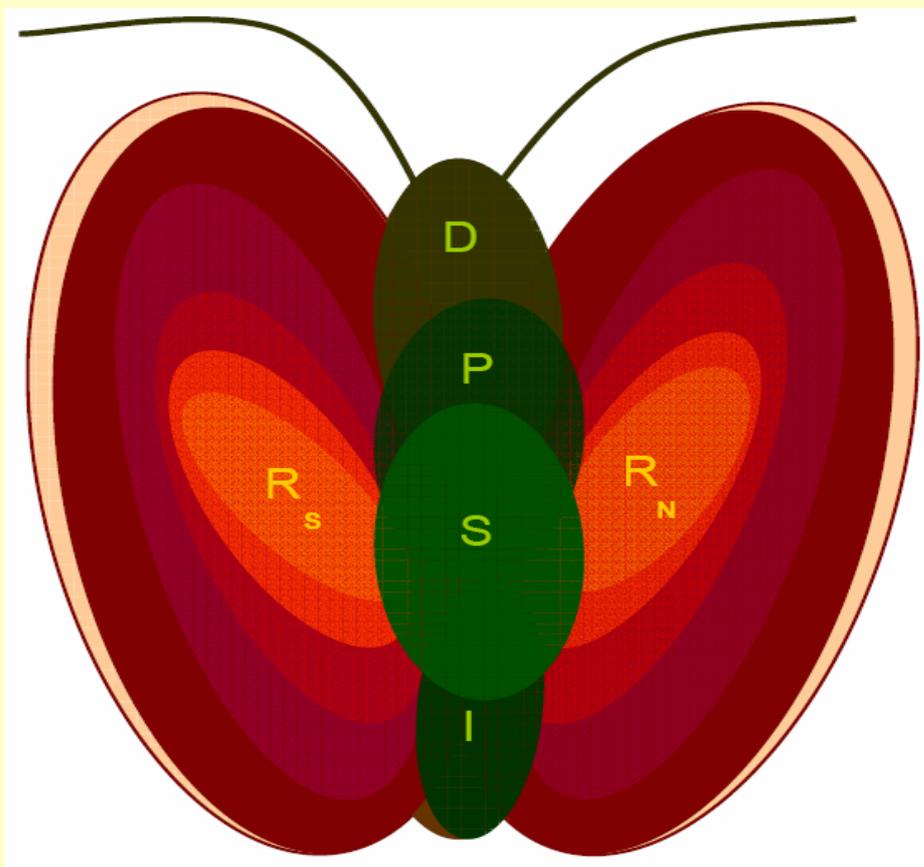


*Strategies and Actions for  
Common Research*

**SACRE**



**CIENS**

**FORSKNINGSSENTER FOR MILJØ OG SAMFUNN**  
Oslo Centre for Interdisciplinary Environmental and Social Research





## PREFACE

“Strategies and Actions for Common Research” (SACRE) is the first long-term plan for common research in the Oslo Centre for Interdisciplinary Environmental and Social Research (CIENS). CIENS is a co-operation between autonomous research institutes and the University of Oslo (UiO), governed by the CIENS Leader Group (CLG). CIENS can act as a legal entity, a foundation, in collaborations and co-ordinated projects.

From October 2006 CIENS will house more than 500 persons in the Oslo Research Park on the UiO Campus. The CIENS partners are: Center for International Climate and Environmental Research – Oslo (CICERO); The Norwegian Institute for Water Research (NIVA); Institute of Transport Economics (TØI); Norwegian Meteorological Institute - Research and Development (met.no); Norwegian Institute for Urban and Regional Research (NIBR); Department of Geosciences, Meteorology and Oceanography Section, UiO (MetOs-UiO); Norwegian Institute for Nature Research (NINA); Norwegian Institute for Air Research (NILU). The Norwegian Water Resources and Energy Directorate (NVE), Division for Hydrology, is an associated member. CIENS partners encompass relevant groups at UiO that will not be moving into the CIENS building. At present this includes hydrologists, chemists, biologists, political scientists, economists, and geographers.

SACRE is the result of an ongoing process that started in 2003 as an integrated part of CIENS. The process has received input from all CIENS partners and co-operating groups at UiO. The publication of SACRE is the third milestone in the process. The first was the preparatory document “ECCO” of May 2003. The second, the completion of a framework plan: “Felles fagprogram for Miljøforskningssenteret ved UiO” in March 2004, represented the end of Phase 1. SACRE ends Phase 2, which received financial support from the Research Council of Norway.

SACRE is based on existing strategies amongst the CIENS partners, the added value brought about by co-location in the Research Park at the UiO Campus, and joint resources. The plans conform well to prevailing Norwegian research policy as presented in two recent Government white papers [(1) Report No. 20 (2004-2005) to the Storting “*Commitment to Research*” and (2) Report No. 21 (2004-2005) to the Storting “*The Government’s Environmental Policy and the State of the Environment in Norway*”], and the Government’s Declaration from 13 October 2005 on a political platform for a majority government.

After an Executive Summary, SACRE contains two main sections. Section I, *General Aspects*, covers underlying principles, strategies and actions, and briefly discusses conditions for a successful implementation. Section II, *Common Research Themes*, presents six research themes. There is a further detailed annex to SACRE intended for internal planning use. The text has been developed by interdisciplinary working teams representing the CIENS partners and relevant groups at UiO. SACRE has been subjected to two rounds of internal review amongst the CIENS partners.

The six CIENS common research themes and associated theme leaders are:

<i>Climate change</i>	<b>Frode Stordal,</b>	MetOs-UiO/NILU
<i>A sustainable atmosphere</i>	<b>Øystein Hov,</b>	met.no/MetOS-UiO
<i>Integrated river basin and coastal zone management</i>	<b>Kari Nygaard,</b>	NIVA
<i>Urban sustainability</i>	<b>Vibeke Nenseth,</b>	NIBR
<i>Sustainable mobility</i>	<b>Claus Hedegaard Sørensen,</b>	TØI
<i>Ecosystem products and services</i>	<b>Bror Jonsson,</b>	NINA

Main contributors to each theme are co-authors of the theme descriptions in Section II. Trond Iversen, MetOs-UiO/met.no, has led the SACRE project, with Jan Vidar Haukeland, TØI, and Haakon Thaulow, NIVA, as co-leaders.

On 16 January 2006 the CIENS Leader Group (CLG) unanimously adopted SACRE as the plan for common research in CIENS until 2012. CLG is responsible for determining the procedures for updating SACRE.

Oslo, 16 January 2006

*Haakon Thaulow*

*Trond Iversen*

*Jan Vidar Haukeland*

## SELECTED ABBREVIATIONS AND ACRONYMS

ACIA	Arctic Climate Impact Assessment
AMAP	Arctic Monitoring and Assessment Programme
CICERO	Center for International Climate and Environmental Research - Oslo
CIENS	Oslo Centre for Interdisciplinary Environmental and Social Research
CLG	CIENS Leader Group (in principle: the Directors of CIENS Partners)
CLIVAR	Climate Variability and Predictability (under WCRP)
CZM	Coastal Zone Management
CLRTAP	Convention on Long-Range Transboundary Air Pollution
DIVERSITAS	An International Programme for Biodiversity Science
DPSIR	Drivers-Pressures-State-Impacts-Response
EEA	European Environmental Agency
ELOISE	European Land Ocean Interactions Studies
ESPON	European Spatial Planning Observation Network
GEOSS	Global Earth Observation System of Systems
GEWEX	Global Energy and Water Cycle Experiment
GMES	Global Monitoring for Environment and Security
GOOS	Global Ocean Observing System
GTOS	Global Terrestrial Observing Systems
GWPS	Global Water System Project
HELCOM	Baltic Marine Environment Protection Commission
HYCOS	Hydrological Cycle Observation System
IAHS	International Association for Hydrological Sciences
ICES	International Council for the Exploration of Sea
ICSU	International Council of Science
ICWRS	International Commission on Water Resources Systems
ICZM	Integrated Coastal Zone Management
IES	Institute for Environment and Sustainability, JRC, Ispra, Italy
IGAC	International Global Atmospheric Chemistry Project
IGBP	International Geosphere-Biosphere Programme
IHDP	International Human Dimension Programme
IHP	International Hydrological Programme
IIASA	International Institute for Applied System Analysis, Laxenburg, Austria
ILEAPS	Integrated Land Ecosystem-Atmosphere Processes Study
IOC	Intergovernmental Oceanographic Commission
IPCC	Intergovernmental Panel on Climate Change
IPY	International Polar Year (2007-2008)
IRBM	Integrated River Basin Management
IWRM	Integrated Water Resources Management
LOICZ	Land-Ocean Interactions in the Coastal Zone
LUCC	Land-Use and Land-Cover Change
MetOs-UiO	Meteorology and Oceanography Section, Department of Geosciences, UiO
Met.no	Norwegian Meteorological Institute
NCC	Norwegian Climate Centre (virtual centre for geophysical climate research)
NIBR	Norwegian Institute for Urban and Regional Research
NILU	Norwegian Institute for Air Research
NINA	Norwegian Institute for Nature Research
NIVA	Norwegian Institute for Water Research
NOOS	Northwest Shelf Operational Oceanography System
NVE	Norwegian Water Resources and Energy Directorate
OSPAR	Convention for Protection of the Marine Environment of the North-East Atlantic
RCN	Research Council of Norway
SACRE	Strategies and Actions for Common Research
SOLAS	Surface Ocean-Lower Atmosphere Study
SPARC	Stratospheric Processes And their Role in Climate (under WCRP)
TØI	Institute of Transport Economics
UiO	University of Oslo
UNEP	United Nations' Environment Programme
UNFCCC	United Nations' Framework Convention on Climate Change
WCRP	World Climate Research Programme
WFD	EU Water Framework Directive
WMO	World Meteorological Organisation

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## EXECUTIVE SUMMARY

*The vision for CIENS (Oslo Centre for Interdisciplinary Environmental and Social Research) is to be internationally highly valued for interdisciplinary environmental and social research producing knowledge, education, and innovation as a basis for decisions for sustainable development.*

The **Strategies and actions for common research (SACRE)** are the vehicle for interdisciplinary research on six themes involving basic and applied research. The research is quality assured by traditional standards in basic disciplines, as well as by innovative interactions between these. These interactions constitute the “Drivers – Pressures – State – Impacts – Response” (DPSIR) philosophy for research in CIENS (Fig. A). DPSIR also generates the knowledge base for sustainable development that balances the need for social equity with the limitations imposed by economic production and environmental protection.

