poor in needs for transport logistics and irreversible material losses from land to sea of e.g. mineral salts and nutrients by improved system-internalized cycling.

d) Political relevance of ICT in the analysed key are:

Internalizing all subsistency functions according to a global set of physical and economic criteria for regionalized circulation systems is providing a flawless regional function as a basis for the sustainable development of the human population. The transparency of these production systems must be the basis for a future economic system providing sustainable development and intergenerative justice.

3) State of the Art - Detailed Analysis

a) Relevance of ICT in sub-categories af Key Area:

In which sub categories are ICTs of relevance:
Since the basis for most ICT applications are dynamic patterns of formation and progression of the systemic properties. Adapted space and time distributed networks at the front end are capable to provide the necessary heuristic processes for process identification and feedback control.
Energy consumption/efficiency: Closing feedback loops by improved control loops between instant energy demand and instant price structure for damping demand according to price information. KI control structures for peak damping. Information on actual demand and price structure maybe distributed instantly by the energy distribution networks

Sustainable Use of natural resources: Needed is:
1.) a time and space distributed information on temperature damping (satellite thermal monitoring e. g. Landsat channel 6) of thermal dynamics at the interface between ground and atmosphere (e.g. cooling by evaporable water in vegetation and soil structures).
2.) Information of matter flow by rivers from the catchments to the sea. Gauges with respect to flow and load. This monitoring is necessary to estimate the irreversible matter flow from land to the sea.

Climate Change: is best monitored by consecutive multitemporal measurement of the distribution and development of cooled and overheated parts of the landscape.

Agriculture: The impact of agriculture on irreversible changes in the landscape are estimated by information on multitemporal thermal distribution and by monitoring irreversible matter losses with respect to bases and nutrients carried away by groundwater and surface water fed rivers and water courses.

Biodiversity: is a (secondary) result of the distribution of the ecological functions in the area as well as distribution of hydrological and thermal gradients controlling structuring and the functions of the various habitats.

Landscape planning: Thermal and evaporation distribution is controlling wind speed and emissions of fine-dust. Thermal damping by evapotranspiration caused by the plant cover is probably the most hopeful approach to decrease emissions and emissions and thereby the ecological functions of cities as well as landscapes.

Sustainable Urban Development: Improving sustainable urban development can be achieved by internalizing subsistence structures and recycling facilities in cities and thereby facilitating sustainable urban development with less dependence on logistics.

Health: is improved by reducing the half life times of dust and airborne matter generating health risks by reducing emissions and immissions in the atmosphere controlling and optimizing evaporating vegetation structures, damping spontaneous climate variations.

Environmental Risk Management: The above named measures are felt to be the most important and efficient contributions to environmental risk management. They can be applied in a cost efficient manor by adopting ICT methods and approaches. Clandestine irreversible matter losses leading to increasing non sustainable local conditions can thereby be traced and avoided. The needed local and regional taskforce can be easily integrated in the network of regional planning and development.

- Space adapted control of production and distribution of subsistency systems can only be achieved in feedback to the spatial physical development

- What kind of relevance do they have (e.g. collection of data, processing of data, generation of knowledge, distribution of knowledge ...) The relevance of all these ICT actions should be seen as a unit, the relevance is always in feedback to the systems dynamics.

  Sampling information on systems quality by a multitemporal, multispatial monitoring of lifebased dissipation processes by evaporable “green” water distribution and local irreversible matter losses from the continental catchment areas.

- Overview of existing methods and tools automatic gauging of water and charge (dissolved matter) loading combined with analysis of multitemporal global satellite thermal- and topographic energy-distribution data (landscape energy, surface energy, heat capacity)

- Extent of application of discussed methods and tools
  References to innovative scientific approach.. These kind of ICT methods are hitherto only used within research projects. Complex analysis tools of landscapes based on diversity or other highly aggregated indices are used by national administration and planning units. However, these methods led to increased areas of nature protection but failed to provide the subsistency functions for society in a sustainable way.

b) Analysis of framework conditions

- Use of ICT discussed in other sustainability research areas: The ICT discussed should consists of two ICT tools of which the first tool enables and controls the payment of transfer money aimed for the land managers into a regional fund according to the load of bases and nutrients provided by water works and sewage treatment plants and land owners in villages or urbanized areas to the receivers.

  Loaded waters could easily be distributed to all kinds of land managers within a catchment with the purpous to evapotranspirate the water by means of vegetation structures. The second tool relies on the heuristics of multitemporally sampled thermal distribution data of the land surface observed by e.g. "Landsat channel 6" and augmented by point observations of surface temperature by gauges with high time resolution.

  According to temperature damping patterns instead of agricultural subsidies money from the fond can be distributed according to the individual temperature damping achievements of the land manager with the result of highly increased sustainable land management.

  Artificial fertilizing especially with nitrogen compounds can thus be omitted. With this two tools it should be possible to recycle all kinds of needed matter and keep it in places covered by vegetation. The allocation of the two most limiting agents in agriculture are at the moment water and nitrogen can be controlled in a much more adapted way. This internalized recycling of water containing nutrients and bases promotes the production of biomass and renewable energy media, building up at the same time fertile soil damping climatic extremata and droughts. The water cycles would be locally intensified and thermal overheating prevented by energy dissipative structures.

- The implementation of such ICT systems together with the technology transfer is probably much cheaper than any other approach because of the global availability of remote sensing and satellite data. Enourmous savings can be achieved shifting from dry greenhouse gases as the cause for the climatic changes to water and vegetation as the true climatic regulators and admitting that global energetics and earth atmosphere are depending on energy dissipative structures *sensu Prigogines* . Fighting global climatic change by means of changing land cover management seems far more promising than relying on simulations without knowledge of time and space distribution of energetic phenomena. Identifying CO2 as the most noxious compound is denying the overall life process as the basis for reducing irreversibility and sustainable development.
- Geographic, country-specific differences in Europe: Country specific differences in Europe with respect to sustainable development are mainly given by the legal framework enabling or hindering the recycling of material necessary to control vegetation and landcover and the losses of resources for the allocation of subsistency products.

c) Short overview of relevant sustainability indicators and policy background

- Overview of used Indicator Systems: Hitherto soil quality indicators have been widely used, however recent restoration work on landscapes as e.g. approaches within NSF (natural sequence farming) as carried out in Australia (Andrews, P. 2006)[1] showed clearly that soil is mostly not an object with certain properties, it is a functional dynamic interface between the geological substratum and the living vegetation cover controlled by the local water cycle patterns. Soil quality is mainly defined by its ability to retain and/or to evapotranspirate water mainly due to the organic and humic capillary structures and the demand for the mineral and nutrient storage by vegetation components.

  These dynamic behaviour of soils being part of the living system makes it extremely diffcult to state an indicative framework and universally applicable indicators.

Used Indicator systems providing classified distribution data for relevant transfer payings to land managers according to their results in stabilizing ecosystems are still rare. Various efforts on national basis. have been the tools of ecological footprints (Rees and Wackernagel 1994 [2], Narodoslawsky, M. & Krotscheck, C. (eds.) (1998) [3], Schmidt-Bleek (1992)[4] and e.g. Umweltbewertungsverfahren für die Landwirtschaft (1997) GD XI European Union).[5]

The use of complex aggregated indicator systems and indices seems however, to be inferior to heuristics on multitemporal observations and with high time resolution of few basic parameters like flows and loads and with high space resolution and showing dynamic distribution patterns of temperature data and remote sensing data as provided by satellite information (e.g. Landsat Envisat data).

4) Future Potential

a) Characterisation of potential and limitations of discussed ICT

Improved management of water and landscape areas for the production of drinking water and food, for sufficient clean water in rivers and lakes, for providing habitats with lowered ageing which is enhanced sustainability for all kinds of organisms and for achieving a stable basis for sustainable development of society in its national borders, become of increasing importance.