### CIENS STRATEGIC INPUT

The **CIENS strategies** (orange in Fig. B) are to realize the potential inherent in CIENS, by

- benefiting from the co-location of leading Norwegian institutes in the Research Park;
- enabling symbiosis between basic research at UiO and applied research in institutes;
- exploiting the resources brought into CIENS: field data, model data, and competence.

### CIENS ACTIONS

**SACRE defines the CIENS actions to reach its goals** (red in Fig. B) as concrete activities that promote interdisciplinary research on the natural environment and its dynamic relations with society, and include *inter alia* to:

- organize research groups in selected themes based on the DPSIR-philosophy;
- carry out research projects in co-operation with relevant research groups at UiO;
- promote publishing in high-impact scientific journals in basic and interdisciplinary fields;
- seek impact by involvement in national and international science programmes and projects;
- co-operate with UiO on educational programmes and a PhD-level research school;
- publicly disseminate results in popular journals, brochures, newspapers, and media;
- commercialize products, by e.g. project-based co-operation in the private sector;
- promote transfer of knowledge to developing countries and countries in transition.

### CIENS GOALS

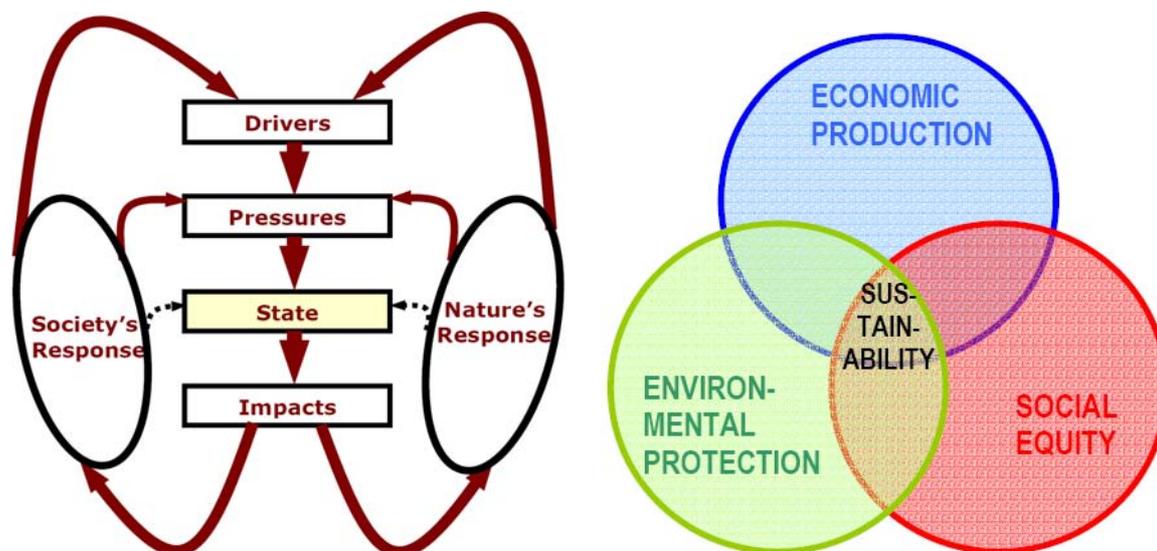
The **goals for CIENS** (green in Fig. B) are overall targets for fulfilling the vision. They aim for research, education, public management, and innovation, in a 5-10 year perspective, to:

- escalate basic and applied scientific comprehension concerning environment and society;
- host a research school for education of scientists with interdisciplinary understanding;
- provide a knowledge base for sustainable policy and decision-making, thus also strengthening Norway’s role in international environmental efforts;
- develop a basis for innovation and transfer of knowledge to developing countries.

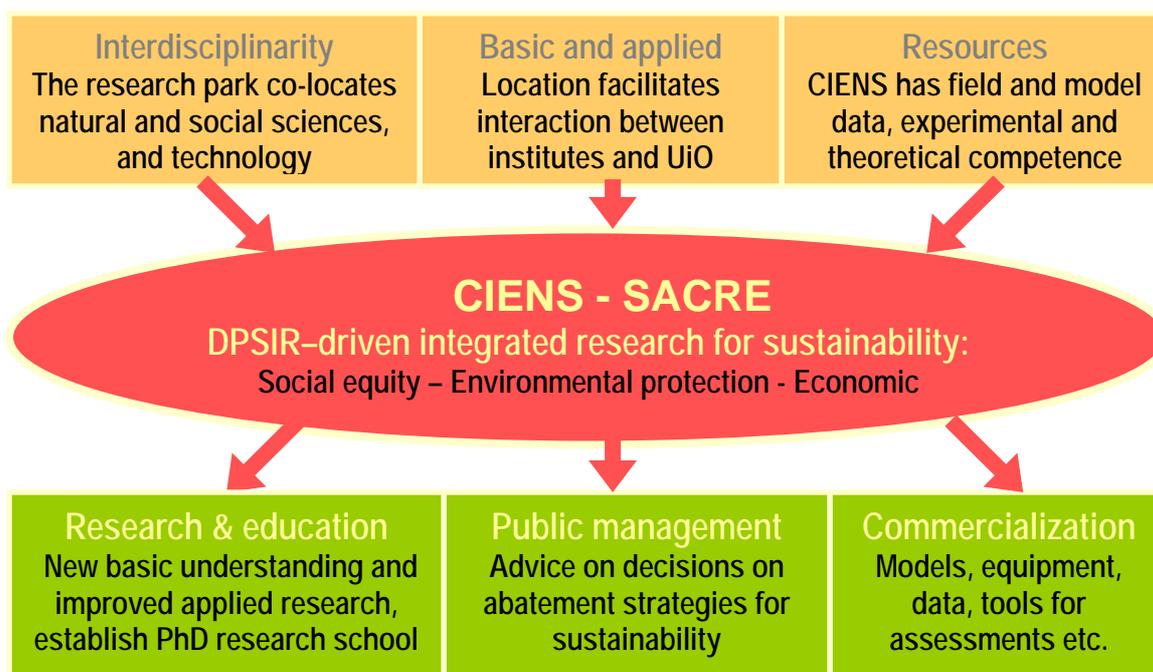
### SIX CIENS COMMON RESEARCH THEMES

have been selected on the basis of relevance and existing scientific quality in CIENS. Themes 1-3 focus on selected environmental issues influenced by a range of human drivers. Themes 4-6 address a range of environmental issues related to selected human activities.

- |  |   |
|--|---|
| 1. <i>Climate change</i>                                     | 4. <i>Urban sustainability</i>            |
| 2. <i>A sustainable atmosphere</i>                           | 5. <i>Sustainable mobility</i>            |
| 3. <i>Integrated river basin and coastal zone management</i> | 6. <i>Ecosystem products and services</i> |



**Figure A:** This pictures the DPSIR-philosophy for research in CIENS, and how it relates to a sustainability concept that balances the need for intra- and inter-generational social equity with the limitations imposed by economic production and environmental protection. The **state** of the environment changes due to **pressures** brought about by **drivers** caused by **economic production** necessary for achieving short-term social goals. The implied environmental **state** change causes **impacts** with unwanted consequences for ecosystems, life, and values. **Nature responds** in the long term by adapting ecology to the impacts which feed back onto the system. Provided **sustainability** is sought after, the human **society responds** by developing new technology (influencing pressures), by adaptation to the impacts by reducing vulnerability, or by taking measures for the drivers to increase **environmental protection** and thus facilitate long-term **social equity**. CIENS produces knowledge in all aspects of the DPSIR-chain in order to ensure decisions for sustainability.



**Figure B:** A schematic illustration of the strategic input to CIENS (orange) which, through actions in CIENS defined in SACRE (red), fulfil the CIENS goals on research and education, public advice, and innovation and commercialization (green).



## Section I : GENERAL ASPECTS

### *THE CIENS VISION*

*is to be internationally highly valued for interdisciplinary environmental and social research producing knowledge, education, and innovation as a basis for decisions for sustainable development.*

### CIENS GOALS

CIENS promotes interdisciplinary environmental and social research for the development of basic understanding and knowledge for sustainable development. The overall goals for CIENS comprise targets for activities devised to ensure achievement of the CIENS vision. They concern research, education, public management, and innovation, and aim in a 5-10 year perspective to:

- 1. enhance basic and applied scientific comprehension concerning environment and society;*
- 2. host a research school for education of scientists with interdisciplinary understanding;*
- 3. provide a knowledge base for sustainable policy formulation and decision-making, thus also strengthening Norway's role in international environmental efforts;*
- 4. develop a basis for innovation and transfer of knowledge to developing countries.*

### MAJOR ELEMENTS OF THE GOALS

Six CIENS themes have been selected as common scientific priority areas for the four overall goals. During the first 2-4 years after start-up, CIENS will need to put effort into establishing new and organizing existing activities in the context of these goals.

**Interdisciplinary research for sustainable solutions.** Sustainable solutions to environmental and social problems require understanding based on interdisciplinary research. Sustainability implies that economic production acts in balance with the natural environment in order to obtain social equity both in the present and for future generations. Human societies need sound mechanisms for selection and correction of imbalances. To develop the knowledge base for such mechanisms, CIENS combines natural and social sciences under the Drivers – Pressures – States – Impacts – Response (DPSIR) philosophy. Research quality is maintained both by regular publication of findings in renowned journals, and by innovative interactions between disciplines provided by the DPSIR-philosophy.

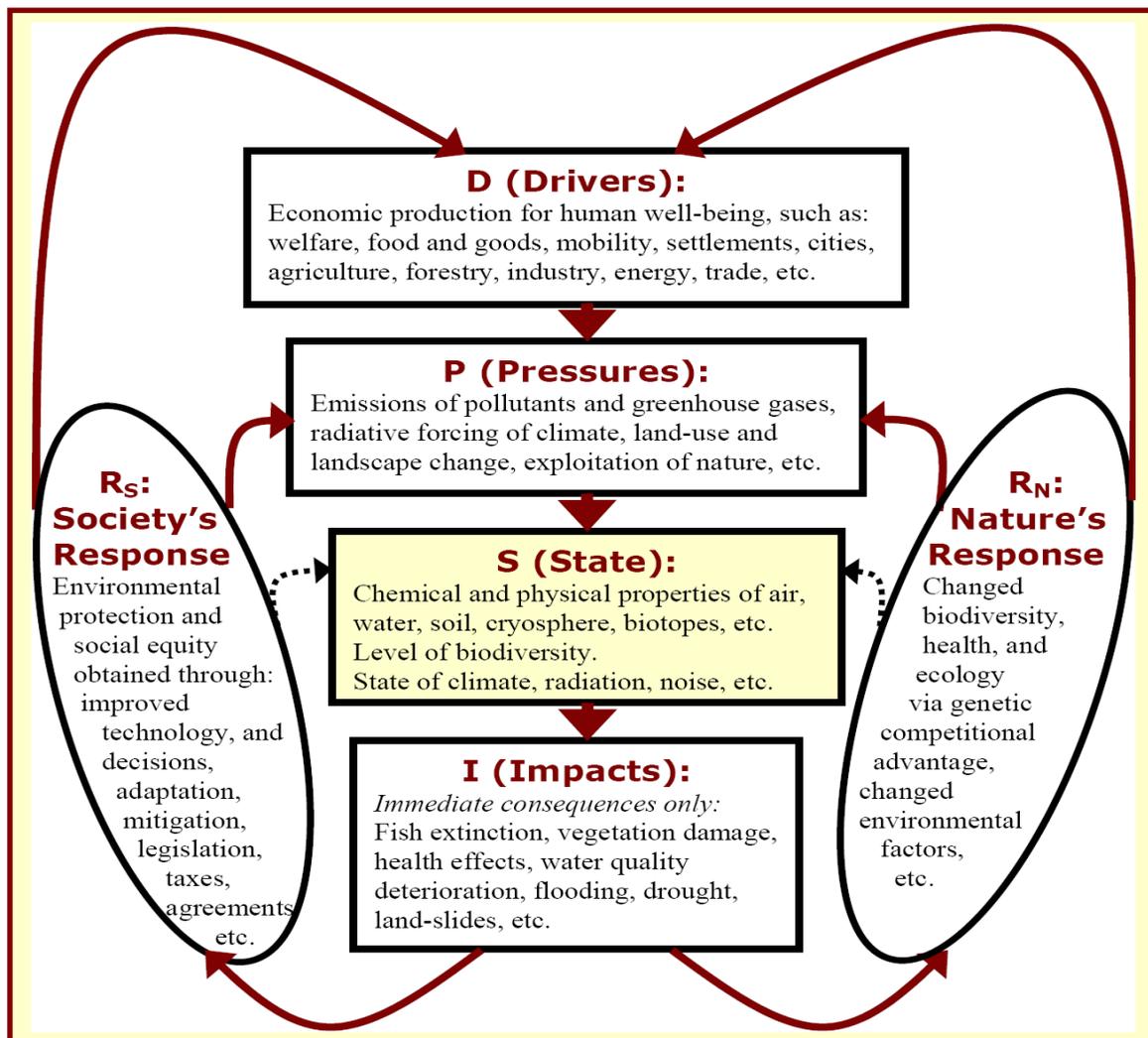
**Projects involving basic and applied research, and increased recruitment.** The new paradigm for research closes the gap between university-based basic research and applied research in institutes. University research increases its relevance whilst progress in basic research to a larger extent may take place in well-equipped applied institutes. CIENS takes a leading role in a symbiosis which ensures progress in basic disciplines and the application of new insights from basic research. The visibility of CIENS and the practical relevance of associated educational programmes will serve to boost recruitment of scientists.

**Substantial influence by joint research groups.** High-quality research amongst CIENS partners often occur in small-sized groups that depend crucially on a few enthusiastic persons. Provided the scientific activities are properly organized, such groups will benefit greatly from enhanced co-operation. CIENS aims to fully realize such benefits, in particular by increasing the research groups' visibility and influence. A major ambition is to significantly influence the international research agenda in the six CIENS themes. This involves scientific programmes in funding agencies, the International Council for Science, ICSU (IGBP, IHDP, WCRP, DIVERSITAS), and organizations under United Nations, UN (UNEP, UNFCCC, UNESCO, WMO). CIENS aspires to be a national focal point for GEOSS (Global Earth Observation System of Systems).

## BASIC CONCEPTS FOR RESEARCH IN CIENS

### THE DPSIR – PHILOSOPHY

The Drivers – Pressures – State – Impacts - Response (DPSIR) philosophy is the key conceptual model for research in CIENS, and is well suited for building the necessary scientific understanding for development towards sustainability. The model motivates both interdisciplinary research and scientific development in basic disciplines. Interdisciplinary research must both meet traditional scientific quality standards in basic disciplines, and be innovative in its exploitation of the interfaces between them. Interdisciplinary progress requires strong interfaces. Mismatches in scientific culture, methods and data are among the major obstacles to be addressed. Data and insight obtained in one field should provide a basis for results in other fields that otherwise would be unlikely. Thus, successful interdisciplinary research also strengthens basic disciplines.



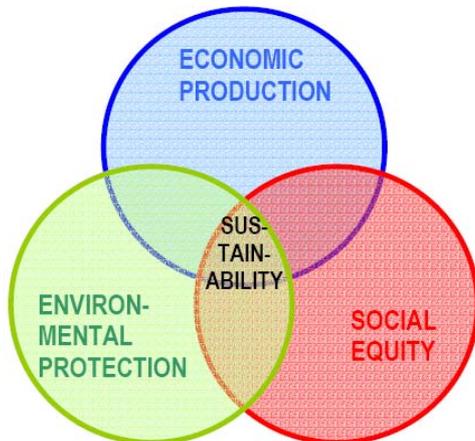
### The DPSIR butterfly: interdisciplinary research and sustainability

Central in the diagram is the state (S) of an environment system, which may change under influence from pressures (P) caused by drivers (D) to benefit human well-being. A perturbed state (S) leads to immediate impacts (I), which may provoke responses in nature (R<sub>N</sub>) or the human society (R<sub>S</sub>).

The society may adapt to impacts by reducing vulnerability, or mitigate impacts through new technology or through policy and decisions. This changes both drivers (D) and pressures (P). Nature's response (R<sub>N</sub>) is often an ecological adaptation which may influence the pressures (P) directly and the drivers (D) indirectly.

**SUSTAINABILITY:****BALANCING SOCIAL EQUITY, ECONOMY AND ENVIRONMENT**

Through the DPSIR-philosophy in SACRE, CIENS provides a scientific basis for policy and decision-making to promote sustainability. Sustainable development safeguards the needs of the present generation without undermining the needs for coming generations. SACRE

**Three-dimensional bottom line.**

Production is economically efficient in the blue circle; social equity is emphasized in the red circle; the environment is preserved for the future in the green circle. Ideally, sustainability implies positive solutions for all components.

applies a concept of sustainability with three dimensions. The *need* for local and global social security, human influence, justice, and societal stability (**Social equity**) is weighted against the *limitations* imposed on production of goods and services normally constrained by short-term concerns (**Economic production**), and the *limitations* inherent in the long-term preservation of ecosystems which, inter alia, conditions life and prosperity for coming generations (**Environmental protection**). Thus, sustainable development implies efficient production of goods and services in ways which facilitate social equity both for the present and for future human generations through protection of the environment.

To obtain sustainability, a thorough understanding of the natural environment and its dynamic relations with human drivers and societal response is needed. The sustainability concept in SACRE is therefore closely linked to the DPSIR-philosophy.

**STRATEGIES AND ACTIONS TO ACHIEVE CIENS GOALS****CIENS COMMON RESEARCH THEMES**

A key action within CIENS is to establish interdisciplinary groups on selected research themes. This has, in fact, already taken place *ad hoc* for the development of SACRE. Based on existing, outstanding and wide-ranging, scientific competence in CIENS as well as the relevance for present environmental challenges in the world, six common research themes have been defined. Aims and strategic actions for the themes are thoroughly discussed in separate paragraphs in section II.

1. **Climate change**
2. **A sustainable atmosphere**
3. **Integrated river basin and coastal zone management**
4. **Urban sustainability**
5. **Sustainable mobility**
6. **Ecosystem products and services**

**STRATEGIC ORGANIZATIONAL BENEFITS**

Three organizational aspects are unique to CIENS and need to be exploited: (1) the interdisciplinary capacity enabled by co-locating research institutes in the Research Park; (2) the symbiotic interaction that location on the UiO campus will facilitate with basic research at UiO; (3) the vast resources within CIENS and the Resource Centre financed by the Research Council of Norway (RCN). Interdisciplinary approaches and extended interactions between universities and applied research institutes are emphasized in various research strategies (EU, UN, RCN, Norwegian Government white paper “Commitment to Research”).

### *General Aspects*

**Interdisciplinary Research** Traditional environment studies were carried out in individual disciplines in natural sciences and for one type of media (water, air, etc.) This is useful for understanding the environment's natural behaviour and documenting anthropogenic influence. However, there is an urgent need to understand the interactions between nature and society to promote formulation of policy and decision-making towards sustainable targets in which compliance can be monitored. This is why the DPSIR-philosophy is the core model for SACRE. Quality in the basic disciplines combined with innovative mechanisms for interactions provide the knowledge base for sound policy and decisions in support of sustainable development.

A few CIENS partners already have considerable experience and success in interdisciplinary research within their own institution (e.g. CICERO), and several are currently participating in interdisciplinary co-operative efforts.