Subsidies for farming will be reduced in the near future and probably augmented or in part replaced by payments from society to land users for providing the basic processes of nature in an optimal distributed way. The processes of nature, as the local water cycle, the temperature damping function, the processes at the land-atmosphere interface ruling the composition and distribution of the atmosphere together with soil fertility and vegetation productivity are the basis of the sustainable society.

Therefore it is necessary to find integrative indicators for describing the spatiotemporal distributed changes in sustainability. Time and space distributed Indicators with short response time to changes of health and efficiency of integrated water and land (watershed-related) ecosystems are needed. At the same time it should be possible to use the same indicators for evaluating the positive efforts and achievements of areal management as a basis of payment to the land users. The flow of money through society which acts as system control at the interface between the ”hardware” shell of nature and the ”software” functions of society cannot be chosen deliberately but must correspond to the hierarchic structure of nature if the gap between national economics and business management should be closed and sustainability in the hardware processes of nature is a desirable target. The solution for these shortcomings may be the development of ICT ´s enabling feedback loops for structuring the subsidies in agriculture according to the achievements of increased sustainable management with improved water and matter cycling.

Sectorized approaches and linear management of nature and environment (agriculture, forestry, water-management, nature protection and landscape planning) have skewed the understanding of water and material cycles as the most important retention processes in the landscape. Despite increasing financial efforts, elaborate monitoring, the development of numerous complex evaluation-indices together with object-oriented indicators for ecosystem quality and rigorous legislation, landscape efficiency is still decreasing. This happens in a nonlinear way by randomizing natural patterns, opening short circuited cycles resulting in increased irreversible flow of dissolved nutrients and minerals (assets in the landscape but nuissance in rivers and lakes) necessary for the vegetation and its productivity from the topsoils to the sea. Habitats and coenotic structures are the result of coevolution and selforganisation were thereby steadily altered and in part irreversibly destroyed, lakes and rivers were eutrophicated and the course of water (local water cycle and run-off) with respect to its spatial and temporal distribution patterns were randomized and damaged.

Robust and quickly responding indicators which reflect landscape energetics and process distribution as the basis for the living structure shall be developed within the proposed project. They enable integrated monitoring approaches which reflect the dynamics of system ageing and direct feedback measures in water and landscape management.

The watercycle in the landscape is the most significant energy-dissipative process determining the areal functions of nature and their local dynamics. Monitoring the water cycle by means of areal temperature distribution and the local thermal damping properties combined with allready accessible GIS-information (land use patterns, a digital elevation model and water distribution models) combined with time related water runoff pattern in the various watersheds and the charges transported from the watersheds irreversibly to the sea provide the necessary information about landscape efficiency and its spatial and temporal distribution. Landscape efficiency, however, is a strong indicator for the ecosystem health, the functionality and sustainability of nature. This functionality results of the proper allocation of soil-, water-and atmospheric processes which are directly coupled to the water cycle and the transport and reaction paths for matter and its spatial and temporal distribution. Therefore this indicators in its spatiotemporal distributed form (seen as a heuristic process) are indispensable tools when sustainable land and water management is to be implemented with the target to improve both water quality, to dampen the runoff patterns and to increase retention of water in the landscape and to retain dissolvable material necessary for productivity of vegetation.

New desirable products can be offered by the land users to society which are clean water in lakes and rivers, the recycling of organic wastes, providing more even temperature distribution in the landscape by means of evapotranspiration and evaporation in the landscapes and regions and finally to keep up soil fertility and in part emission and immission control. By covering sites carrying scarce vegetation with more productive and increased vegetation biomass and enriching soils with organic humic substances, more water will be retained in the landscape favouring the water cleaning process by distillation instead of increased ground water flow. It will provide more and more even distributed water vapour in the atmospheric layers close to vegetation and soil thereby cooling the heat radiating solid interface, filtering the infrared radiation by absorbing water vapour, damping the greenhouse effect due to carbon dioxide and changing the carbon dioxide balance by increased photosynthetic carbon fixation in a most favourable way.