**Interacting Basic And Applied Research** Traditionally, research in universities does not pay much heed to temporal or relevance perspectives, whilst applied research issues call for swift solutions. Increasingly, university research has come to address shorter term issues, while well-equipped, applied research unites are increasingly contributing to advance aspects of basic research. The symbiotic interaction between relevant research groups at UiO and applied institutes is a key to fulfilling the CIENS goals. The UiO research groups will have access to operational data, competence, tools, and infrastructure from the applied institutes. The institutes may be directly involved in common projects producing new knowledge in basic disciplines which make it possible to find solutions to new types of applied questions. Both will benefit from increased recruitment of motivated students.

Some of the disciplines amongst CIENS partners already have long-standing traditions in mixing basic research with application (e.g. weather and climate modelling at MetOS-UiO, met.no, CICERO). In environmental applications there are many examples where apparently useless basic research has proven crucial to solving acute problems at hand.

### **Strategic Resources**

*Human resources.* The main capital in CIENS is its human resources. The CIENS partners include research groups of high international standing and standards. Some partners have a long-standing record from interdisciplinary research.

*Data and models.* Together, the CIENS partners have in their possession a huge amount of observational data, both from operational routines and extraordinary data from field campaigns. Furthermore, there are advanced infrastructures, laboratories, and equipment. Advanced tools like mathematical models and experimental facilities are available. Common scientific infrastructure and tools improve research and facilitate interdisciplinarity. It is assumed that adequate super-computers are provided nationally.

*The CIENS Resource Centre* is a common unit in the CIENS building financed by RCN and organized as a private foundation "Stiftelsen CIENS Fagsenter". The goals of the Resource Centre are to promote common scientific activities, to facilitate public dissemination of research, and increase the visibility and impact of CIENS in society. The centre includes meeting rooms, an auditorium, an exhibition area, documentation facilities, "project toolbox" facilities, an intranet-based common library function, and a common Web-portal.

### **CIENS Actions:**

- Organize cross-cutting research groups on selected themes based on the DPSIR-philosophy.
- Develop and seek funding for interdisciplinary projects in co-operation with UiO.

- Promote publication of interdisciplinary work in high impact scientific journals.
- Establish a CIENS project for co-ordination of the large data sets on environment and social sciences, owned by CIENS partners, for national and international use.
- Establish at least one Centre of Excellence with interdisciplinary and integrated basic and applied research with a CIENS partner as host institution and with UiO participation.
- Propose to the Research Council of Norway (RCN) to establish relevant research programmes on interdisciplinary and integrated basic/applied activities.
- Develop a plan to further expand the co-operation with research groups at the UiO.
- Develop a plan for co-operation with other applied research units in the Oslo area.
- Extend the possibility for CIENS scientists to be adjunct professors at UiO, and for UiO professors to be adjunct scientists in CIENS.
- To provide office space in CIENS for *ad hoc* visits from UiO scientists.

## INTERNATIONALIZATION

Internationalization is essential for ensuring the quality of most research, for influencing scientific priorities, and for securing funding. The recent Government white paper “Commitment to Research” defines internationalization as one of its foremost strategies in its ambitious objective of developing Norway as a leading research nation in selected areas. For CIENS this is also obvious since environmental problems often are trans-boundary and require international actions. The implementation of measures is to a large extent based on international law, agreements and directives.

**Critical mass of research groups** CIENS encompasses several excellent research groups. While quality is important, such groups need to be of a certain size to be visible and have an impact internationally. CIENS provides a vehicle for establishing high-impact research units on selected themes.

**International channels** EU’s framework programmes will continue to be of great importance for research for CIENS partners. Furthermore, efforts are underway to strengthen bilateral research co-operation with North America, Japan, China, and India.

Important scientific priorities for research relevant for CIENS are assigned in the committees under ICSU (International Council for Science) and in associated sub-programmes. The relevant committees for CIENS are those under the Earth System Science partnership (<http://www.ess-p.org/>):

- IGBP (International Geosphere-Biosphere Programme);
- IHDP (International Human Dimension Programme);
- WCRP (World Climate Research Programme); and
- DIVERSITAS (Integrating biodiversity science for human well-being).

There are also several important programmes and organizations under United Nations, such as the Climate Convention (UNFCCC) and the associated Intergovernmental Panel of Climate Change (IPCC). Framework conventions under the auspices of UN are also central, e.g. the Convention on Long-range Transboundary Air Pollution (CLRTAP).

**GEOSS (Global Earth Observation System of Systems)** is a completely new “top-down” global effort to reduce environmental risks through the merging of disciplinary data streams and research methodology, with nine societal benefits themes: (1) Reducing loss of life and property from natural and human induced disasters; (2) Understanding environmental factors affecting human health and well-being; (3) Improving management of energy resources; (4) Understanding, assessing, predicting, mitigating and adapting to climate variability and change; (5) Improving water resource management through better understanding of the water cycle; (6) Improving weather information, forecasting and warning; (7) Improving

**General Aspects**

management and prediction of terrestrial, coastal and marine ecosystems; (8) Supporting sustainable agriculture and combating desertification; (9) Understanding, monitoring and conserving biodiversity.

Research and development in CIENS relate heavily to the social benefit themes of GEOSS. The vision for GEOSS (taken from the 10-year implementation plan) is “to realize a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations and information.”

**CIENS Actions:**

- Establish an International Scientific Advisory Board for CIENS.
- Explore the potential role of CIENS as a focal centre for GEOSS.
- Strengthen links to ICSU programmes: IGBP, IHDP, DIVERSITAS, WCRP.
- Contribute to planning of EU’s framework programmes and take on central duties in EU projects.
- Develop scientific networks with institutions in priority regions (North America, Japan, India, China).
- Develop fellowships and programmes for exchange and visits of guest scientists.
- Arrange workshops in the six CIENS themes, and establish regular CIENS conferences.
- Seek to establish a “CIENS prize” for outstanding contributions to research on the environment and conditions for sustainable development.

**RECRUITMENT AND EDUCATION**

One of the goals of CIENS is to improve university education in disciplines with environmental relevance and increase the recruitment to research. This is also a relevant follow-up in the context of the Government white paper on research. CIENS aims at co-operating with UiO on existing academic programmes and courses. Educational aspects directed towards students in primary and secondary schools are also linked to dissemination of knowledge.

A major ambition is, in co-operation with UiO, to establish a PhD research school with interdisciplinary emphasis in the common CIENS themes. This will require a considerable number of PhD-fellowship positions, as well as taking on supervisory responsibility for Master’s degree students. The CIENS Resource Centre should serve as a contact point for students. A Centre of Excellence, if established, would provide an excellent platform for further recruitment.

CIENS also wishes to increase the number of post-doctoral positions, and to strengthen participation in international exchange programmes at all levels. Internationalization of education and recruitment is crucial in encouraging the exchange of research staff.

**CIENS Actions:**

- Co-operate with UiO on educational programmes for Bachelor’s and Master’s degrees in fields relevant to the common CIENS themes.
- Actively use the CIENS Resource Centre for educational programmes.
- Give high priority to establishing a PhD research school in co-operation with UiO.
- Collaborate with UiO to apply for a Marie Curie Early Stage Training Site with a strong focus on basic research training.
- To develop courses for education of managers within public administration and private industry.

- To continue the involvement of CIENS partners in the “network for environmental education” in Norwegian schools [www.miljolare.no].

### **PUBLIC DISSEMINATION OF KNOWLEDGE**

CIENS will strive to maintain an active approach towards the general public. Research-based information is vital to enhancing the level of insight of the public. A well functioning democracy depends on public awareness of scientific achievements. Dissemination of knowledge will also stimulate young people’s “need to know”. CIENS will seek to provide stakeholders with adequate information, thereby allowing them to gain common knowledge which may help to bridge the gap between opposing interests.

The Resource Centre in CIENS provides an excellent basis for dissemination of research from CIENS and others. Joint internet solutions make the individual researchers’ work available at an early stage. Many activities, particularly in monitoring and status reporting, include visualization, graphic interfaces and extensive use of geographical information technologies. CIENS partners will also continue to use traditional information channels and media (newspapers, radio, television, etc.), publish articles in popular scientific journals, and participate in the public debate to disseminate research on sustainability issues.

CIENS will contribute scientific input to meetings with public authorities and other relevant user interests. NGOs and Public Interest Advocacy Groups include organizations devoted to issues such as environment, sustainable development, health, agriculture, energy use, co-operation with developing countries, etc. This includes groups capable of influencing public opinion and decision and policy-makers.

#### **CIENS Actions:**

- Use the CIENS Resource Centre to disseminate knowledge produced by CIENS partners. This includes advanced information technology and active use of the internet.
- Use various other electronic publishing channels, e.g. RCN’s Research Portal and the web pages of the participating institutions and of CIENS.
- Actively inform public authorities, NGOs and other relevant stakeholders.
- Establish networks with journalists and media, e.g. through the expert portal of journalists planned by RCN.
- Continue to publish articles in popular scientific journals such as *Cicerone*, *Plan*, *Naturen*, *Fauna*, *Samferdsel*, etc., produce articles and give interviews in journals and newspapers.
- Produce appealing brochures for distribution e.g. to schools (in particular at senior high school level).

### **INNOVATION AND COMMERCIALIZATION**

Innovation and commercialization are here understood to be knowledge and products from research in CIENS which, through further exploitation and marketing, can be introduced as commercial products. While research in CIENS has limited potential for commercialization compared to technological research and development, interdisciplinary research in CIENS can help to identify areas in which innovation and industrial development are needed to implement adaptation and mitigation strategies.

An increasing need for customer-adapted products concerning the future climate and environmental state will emerge, in particular those influencing human health, ecological invasions, infrastructure, buildings etc. Similarly, increased demand for short-term forecasts of disasters is also likely.

CIENS products for commercialization may comprise software – mathematical models for simulation of natural processes, decision support systems, integrated assessment models for

### *General Aspects*

nature and society, general tools for environmental indicators, and in situ monitoring packages – or more traditional hardware products such as measurement sensors, sampling devices, energy saving technology, etc. A common denominator will be the need for patents and financial resources to bring the products to the commercial market.

Development of a CIENS infrastructure such as a knowledge and information bank, will have significant utility aspects. The public sector and private corporations will benefit from using CIENS data to develop a sustainability profile in their own context. Implementation of governmental measures for increased sustainability (taxes, legislation, etc.) will condition new competitive perspectives.

Co-operation with business sectors as well as public and private enterprises is important to the development of Corporate Social Responsibility (CSR), environment certificates, etc. Such strategies are generally based on mixed motives involving ethical concerns, reputation, as well as profit maximization. CSR can be a form of self-regulation of environmental drivers that serves as an innovative supplement to implementing policy measures.

Ideas for commercialization will be explored through the innovation and technology transfer offices of Oslo Research Park (“Oslo Innovation Centre”) and UiO (“Birkeland Innovation”).

### **CIENS Actions**

- CIENS will co-operate with the innovation units at the Oslo Research Park and UiO to stimulate constructive ideas from research to commercialization.
- CIENS will utilize existing and develop further co-operation with the public sector and the business community to assist in enhancing its Corporate Social Responsibility (CSR).

### **TRANSFER TO DEVELOPING COUNTRIES AND COUNTRIES IN TRANSITION**

The eradication of poverty is crucial to sustainable development through the dimension of social equity. Sustainability is predicated on environmental protection for the benefit of coming generations, but cannot be achieved without access to decent living conditions and social equity globally for the present generation. The UN millennium goals for poverty eradication, education, economic development, depend on three pillars: good governance, capacity building and financing. Transfer of knowledge is a key component of capacity building, it is an important policy element, and there are many research and collaboration programmes.

CIENS partners have amassed a great deal experience in the transfer of knowledge through research collaboration with developing countries, and gained some experience with countries frequently classified as “in transition”. Groups at UiO have also participated in exchange programmes and twinning arrangements. CIENS will thus build its efforts on a firm base. Activities related to drivers, impacts, and society’s response are of particular importance.

Transfer of knowledge may be supported by educational and joint projects. Usually, international educational programmes involve the exchange of teachers. Visiting scientists financed by special grants could also prove efficient, as could web-based solutions. Courses for decision-makers based in developing countries are important. The courses should be integrated as part of “Continued Learning and Distant Education” of the UiO and offer formalized diplomas.

CIENS expert teams for international work could be established, including competitive bidding on relevant calls and tenders. Using SACRE, CIENS can promote interdisciplinary and educational capabilities for contracts through the Ministry of Foreign Affairs (UD) and the Norwegian Agency for Developing Aid (NORAD). Potential international institutions

and agencies comprise the UN system, including the World Bank, the Inter-American Development Bank, and the Asian Development Bank.

For countries “in transition”, CIENS will seek to develop partnerships in the new EU member states and candidate countries where the EEA Financial Mechanism and the Norwegian Financial Mechanism offer a funding opportunity. China, with its huge environmental and sustainability challenges, is a national priority for research collaboration.

### **CIENS Actions**

- Collaborate with UiO to establish international educational programmes, grants for visiting scientists, and courses for decision-makers. A PhD research school may also be instrumental in efforts to promote knowledge transfer.
- Establish expert teams for international work involving transfer of knowledge.
- Promote cross-sector and interdisciplinary capabilities, and actively seek contracts through Norwegian and international environmental research and assistance programmes.

## **REALIZATION AND IMPLEMENTATION**

CIENS and SACRE are constructed “bottom-up” based on enthusiasm amongst the partners. The support of Research Council of Norway (RCN) has been instrumental in bringing CIENS to fruition. Support from the Ministry of Environment and the Ministry of Research and Education has also been important. The Government white paper on research (2005) acknowledges CIENS as an important structure in the national research strategy.

SACRE needs significant funding to be realized. A success criterion for CIENS over the coming 5-10 years will be to ensure that a high proportion of new interdisciplinary research, with significant participation from UiO, is based on SACRE. The projects are expected to be funded primarily by RCN and EU. PhD fellows in CIENS themes should also be allocated by UiO, and co-operation with UiO-based supervisors will be imperative.

The realization of interdisciplinary research with symbiotic interactions between basic and applied research will require resources beyond regular external projects. It is envisaged that CIENS will receive basic economic support as a part (e.g. 30-50 %) of the announced increase in basic long-term grants to environment-oriented, applied research institutes.

SACRE should be co-ordinated by a scientist financed full-time for the purpose, and be supported by (at least) part-time theme leaders. The possibility to finance internal projects for strategic competence building will greatly facilitate the implementation of SACRE and the development of common scientific activities within CIENS.

It is urgent that some funding for further concretization of SACRE in 2006 be secured. Without interim financial support, the economic situation is such that CIENS partners may be forced to give SACRE efforts low priority. This could result in an unfortunate situation in which the implementation of SACRE would at best be substantially delayed when CIENS is launched in 2006.

## Section II: COMMON RESEARCH THEMES

### THEME SUMMARIES

This section covers strategies and actions for 6 common research themes in CIENS. On the first two pages the summaries for each theme are given. A full analysis of the themes is given on the following pages.

#### 1. Climate change

**Summary** *How hot will the greenhouse be, and how can we cope with the effects? CIENS is well-positioned to produce new and highly relevant knowledge about this and other pressing questions relating to climate change. CIENS combines the best of pure and applied research and includes scholars from a wide range of disciplines in natural as well as social sciences: radiative forcing of gases, aerosols and clouds, natural processes in the climate system (atmosphere, ocean, hydrosphere, cryosphere, biosphere), impacts of climate change on nature and society, and the development and implementation of effective political measures. A particular research challenge involves how to tackle the boundaries and linkages between individual research disciplines in natural and social sciences. As the broadest climate research consortium in Norway CIENS is well suited for meeting this challenge.*

#### 2. A sustainable atmosphere

**Summary** *Can we determine the bounds on human activity required for the composition of the atmosphere to support sustainable development? The CIENS partners are highly rated internationally for their competence in analyzing atmospheric sustainability, including the interaction with terrestrial and aquatic systems as well as societal impacts and responses. There is a strong tradition for linking basic and applied science and for constructive interactions between science and policy making. The CIENS expertise is developed and applied not only in Scandinavia and Europe, but also in other parts of the world with an emphasis on institution-building and competence in developing countries in Africa and Asia. CIENS aims to utilize its competence to develop new understanding of natural and man-made changes in the composition of the atmosphere, how changes in soil and water can enforce or weaken the atmospheric perturbations, and how political and economical drivers will influence the emissions to the atmosphere. Important issues are air quality and health, trans-boundary air pollution, climate change, stratospheric ozone change and UV radiation, and the cycling of toxic trace species through the atmosphere.*

#### 3. Integrated river basin and coastal zone management

**Summary** *How can we achieve sustainable management of our limited freshwater resources and vulnerable coastal zones? Within Integrated River Basin Management and Coastal Zone Management (IRBM and CZM) CIENS has high international-level competence within social and natural sciences on drivers, pressures, state and impacts, and feedbacks and responses related to river basins and coastal zones. Particular note should be given to the environmental monitoring and large-scale information systems managed by the CIENS partners. The expertise in CIENS will contribute to improved understanding of processes, solution of conflicts, and balancing of the stakeholders. CIENS intends to establish a centre of expertise in IRBM and CZM that will give scientifically sound advice to the authorities on e.g. implementation of EU's Water Framework Directive and the new EU Marine Strategy, as well as on national activities within integrated management of the river basins and coastal zones.*

#### 4. Urban sustainability

**Summary** *What are the conditions for a long-term and balanced development across environmental, economic, and social concerns (i.e. sustainable development) of towns and cities in a local and global perspective? CIENS offers unique interdisciplinary research competence on interactions between societal, political and economic drivers on the one hand and environmental impacts and responses on the other, in an urban context. In particular, environmental qualities and a sound urban structure are addressed, such as the technical, blue-green, and social infrastructure. Urban sustainability necessitates the political and scientific involvement of a multitude of actors, as well as innovative perspectives and processes. CIENS' interdisciplinary and cross-institutional endeavour for high-quality research aims at providing comprehensive tools and policy instruments for improved planning and implementation of sustainable development in urban regions. Risks and potentials created by urbanization in developing countries will be given special attention.*

#### 5. Sustainable mobility

**Summary** *What policies can cities and countries adopt for themselves, and agree to between themselves, to develop and ensure mobility benefits while environmental and social goals are given increased priority? Access and productive relations depend on mobility, and therefore on transport of goods and people, while also involving environmental and other governance challenges locally, nationally and globally. Societal responses to environmental and social pressures and impacts place demands on interdisciplinary research, both in terms of descriptive and analytic systemic aspects and in terms of recommendations on institutional change and policy. The strength of CIENS is the representation of more academic disciplines than normally seen in transport research. CIENS has and will continue to have competence in all aspects of the DPSIR-chain, but will develop an interdisciplinary focus around societal responses. The vision is that the unique, interdisciplinary competence gathered in CIENS will result in high quality research, combining analysis of mobility benefits with environmental, social and economic aspects.*

#### 6. Ecosystem products and services

**Summary** *Do we need all species of plants, animals and microbes? The extent to which all species are needed is still a mystery, but when symbiotically functioning together in balance with the physical environment, they constitute the basis for life on earth, including economic production for humans. Sustainable development requires knowledge of nature's ability to deliver products and services to humans in an economic way. CIENS develops such knowledge in relation to socio-economic and cultural/social conditions associated with drivers and pressures for environmental change, ecosystem impacts and responses by the ecosystems and society to it. In line with the Biodiversity Convention and themes of the Millennium Ecosystem Assessment, CIENS builds a dynamic and integrated approach to biodiversity through interdisciplinary research. CIENS research emphasizes implications for ecosystem functions and services, and incentive systems as in the proposed Biodiversity Act. These include principles such as: precautionary, polluter pays, aggregate environmental damage, environmental liability, and compensation for foregone opportunities and land-use rights.*

## **Climate Change**

### **Forcing, responses and strategies**

**Frode Stordal**, MetOs-UiO/NILU; **Jan Fuglestad**, CICERO; **Hege Hisdal**, NVE; **Terje Kleven**, NIBR; **Cathrine Hagem**, Economy-UiO; **Rolf Hagman**, TØI; **Jon Hovi**, Political Sciences-UiO; **Eivind A. Martinsen**, met.no; **Claus Nielsen**, Chemistry-UiO; **Odd Stabbetorp**, NINA; **Richard Wright**, NIVA

### **Summary**

*How hot will the greenhouse be, and how can we cope with the effects? CIENS is well-positioned to produce new and highly relevant knowledge about this and other pressing questions relating to climate change. CIENS combines the best of pure and applied research and includes scholars from a wide range of disciplines in natural as well as social sciences: radiative forcing of gases, aerosols and clouds, natural processes in the climate system (atmosphere, ocean, hydrosphere, cryosphere, biosphere), impacts of climate change on nature and society, and the development and implementation of effective political measures. A particular research challenge involves how to tackle the boundaries and linkages between individual research disciplines in natural and social sciences. As the broadest climate research consortium in Norway CIENS is well suited for meeting this challenge.*

### **VISION**

CIENS is recognized as the leading Norwegian interdisciplinary climate research group and is well known as a high quality research institution by the national and international scientific community as well as by stakeholders and policy makers for advancing our understanding of the natural climate system and its interactions with society.