In this way, for all European countries the most important goal functions of the EU-framework for water will be met and could be pushed forward on a regional level according to the principle of subsidiarity without centralistic laws and law enforcement.

The objectives are based on the following theses:

1. Nature is a recursive, sustainability promoting, self-structuring process under the given general energy- and spatial conditions.
2. The natural functions necessary for society occur and are provided on the entire land surface. This includes the dissipative water balance (circulation) as a prerequisite for potential distribution of solar energy and temperature regulation on the landscapes surface, soil fertility (production, respiration, material retention) and the composition and distribution of the atmosphere.
3. Material flow has been dramatically increased by opening up the soils through meliorative intervention in the water balance and the vegetation cover of the landscape. The primary factor is charge-flow with stretches of running water, but the control of emissions, immissions and erosion by damping thermal potentials and enforcing vegetation biomass and productivity is of equal significance.
4. The quality of necessary natural functions is reflected by the extremata of land surface temperature and its distribution pattern on the one hand, by the drainage behaviour of individual catchment areas and material flow on the other.
5. Both temperature function and distribution of water circulation (quality and quantity) are determined by vegetation and water and its distribution in the soil. In this connection, the vegetation cover forms the most important energy dissipation processor for the landscape in interaction with the water balance. This has strong implications on the presumed greenhouse effect and the carbon dioxide balance.
6. In recognition of these points, an integrated water and land management action is necessary. This can only be achieved by land management specialists (farmers and foresters), if the management objectives include not only food production but also bringing purified water back into the landscape, providing drinking water from rivers, disposing of household organic waste in suited parts of the landscape, and thus optimize the maintenance of land surface-related natural functions with minimised material loss.
7. An innovative spatiotemporal indication system describing the basic functions of nature in efficiency terms is a prerequisite for sustainable water and land management.

The further development of sustainability consciousness with the objective of promoting a sustainable system development necessitates focusing more on the functionality of a healthy nature. This is closely related to the land surface and land cover. The performance of nature must be prioritised on a maximum of the landscapes surface, i.e. in the managed cultivated land and as far as possible also in residential, industry and traffic areas, since the performance of nature is the basis of society and must be maintained in the long run. In order to increase the chances for sustainable solutions, the biophysical prerequisites for social and economic developments must be reestablished and given more weight in decisions (Folke & Falkenmark, 1998, S. 274)[6].

b) Research demand concerning ICT in the relevant key area

Until today, a more structural perspective of nature has been predominant, with the effect that rarity, variety, uniqueness, etc. of animal and plant species were the almost only criteria for protection measures. Protection measures were implemented for habitats or for certain means of land management only as long as these species were involved. In many of these cases, nature was preserved in an artificial state. Nature as a dynamic, sustainability-increasing process is, however, in constant change and develops from less durable to more durable structures with a constantly improving, i.e. increasingly short-circuited material circulation.

Accounting for a dynamic system, local and temporal changes are to be classified The landscape analysis will therefore be based on a synthesis of punctual measurements highly resolved in time, pattern recognition of the time series and the identification of the sources of temporal variance.

- This will be accomplished by continuously measuring observation probes (gauges) placed in the landscape at different sites measuring (water table fluctuations and water levels of rivers) for water level and run-off determination by pressure sensors.

- Temperature sensors with high time resolution arranged in four channels and placed at different sites at 10 cm below soil surface, at soil surface, 10 cm above soil and 200 cm above surface level.

- Conductivity probes with compensation 4 electrode circuitry are placed in brooks and rivers to register the charge flow.

All these probes work with a measuring interval of 20 minutes. Since each probe has a clock function, all measurements can be carried out synchronously in all sites and in all participating landscapetypes.

- At the same time the irreversible charge flows from the different catchments and subcatchments can be derived from the probe information for run-off and charge density (conductivity).