### **OVERALL AIM**

CIENS will establish and operate a climate research program with emphasis on interdisciplinary challenges and important uncertainties in basic understanding of the geophysical climate system and its interactions with environment and society at large. A long term goal is that CIENS operates a common earth system model with full interactions between geophysical, chemical, and selected biological processes, which links to models of socio-economic impacts and responses from society and can be used to provide climate projections for the next decades.

### **DEFINITIONS AND DELIMITATIONS**

In relation to climate change and its impacts we define the different elements of the DPSIR philosophy as follows:

**Drivers** The underlying natural and anthropogenic (demographic and socio-economic) factors – processes, products, development trends that lead to increase in the concentration of greenhouse gases and aerosols in the atmosphere: i.e. energy production and consumption, transportation, industrial development, population increase, agricultural production and land use etc.

**Pressures** The effect of the drivers on processes leading to global radiative forcing and the different parameters determining global, regional and local weather and climate conditions, i.e. natural and man-made emissions of climate gases and aerosols, and changes in land-use.

**States** The full statistical behaviour of global, regional and local weather, ocean- and land surface state (i.e. climate), as described by climate elements such as temperature, moisture, cloudiness, precipitation, wind, sea level, ocean temperature, ocean currents, sea and freshwater ice, permafrost, glaciers, snow cover, streamflow, soil wetness, geochemical fluxes, etc.

**Impacts** Short term (negative and positive) effects of climatic change including extreme climate events (hazards) on natural (geo-biophysical) and socio-economic systems, i.e. changes in natural resource services (length of growing seasons, conditions for tourism), frequency and magnitude of floods and droughts, effects of new types of weather-related extremes on the natural and man-made environment, erosion and land-slides, human health and mortality, buildings and constructions, hydropower production, recreational activities etc.

**Response (nature)** Natural adaptation to climate change on a longer term of regional and local flora and fauna, i.e. biodiversity and ecology. The response of natural systems to climate change will depend on their responsiveness to the impacts and resilience of the system, i.e. its capability and capacity to resist and/or adapt to the imposed changes.

**Response (society)** Automatic or planned responses to the impacts of climate change on socio-economic conditions (energy use, economic production, living conditions, settlement and land use patterns, demographic processes etc.), implying the implementation of policies and strategies of mitigation and adaptation.

*Mitigation* policies and strategies aim at restricting or reducing emission of greenhouse gases and aerosols. *Adaptation* are policies and strategies aimed at adjusting natural and human systems in response to experienced or future climatic conditions and their impacts (which may be beneficial or adverse). Adaptation is about a system's preparedness and capability – the system's *adaptive capacity* – to cope with the impacts of climate change and to reduce its *vulnerability* to climate hazards. Vulnerability in this sense is understood as to what extent a system is exposed to and/or unable to cope with harmful climate events caused by climate variability or extremes.

## GENERAL OBJECTIVES

How hot will the greenhouse world be? This is one of the top 25 big questions facing science over the next quarter-century, according to *Science Magazine* (July 1<sup>st</sup> 2005). The urgency of the question is obvious, as climate change is threatening to have large effects on the physical climate system, on the biosphere, and for human health, well-being and the society at large. The reason for posing the question is the large uncertainties that still exist in our knowledge about the functioning of the climate system and how it will be affected by man made activities. The uncertainties that are emphasized in *Science* are in determining the effects of aerosols and cloud feedbacks on climate. As demonstrated in *climateprediction.net* the uncertainty turns into a considerable risk for much larger global climate change than presently estimated from the “best guess” state-of-the-art climate models.

CIENS is an ideal vehicle to address this and other urgent research issues that calls for a multidisciplinary and interdisciplinary scientific approach.

**The objectives of the climate program are threefold:**

(i) Each of the research institutes will advance their ongoing work within their own research disciplines, covering a wide range of elements in the DPSIR chain. This includes:

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*Drivers:* the natural, demographic and socio-economic factors that lead to increase in the concentration of greenhouse gases and aerosols in the atmosphere;

*Pressures:* the resulting radiative forcing – including the important effects of aerosols on clouds;

*State:* the effect on weather and climate parameters as temperature, moisture, precipitation, wind, and sea level – including extreme events *and their predictions*;

*Impacts:* effects on natural and socio-economic systems, i.e. cryosphere changes (ice cover, snow, glaciers and permafrost), impacts on biodiversity and natural resource services, frequency and magnitude of floods and droughts;

*Nature's Response ( $R_N$ ):* adaptation to climate change in flora and fauna (biodiversity);

*Society's Response ( $R_S$ ):* and finally responses to the impacts of climate change on socio-economic conditions – including implied implementation of policies and strategies of mitigation and adaptation.

This long list of research topics will be addressed by a variety of monitoring, experimental, theoretical and modelling approaches, including a focus on risk assessments.

(ii) Multi- and interdisciplinary research will be further developed. CIENS is well-positioned to produce new and highly relevant knowledge that draws from and integrates many different disciplines, as well as combining the best of pure research and applied research. Particular focus is needed on the boundaries and linkages between individual research disciplines, in order to investigate important impact chains and couplings between changes in the geophysical climate system and their impacts on nature and socio-economic conditions. A broad research program will be established, aimed at integration of all the elements in the DPSIR chain. Use of a common earth system model will be considered, and also linking this model to integrated models of socio-economic impacts and responses from society – including assessment of the uncertainties and risks cascading through the system.

(iii) The knowledge gained and the models developed as a result of climate research in CIENS will be used to provide information and guidance stakeholders and policy makers and the society at large regarding climate change in the decades to come. In particular, climate projections for the next decades will be made, including assessment of their uncertainties.

Focus will be on all spatial scales from local via regional to global scales, in natural as well as political and social sciences. For example, climate is changing on a global scale and will be studied by global models. However, effects must be understood and quantified on regional and local scales. Climate change yields challenges for the society on local scale, however, agreements to reduce emissions need to be established on an international level. There are strong couplings between the various scales both with regard to natural and societal sciences.

## **STATUS**

The participating institutions in CIENS cover a wide range of research within the whole cycle of climate change, and many of the institutions hold an internationally high level of competence and perform both applied and basic research within various sectors of the DPSIR model. This can be summarized as follows:

**Drivers**      CICERO, NILU, MetOs-UiO and TØI give important contributions to research on natural and anthropogenic processes that lead to increase in the concentration of greenhouse gases and aerosols in the atmosphere.

**Pressures** CICERO and MetOs-UiO have a wide expertise in modelling atmospheric concentrations and radiative forcing of climate from short-lived and long-lived greenhouse gases as well as aerosols and their interactions with clouds. Also, met.no, and NILU study the effect of drivers on processes of global heating. Chemistry-UiO have given important contributions on the characterization of processes leading to radiative forcing.

**States** Met.no, NVE, NILU, and NIVA have the responsibility for monitoring of climate, hydrology, glaciers, air pollution, and water quality in Norway and as such hold unique databases with short and long time series. Together with met.no, MetOs-UiO has over many years used and modified a state of the art global climate model for the study of climate effects of aerosols and clouds, as well as stratospheric processes. Met.no runs regional climate models and has strong competence in statistical downscaling of global climate scenarios. Met.no and MetOs-UiO has expertise on probabilistic predictions of weather extremes.

**Impacts** Met.no, NVE, Dep. of Geosciences (Hydrology and Geography) - UiO have all wide competence in climate change impact studies involving meteorological parameters, hydrology and the cryosphere, e.g. extremes involving winds, floods, droughts, land-slides etc.. NINA, NIVA, and Ecology-UiO have expertise in ecological and biological impacts. NIBR, TØI and CICERO perform research on impacts of climate change on infrastructure and society at large.

**Response (nature)** NINA and NIVA conduct research on ecological and biological responses to climate change. Ecology-UiO has competence on the highest international level.

**Response (society)** CICERO carries out research on climate policy at all levels, from the negotiation and design of international and regional agreements, to the formulation of climate measures at the national and local level. Economic modelling and integrated assessment studies are also performed by CICERO. NIBR has wide experience in policy analysis and studies of socio-economic impacts of externally driven change processes, similar to those likely to be initiated by climate change. Economy-UiO and Political Sciences-UiO have strong expertise in the field of optimal strategies and policy development.

**Collaboration** It will be natural to collaborate nationally with the Bergen-based Bjercknes Center for Climate Research (BCCR) within the area of global climate processes, paleo-climatological issues, and preparation for impacts studies. BCCR and met.no have established the virtual Norwegian Climate Centre (NCC) on geophysical climate research and climate predictions on the scales of season, decade and century. NCC has recently been extended with the CIENS partners MetOs-UiO and CICERO. Being in its incipient planning phase, NCC is potentially very important for CIENS.

The participating institutes have a large network of cooperating partners and contacts in the EU (especially through joint EU projects), the United States, Canada, China, and India.

## TOOLS AND METHODS

**Data.** Participating institutes in CIENS have access to a large amount of *data* on climate related parameters. The data originate from long-term *monitoring* programs and research campaigns, and are partly collected by the partners. They are mostly from Norway, but in some cases cover other regions, often Europe, and in some cases have a global coverage. Generally there is expertise at the institutes to analyse and exploit the data. Such data include weather and climate observations, weather analyses, concentrations of climate gases and aerosols in the atmosphere, radiation in the atmosphere, extension and types of sea ice, hydrological data from rivers and lakes, sediments, ground water and soil moisture, snow cover, mass balance of glaciers, coverage of forests and marsh, sediments in rivers, lakes and

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glaciers, chemical components in rivers and lakes, population data for selected species (birds, rodents, fish), vegetation data, emissions of aerosols and climate gases, trade data, and data on socioeconomic and demographic institutional and organisational change.

**Laboratories and field studies.** A wide range of *laboratories* and *experimental stations* are run by CIENS partners. One group of laboratories makes analyses of field data, such as the chemical composition of the atmosphere, water quality, sediments in rivers and lakes as well as genetics in the biosphere. Another is laboratories where experiments are performed to understand or manipulate processes, such as a laboratory for atmospheric chemistry, and a laboratory to study effects of changes in climate parameters on ecosystems.

**Earth-system modelling with biogeochemistry and state-of-the-art hydrology: predictive capabilities.** A wide range of *numerical models* are also in use in the participating institutes. Several institutes run atmospheric dynamics, chemistry and radiation models; and dynamical and physical oceanographic models (MetOs-UiO, met.no, NILU, Cicero). There are coupled atmosphere and ocean models on a regional and global scale. A hydrological model for Norway has been developed and various hydrological models are used to study hydrological processes at various temporal and spatial scales (NVE, Hydrology-UiO). Coupling between these state-of-the-art hydrology models and atmosphere-ocean models is missing. There are models for sea ice and mass balance of glaciers, for chemical species in rivers and lakes.

A particularly important instrument for future work in this area will be the global climate model from the National Center for Atmospheric Research (NCAR), USA. Groups in CIENS (MetOs-UiO) have contributed to development of modules in the models, and work is going on to further expand own modules for atmospheric chemistry, aerosol- and cloud physics. This work should be strengthened and broadened in the climate program in CIENS.

**Regional climate models and statistical techniques.** An important mismatch on interdisciplinary interfaces in climate change research is related to the coarse spatial resolution of global climate models relative to the requirements of impact studies. CIENS-partners at met.no have long-standing competence on the international level on regionalization of data from global climate models. Both regional climate models and statistical techniques are used.

**Tools for predicting risks of extremes.** One aspect of global warming appears to be a tendency towards increased risks of extreme weather (e.g flooding, land-slides, droughts). Forecasting such events may therefore become increasingly important in order to adapt to climate change and reduce vulnerability. CIENS (met.no, MetOs-UiO, NVE, Hydrology-UiO) has expertise and tools for such predictions.

**Economy models.** Models of local, regional and global economy are also developed and used. The economy models are also coupled to a simplified model-representation of climate change, to form a climate-economy model for integrated assessments (CICERO). Based on the general knowledge of basic processes in most parts of the natural and social climate system on one hand and expertise in numerical modelling on the other, there is a large potential for developing novel models coupling various compartments.

## **RELEVANT INTERNATIONAL PROGRAMS**

There is a wide range of international research programs managed by several international bodies that are highly relevant for climate research in CIENS. Some major programs are described in the following, organised under ICSU (WCRP, IGBP, DIVERITAS, and IHDP) and UN (e.g. HWRP, and IHP). Further, IPY (International Polar Year) is highly relevant for the climate program in CIENS.

**GEOSS.** Many of the observations made by or exploited by CIENS partners will fit in the global measurement program Global Earth Observations System of Systems (GEOSS), which is now being designed, in which GMES is the European component. One of the nine societal benefits themes in GEOSS is “Understanding, assessing, predicting, mitigating and adapting to climate variability and change”, which fits the objectives of the climate program in CIENS.

**WCRP** Several WCRP programs are relevant for CIENS, especially CLIVAR and SPARC.

- *CLIVAR (CLimate VARIability and predictability)* has as a primary goal of to better understand the climate variability and predictability from seasons to centuries. Typical questions that are addressed and which are highly relevant for CIENS research are: Will there be an El Niño next year? Will the next monsoon cause drought or flooding? 'Warm and wet', 'cold and dry': What will next winter be like in Europe? What are the roles of natural variability or human influence? Could climate make a sudden switch? Should we expect more extreme weather events? How much will sea level rise?

- *SPARC (Stratospheric Processes And their Role in Climate)* is focuses towards stratospheric processes that play a significant role in the earth's climate. E.g. the absorption of solar radiation in the stratosphere by ozone modulates the solar forcing of climate. The concentrations of some stratospheric gases, principally ozone, carbon dioxide and water vapour, determine significant radiative forcing terms, and there is two-way interaction between stratospheric and tropospheric dynamics. These are research questions that are dealt with in CIENS.

**IGBP** Several IGBP programs are addressing research topics studied in CIENS, in particular IGAC, SOLAS, and ILEAPS.

- *IGAC (International Global Atmospheric Chemistry Project)* was created to address growing international concerns over rapid changes observed in Earth's atmosphere. The objectives of the project are (i) to accurately determine global distributions of both short and long lived chemical species in the atmosphere and to document their changing concentrations over time, (ii) to provide a fundamental understanding of the processes that control the distributions of chemical species in the atmosphere and their impact on global change, and (iii) to improve our ability to predict the chemical composition of the atmosphere over the coming decades by integrating our understanding of atmospheric processes with the response and feedbacks of the Earth System

- *SOLAS (Surface Ocean - Lower Atmosphere Study)* addresses several research topics that are studied in CIENS, such as biogeochemical interactions and feedbacks between the atmosphere and the ocean, processes governing atmosphere-ocean exchange – including exchange of CO<sub>2</sub> and other climate gases.

- *ILEAPS (Integrated Land Ecosystem - Atmosphere Processes Study)* has as its objective to provide understanding of how physical, chemical and biological processes interact to transport and transform energy and matter through the land-atmosphere interface. ILEAPS has identified four key science foci; i) land-atmosphere exchange of reactive and conservative compounds, including key feedbacks in the Earth System, ii) feedbacks between land biota, aerosols and atmospheric composition in the climate system, iii) feedbacks and tele-connections in the land surface–vegetation–water– atmosphere–system, and iv) transfer of materials and energy in the soil/canopy/boundary-layer system, using measuring and modelling

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**IHDP** takes an interdisciplinary social science perspective on global change and works at the interface between science and practice. In the context of global environmental change IHDP focus on various themes relevant to climate change, i.e. land-use dynamics and land-cover change (joint with IGBP), sustainable production and consumption systems, interactions between institutions and global environment, as well as water issues, and carbon cycle management. IHDP's core research projects are linked by the crosscutting themes of vulnerability, resilience and adaptation; the recognisance of long-term trends, transitions and thresholds; issues of Governance; and knowledge production and social learning for improved management of tightly coupled environmental and social systems.

**DIVERSITAS** By linking biology, ecology and social sciences, DIVERSITAS produces socially relevant new knowledge to support sustainable use of biodiversity. There are three sub-programs, and they are potentially relevant for CIENS:

- *bioDISCOVERY*: Assessing current levels of biodiversity; developing the scientific basis for monitoring and observing; understanding and predicting changes.

- *ecoSERVICES*: Expanding biodiversity and ecosystem functioning science to larger scales and over a greater breadth of the biological hierarchy; linking changes in ecosystem structure and functioning to changes in ecosystem services; assessing human response to change in ecosystem services.

- *bioSUSTAINABILITY*: Developing new knowledge to guide policy and decision making that support sustainable use of biodiversity; evaluating the effectiveness of current conservation measures; studying the social, political and economic drivers of biodiversity loss, as well as social choice and decision making.

**UN programs** WMO seeks to facilitate world-wide cooperation in the establishment of networks of stations and to promote activities in operational hydrology and to further close co-operation between Meteorological and Hydrological Services. CIENS includes the operational meteorological and hydrological institutions in Norway and will thereby contribute to maintain the network of stations and studies of long time series. The main long-term objective of the Hydrology and Water Resources Programme (HWRP) on Forecasting and Applications in Hydrology is: To apply hydrological modelling and forecasting techniques and related technology for the mitigation of water-related disasters of both natural and anthropogenic origin and for studies of global change, including impact of climate change on water resources. The objectives of the Climate group in CIENS directly relates to this. UNESCO runs the International Hydrology Programme (IHP) on Global Changes and Water Resources.

**International Polar Year** The International Polar Year (IPY) 2007-2008 will be an intense, internationally coordinated campaign of research that will initiate a new era in polar science. IPY 2007-2008 will include research in both polar regions and recognise the strong links these regions have with the rest of the globe. It will involve a wide range of research disciplines, including the social sciences, but the emphasis will be interdisciplinary in its approach and truly international in participation. It aims to educate and involve the public, and to help train the next generation of engineers, scientists, and leaders. Several of the institutions in CIENS have relevant competence to be strongly involved in IPY initiated research over the next years. IPY projects with CIENS participation will be used as a vehicle for CIENS collaboration

### **OPERATIONAL AIMS AND STRATEGIES TO ACHIEVE THEM RESEARCH QUALITY AND MULTI-FIELD ASPECTS**

**Objectives** Within the planning period the program aims at developing the capability and capacity of CIENS to undertake high quality multi disciplinary and trans-institutional climate research in research fields defined across single disciplines and with joint contributions from natural scientists and social scientists alike.

**Strategy** Strategies to reach this goal would be, inter alia (i) to develop and submit joint research proposals to national as well as international research programs, (ii) to establish internal forums within CIENS to discuss and develop thematic areas for multi-disciplinary studies in order to enhance professional understanding between fields like geophysics, biology, economics and social sciences, and (iii) to invite international researchers engaged in multi-field climate research to motivate for and contribute in multi-disciplinary project development.

## INTERNATIONALIZATION

**Objective** The climate program in CIENS aims at being an active and attractive collaborative partner internationally.

**Strategy** Several instruments will be used in order to achieve these goals, such as:

- *International committees:* CIENS scientists are working actively in international research committees, e.g. in ICSU programs, in EU and NFR, to define future research needs.