- Additionally chemical analyses for all anions of significance (alkalinity, sulphate, chloride and nitrate) for the cations (protons, calcium, magnesium, sodium and potassium) together with the nutrients (total phosphorus, total nitrogen and silica) and the metals (iron and manganese) will be carried out 6 times a year in order to get the autocorrelation functions and correlated patterns to conductivity measured with high time resolution.

- The chemical efficiency as a measure for the retention of the various catchments are thereby derived and delivered as maps. Landscape process efficiency can also be estimated on the basis of catchments and subcatchments by estimating area gross-productivity in terms of locally cycled protons per area and time (on a yearly basis), irreversible losses in terms of proton equivalents = positive charges and organic carbon ($1C=2H^+$) with the rivers.

- With the use of temporal high-resolution probes for observing the water balance, conductivity and temperature, land processes today can be registered relative easily, and their deviation in space and time can be analysed. Material outflow patterns of the landscape are measured supplementary with physical-chemical monitoring of outflowing water.

Account for multi-temporal space distributed pattern recognition with high spatial resolution and low time resolution by evaluating satellite scenes taken by Landsat.

- The thermal channel 6 and the visual channels are of special interest for the estimation of land use patterns.
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- The temperature data will be corrected for the radiation properties of different surfaces and sites. The evaluation will be done with the aim, how spatial temperature potentials are distributed and how they change during the various seasons.

- 12 scenes for all sites will be evaluated in a multi-temporal mode. The GIS (Geographical Information System) of land use and the GIS of energy dissipation (cooling) performance are the basis for the estimation of the landscapes thermal efficiency, which is closely related to water retention and the capability for evapotranspiration.

- The thermal dampening factor in the landscape is mediated by water, which can evaporate from soil and can be actively evapotranspirated by vegetation. The resulting water cycle should be as short circuited as possible to equalise day- and night-temperature.

- Local thermal time series were used to characterise various habitats by Ripl et al. (1995)[7] and by Hildmann (1999)[8]. Patterns of overheated (hot spots) and cooled parts of the landscape together with low and high temperature variances can be resolved. This patterns are directly related to local water distribution, evaporative capabilities and seasonal changes in the landscape as well as emission and immission areas according to the thermal potentials.

- The indicator of thermal efficiency has extremely short time lags and is therefore an excellent estimator for intensity and distribution of landscape processes.
- This approach uses as a reference the digital elevation model, which can be combined to produce a distributed water flow model showing space distributed natural sites for wetlands and other land-cover formation. It can be combined with the evaluation of spatially highly resolved satellite scenes in a multi-temporal way to produce the thermal efficiency information and its changes.
- From this reference and the actual efficiency dynamics, the bottlenecks of the landscape can be identified and assembled to a map showing landscape deficiencies. The distribution of deficiencies with respect to material retention due to the vegetation cover and the dissipative properties of the water in the landscape can be derived.

Examination of matter and energy fluxes

The ‚sustainable usability‘ of a landscape for plants, animals and humans is determined essentially by the ratio between cyclic matter flow processes and irreversible matter loss processes of a spatial and temporal defined region. For the estimation of this ratio two approaches, different in their spatial and temporal resolution, can be used:

A) Estimation of matter- or chemical efficiency

The estimation of chemical efficiency for a catchment needs a heuristic process. It needs to differentiate land use classifications with respect to the time course of matter turnover and distribution features. The chemical efficiency of a landscape is represented by the ratio between the total area matter turnover and the matter loss processes – each of them in proton-equivalents. Total turnover is mainly controlled by production and respiration of vegetation, matter losses mostly occur with run-off. Area chemical landscape efficiency is the standardised specific chemical energy flow in energy units of proton-equivalents. The irreversible matter losses (cation equivalents and organic carbon) must be converted into energy units of proton fluxes for a specific area (equivalents /(ha*a)) and are expressed in the simplified formula:

chemical efficiency = (matter turnover – matter losses) / matter turnover

To improve knowledge about the spatiotemporal distribution of biological matter turnover for most parts of the world and the various land use patterns, the heuristic process of consecutive pattern recognition is needed. Until now especially the quantity of matter, which is irreversibly lost from the landscape with the watercourse is estimated by measuring run-off and conductivity in highly resolved time series. The matter loss is closely related to the spatial and temporal distribution of run-off in a catchment. Catchments are especially suitable as system boundaries, because they form an area with directed water flow, mediating the matter transport. A spatial estimation of chemical efficiency is more precise for larger catchments with good conditions to estimate the water flow in a precise way.

B) Estimation of thermal efficiency

The second approach is derived by estimating energy dissipation of a managed landscape through evaporation and condensation of water, especially by evapotranspiration of vegetation. The damping of the daily energy pulse in the landscape is estimated from the landscapes surface temperature (black body radiation) and its spatial distribution. Because the quality of the systems energy dissipation is reflected by improved spatial and temporal temperature distribution processes, the formula for the estimation of thermal efficiency consists of two parts. The first one is the mean or median of temperature, which represents the spatial part, and the second one is the amplitude of temperature, which reflects the temporal part or temporal dynamic. Simplified the thermal efficiency is described by the formula:

thermal efficiency = (mean of temperature – amplitude of temperature) / mean of temperature

Until now a so-called pixel based thermal efficiency was estimated by the black body temperature of a landscape, which was derived from satellite data in a multi-temporal mode. Statements about the dissipation of energy by means of evaporation and condensation for areas of 120m by 120m can be evaluated and the method is therefore specific for temperature distribution patterns in local areas. The estimation of thermal efficiency show regions with better or worse energy dissipation by the water cycle. As low run-off, high evaporation and the cooling of the landscape are correlated, there is also a positive correlation between high thermal efficiency and low matter losses.

The estimation of the chemical and thermal efficiency in spatiotemporal delimited landscape systems
needs knowledge about the distribution of energetic, matter transport and reaction processes in the landscape. The basis for this knowledge is the observation of these processes in spatially delimited catchments, which shows a directional water and matter flows. Observations has to be made in the more closed cyclic intervals of the natural dissipation process (daily and annual cycles).

After a sufficient observation period landscape process efficiency as a measure for sustainability can be derived from the temperature, precipitation, ground-water table and run-off changes.

Prerequisite for the reduction of material losses from the landscape by an improved local management is a monitoring-tool. This tool must provide the spatiotemporal distributed material loss patterns. Goal for estimating the efficiency terms is to depict and to identify the local processes as the basis for a more adequate management in order to improve the sustainability on site.

Such an approach should lead to a better understanding of the distributions of material flows in the various regions. The water quality within the watershed will be linked to socio-economic activities. In a participatory process the priorities for land-use (including diffuse pollution) and land-cover changes will be set. Methods for regional interpretation of watershed analyses, stakeholder participation, priority setting and regional implementation are to be developed. In the medium term detection, monitoring, assessment and implementation instruments are established in the region. The models have to be indicative on regional level as well as on the level of the problem/socio-economic activity and have to include the ecological, social and economic dimension of changes (e.g., Narodoslawsky et al. 1998)[3]. The development of regional indicators for monitoring and evaluation will be part of the research.

The coupling of regional landscape process efficiency models with technologies to close nutrient cycles between urban and rural areas and the analysis of the agricultural and industrial potentials of new patterns of land use will ensure sustainable water management and long term soil fertility. The combination of regional landscape process efficiency models and technologies to use green biomass, forestry products and short rotation systems should help to couple possible additional sources of income in rural areas with high landscape process efficiency.

The method will analyse the results of previous experience according to the following aspects:

- identification of types of regional stakeholders for LUCC,
- identification of information needs and information channels to reach these stakeholders,
- syntheses of an information strategy to relay relevant natural science information to the stakeholders,
- development of a method to reflect stakeholder decisions in scenarios based on natural science analyses,
- syntheses of priority measures to attain sustainable land use in the view of water management,
- the transferability of the interaction model to the different regions is discussed in an international project forum.

This analyses will lead to the construction of a regional negotiation process based on the findings of water balance based landscape analyses that is necessary (1) to build awareness, (2) select and (3) implement sustainable regional development in the ecological dimension under the constraints of social acceptance and economic welfare:

(1) the assessment of cross-media substance flows on the regional scale must end up in maps with classified areas; areas with low ecological efficiency have to be focused on; it is important to link the results of the analyses with socio-economic activities, which are the cause of the disturbance (state – level)

(2) the negotiation of alterable activities (its effects on different levels) has to encompass regional authorities and concerned stakeholders; some activities with high ecological pressures have a high cultural or economic impact; the project must create possibilities to search for regional priorities with view to the ecological burden as well as the social and economic welfare (pressure – level)

(3) Selected areas within the region will be part of structural change; a method has to be developed to design LUCC in the region more sustainable; the question of implementation has to deal with stakeholder analyses, power analyses and legal constraints (response – level)

The exciting cultural landscape has a great variety and charm. Within the development of the regional vision the preservation of this characteristic landscape was one of the priorities, although many of the land-use patterns are not sustainable.

The water balance based landscape analyses for strategic environmental assessment in the various case study regions will be used as the starting point of a controlled land-cover change and monitoring process. Areas of unsustainable cultivation methods or high industrial pollution have to be found and evaluated. It is the task of the various ICT developing institutes to develop and set up integrated management tools for LUCC (e.g., LUCC 1997)[10] together with regional authorities as well as persons affected. The R&D projects will build on promising preliminary work to establish a Regional and Local Agenda 21 process on different hierarchical levels.

To make knowledge accumulation on the regional scale a permanent process, a method for monitoring, evaluation and feedback in the field of LUCC should be developed for each case study region. The feedback cycles and time series of the monitoring process should enable a basic understanding of pressure-state-response chains. In this respect the knowledge on how projects and programs can affect LUCC as well as their dependency on socio-economic constraints is accumulated. At this level a ‘regional learning’ process is achieved.

The decision support system is based on the local information about the dynamics of the landscape rather than on sectored knowledge. Such a system has to meet the following requirements: It has to be easily accessible for the authorities, the water and land managers and the public preferably in local home pages providing maps, which show changes in water balance and material loads in rivers and water courses.

Important is a referenced (heuristic) data base and an electronic manual containing the needed software, which can be offered on a CD-ROM for self-instruction. For implementation of the Decision Support System on various local levels the establishment of a dense national and European network is needed. This network contains continuously updated tables and maps in sufficient resolution and can be used locally.

c) Importance of relevant research fields for future research programmes

According to my own experience the most important field of research and development with respect to natural resources is the research on the most important energy dissipative medium “Water” It does not make much sense to separate water research in quantitative (hydrological) and qualitative (limnological) research since it was repeatedly shown that strong feedback interactions are to expect between these matter subjects. Life sciences on any level try to explain the life processes by neglecting in part the basic properties of water as are charge separations, chemical reactivity and the ability of water to mediate mattercycles. Large effort in water science is necessary to correct the most basic flaws in water management as are the waste water treatment and the discharge of needed matter in the landscape towards the sea converting sustainable management into irreversibility. This is also the case with climate change modelling where the water cycles and the temperature damping role of evapotranspirating vegetation for temperature regulations are neglected.

5) Networking Activities

Remark of the ICT-ENSURE Project Consortium: Information about national research programmes, organisations, research institutions and experts contacts has been collected, but will not be displayed in this public website-version of the survey. Some of the information will be available on the research programmes information system.

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Procházka Jan$_1$, Pavlína Hakrová$_1$, Jan Pokorný$_2$, Emilie Pecharová$_1$, Tomáš Hezina$_1$,Martin Šíma$_3$ and Libor Pechar$_{1,2}$ 2008:-
Effect of different management practices on vegetation development, losses of soluble matter and solar energy dissipation in three
small mountain catchments.
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ANNEX I - Examples for ICT-fields relevant for ICT-ENSURE

7) Importance of ICTs for sustainable use of natural resources

Please explain the importance of these Technologies in the area of sustainable use of natural resources:

Short name	Importance*	Application for…
Information management	++	Temperature damping by evapotranspiration Increased local retention of soil components and Increased local recycling between vegetation and environment.
Artificial intelligence, knowledge management	++	Heuristics in pattern distribution and dynamics (surface temperature, chargeflow in catchment based watercourses)
Human-computer-interaction	++	To show dynamic trends and feedback interactions in tables and graphs and to adapt transfer payments to environmental achievements of landmanagment
Personalised information, eLearning	+	To increase understanding of natures interface with society. The role of concentrations and flow in local and regional natural energetics.
Communication, networks, Internet	++	Automatized allocation, distribution and transmission of sensor- and actor-data and their time and space distributions
Integration, inter-operability, services	+	The ICT technology has to be adapted and dynamically adjusted to the local and regional conditions.
Cooperative systems	+	A good documentation of these R&D is very favourable
Modelling and simulation	0	Lacking knowledge about the actual data distributions and dynamic feedback makes these method hardly reliable

Monitoring & control, sensors	++	Are always improved and refined and should therefore be adapted and always improved
Geographical information, GIS	++	Is a most useful tool for handling multitemporal space distributed satellite data, pattern recognition and evaluation of pattern dynamics
Mobile systems	+	Is of secondary importance

***Importance:**

0 not important
+ important
++ very important

Explanation of ICTs:

Explanation of ICTs:

Short name	**Additional Info**
Information management	Incl. Information systems, data bases, metadata catalogues …
Artificial intelligence, knowledge management	Incl. decision support systems, expert systems, planning systems, cognitive systems, agent systems…
Human-computer-interaction	Incl. Human-computer-interface, visualisation, computer graphics, ergonomics, multimedia, barrier-free access, rich Internet applications …
Personalised information, eLearning	Incl. generation of personalised information, knowledge transfer …
Communication, networks, Internet	Incl. Web-based systems, portals, wireless telecommunication …
Integration, inter-operability, services	Incl. services concepts, SOA, service infrastructures, distributed systems, GRID, ubiquitous computing, pervasive computing …
Cooperative systems	Incl. CSCW, Web 2.0, social Web …
Modelling and simulation	Incl. methods and tools, applications …

Monitoring & control, sensors	Incl. monitoring networks, sensor webs, remote sensing, measurements …
Geographical information, GIS	Incl. location-based information, visualisation of geogr. Info …
Mobile systems	Incl. mobile phone and PDA based systems …

ANNEX III - Environmental Sustainability Fields relevant for ICT-ENSURE

Climate Change: is best monitored by consecutive multitemporal measurement of the distribution and development of cooled and overheated parts of the landscape.

Agriculture: The impact of agriculture on irreversible changes in the landscape are estimated by information on multitemporal thermal distribution and by monitoring irreversible matter losses with respect to bases and nutrients carried away by groundwater and surface water fed rivers and water courses.

Biodiversity: is a result of the distribution of the ecological functions in the area as well as distribution of hydrological and thermal gradients controlling the functions of the various habitats.

Landscape planning: Thermal and evaporation distribution is controlling wind speed and emissions of fine-dust. Thermal damping by evapotranspiration is probably the most hopeful approach to decrease emissions and emissions and thereby the ecological functions of cities as well as landscapes.

Sustainable Urban Development: Improving sustainable urban development can be achieved by internalizing subsistence structures and recycling facilities in cities and thereby facilitating sustainable urban development with less dependence on logistics.

Health: is improved by reducing the half life times of dust and airborne matter generating health risks by reducing emissions and immissions in the atmosphere controlling and optimizing evaporating vegetation structures, damping spontaneous climate variations.

Environmental Risk Management: The above named measures are felt to be the most important and efficient contributions to environmental risk management. They can be applied in a cost efficient manor by adopting ICT methods and approaches. Clandestine irreversible matter losses leading to non sustainable conditions can thereby be traced and avoided. The needed local and regional taskforce can be easily integrated in the network of regional planning and development administration.