- *Comparative advantages:* Climate research in CIENS will take advantage of the interdisciplinary potential and a strong contact with environmental authorities.

- *EU 7 FWP:* CIENS will participate in several climate related projects in EU (7 FWP). CIENS will actively seek to influence call texts and maintain its strong links to the European research community. In cases when a CIENS partner participates in an EU funded project CIENS will seek to raise funding (e.g. from NFR) for contributions from additional CIENS partners when relevant.

- *Nordic collaboration:* CIENS will contribute to establishing climate change research on a Nordic level. Existing networks established through Nordic projects (e.g. Climate and Energy: <http://www.os.is/ce/>) will be further developed. National projects covering the Nordic region such as RegClim's sister projects in Sweden, Denmark and Finland will be further developed.

- *International partners:* CIENS will seek to establish formal agreements with some key international research institutes, An extensive list of collaborative partners will not be listed here, but we will highlight a few institutions being particularly relevant for (i) interdisciplinary climate research: Potsdam Institute for Climate Impact Research Potsdam, MPI Jena, IIASA, and MIT, and (ii) for climate modelling: the Hadley Centre, MPI Hamburg, and NCAR.

- *Visiting scientists:* CIENS will seek to establish a broad climate research exchange program for visiting scientists at all levels (PhD, Postdoc and professor levels)

- *International conventions:* CIENS will take an active part in preparing scientific input to Norway's contributions to the development and implementation of international conventions (regarding climate research especially UNFCCC). In particular, studies and activities under the climate program in CIENS will play an active role in the preparation of the Fifth Assessment Report (like in the ongoing Fourth) of IPCC, as well as with regard to climate related issues under the Convention on Biological Diversity and the Vienna Convention on

### *Climate Change*

the Ozone layer (Montreal Protocol). Work on following up on ACIA is in progress. CIENS needs to be involved on national and international levels.

### **INTERACTING BASIC AND APPLIED RESEARCH**

**Objective** The climate change program in CIENS aims at combining basic and applied research.

**Strategy** CIENS is well-positioned to produce new and highly relevant knowledge that draws from and integrates many different disciplines, as well as combining the best of pure research and applied research. Some of the institutes represented at CIENS already have long experience with interdisciplinary research within the field of climate change, but joining forces under a single roof will provide even greater opportunities for cooperation. This type of cooperation is essential for research on the climate system and the human response to natural and man-made changes because the issues that must be addressed relate to basic as well as applied research.

### **INNOVATION**

**Objectives** Climate change will have economic and ecologic consequences. Major important sectors in society will be affected. One aim of the climate research program is to see to that increased understanding will help society and industry to better adapt to any negative impact or to take advantage of changes that may prove positive, e.g. in relation to the development and use of renewable energy resources.

The demand for specialized products regarding short-term forecasts of extreme events and disasters will probably increase with global warming.

**Strategies** CIENS will seek co-operation with business and commercial interests within e.g. agriculture, forestry, aquaculture, infrastructure, buildings, energy including hydropower, and tourism. This will be done in order to identify major consequences, develop mitigation strategies, investigate the need for technological development, and commercialise specialised products (e.g. Decision Support Systems).

For short-term predictions, several CIENS partners can design customer adapted products. Co-operation with institutes in the neighbourhood will expand the possibilities.

### **TRANSFER OF KNOWLEDGE TO DEVELOPING COUNTRIES**

**Objective** There is a great need for knowledge on climate change and capacity building in developing countries. An aim of the climate research program is to help conveying this.

**Strategies** The various activities undertaken under the program will have an obvious international orientation thus contributing to capacity building and to the general transfer of new and improved knowledge on drivers, pressures, states, impacts and responses to climate change. In particular, activities undertaken in the program related to socio-economic impacts of climate change, studies of vulnerability to climate impacts and the responses from the society, local communities and individuals to handle the impacts will be valuable for policy formulation and planning of Norwegian assistance to climate vulnerable countries.

### **RESEARCH INITIATIVES AND PROJECTS**

Several research groups are involved in large coordinated networks and projects on a European (IP, NoE), Nordic (CoE) and national (integrated projects) level. Under the framework of CIENS it is applied to the Research Council of Norway to be nominated as a Centre of Excellence in the field of the global water cycle. The centre will involve the

university as well as several research institutes and address many of the scientific issues of the CIENS climate program.

In order to establish a strong base for climate research in CIENS it is necessary to identify major research gaps where methods need to be established or will need further development. Part of this evaluation would be a ranking of existing methods that might be further developed in relation to costs and potential research benefits. A particular focus is needed on the interfaces between individual research disciplines.

Next, and based on the above research priorities, a broader climate research program needs to be designed, with main emphasis on inter-disciplinary approaches, covering important impact chains, as well as potential couplings, between changes in the geophysical climate system and their impacts on nature and socio-economic conditions. With some new basic funding, a few pilot projects covering major research gaps, would be carried out.

Only under a substantial funding scenario can a broader research program be implemented. Then integration of a larger part of the DPSIR chain will be obtained. The geophysical climate system and changes in nature can be studied in one common earth system model, which can be linked to models of socio-economic impacts and responses from society.

## **A Sustainable Atmosphere**

### **Atmospheric fluxes and concentrations**

**Øystein Hov**, met.no/Met-Os-UiO; **Thorjørn Larsen**, NIVA; **Kristin Rypdal**, CICERO;  
**Hans Martin Seip**, Chemistry-UiO/CICERO; **Kjetil Tørseth** NILU

#### **Summary**

*Can we determine the bounds on human activity required for the composition of the atmosphere to support sustainable development? The CIENS partners are highly rated internationally for their competence in analyzing atmospheric sustainability, including the interaction with terrestrial and aquatic systems as well as societal impacts and responses. There is a strong tradition for linking basic and applied science and for constructive interactions between science and policy making. The CIENS expertise is developed and applied not only in Scandinavia and Europe, but also in other parts of the world with an emphasis on institution-building and competence in developing countries in Africa and Asia. CIENS aims to utilize its competence to develop new understanding of natural and man-made changes in the composition of the atmosphere, how changes in soil and water can enforce or weaken the atmospheric perturbations, and how political and economical drivers will influence the emissions to the atmosphere. Important issues are air quality and health, trans-boundary air pollution, climate change, stratospheric ozone change and UV radiation, and the cycling of toxic trace species through the atmosphere.*

#### **VISION**

CIENS contributes as one of the world leading research centres to the understanding of the mechanisms that determine the changes in atmospheric composition and fluxes, how such changes affect environment and society, and to the underpinning of policy decisions needed to ensure atmospheric sustainability in the short and long term.

#### **OVERALL AIM**

CIENS will utilize the highly rated international competence in CIENS to develop new understanding of natural and man-made changes in the composition of the atmosphere, its impacts on environment and society, and how natural, political and economical drivers influence the emissions to the atmosphere

#### **DEFINITIONS AND DELIMITATIONS**

By “a sustainable atmosphere” or “atmospheric sustainability” is meant the range of atmospheric conditions regarding composition and fluxes of constituents, which support and reinforce sustainable development, after balancing needs of short-term social equity with limitations set by economic production and environment protection in the long term.

**Drivers** are the economically driven, man made actions that impose a pressure on the environment. Important drivers regarding atmospheric sustainability are population growth, land-use change, consumption and transportation growth, industry, energy production, distribution patterns, technological innovations and institutional and political frameworks.

**Pressures** are emissions of atmospheric pollutants and their distribution on activities/societal sectors, as well as magnitude and change in natural fluxes as a function of changes in land use, climate, agriculture and other resource exploitation.

**State** describes the composition of the atmosphere and fluxes to and from the atmosphere. This involves interactions with the terrestrial, aquatic and marine compartments of the earth system, and its understanding is based both on observations and model calculations taking into account physical and chemical processes.

**Impacts** denote how air pollution affects ecosystems, human health, materials and climate.

**Response** includes how nature adapts to environmental impacts of changed atmospheric concentrations and fluxes ( $R_N$ ), and how societies design mitigation and adaptation strategies and their implementation in response to the impacts ( $R_S$ ).

## **GENERAL OBJECTIVES**

Environmental issues are interlinked. A given pollution release can be a problem both at the source, as long-range transport, and as a hemispheric or global issue, and can affect human health as well as other parts of the biosphere, ecosystems, materials, climate, fresh water, oceans and soils. Atmospheric composition and fluxes of constituents change over a wide range of scales from a single street or a tiny ecosystem to the whole globe, with variations extending from minutes to several years.

The most important research challenges that will be addressed by CIENS related to atmospheric sustainability include

**Coupling between atmospheric composition and climate change** (both directions). This requires identification and quantification of climate-driven change of processes that influence air quality; such as changes in temperature, precipitation, humidity, length of dry spells, cloud cover and volume, and fluxes of momentum, sensible and latent heat, and trace species between the surface and the atmosphere.

**Changes in the biogeochemical cycling of elements due to human impacts.** Cycling of nitrogen is emphasized, which is regulated in particular by the burning of fossil fuels with transportation as a major component, and agriculture. The approach includes the modelling of fluxes of nitrogen between the soil, atmosphere and aquatic systems, and how these fluxes are determined by drivers such as transport and agriculture. Other elements with important research challenges are mercury and persistent organic pollutants.

**Changing air quality and its impact on human health and the environment.** The approach is to combine dose/response relationships, derived in epidemiological investigations, with the knowledge of the air pollution exposure on the individual level. The results are aggregated to the appropriate macro-level (cities, countries etc.).

**How changes in drivers influence pollutant emissions.** Enhanced transportation, energy use, and relocation of industries in a globalized economy lead to growth and redistribution of emissions to air. Further on the DPSIR chain we derive the consequences for the atmospheric composition and fluxes, and finally the changed impact on the environment.

**The significance of population growth, urbanisation and mega-city development.** This will affect exposure and deposition on different scales in space and time. Following the DPSIR chain, the challenge is to derive how changes in population and its spatial aggregation, will modify the pressures (emissions) and the consequence for the composition of the atmosphere and the changed impact on the environment.

**The coupling of biogeochemical cycles with the hydrological cycle.** This is a challenge on the catchment level, regional level, national level, continental and global levels. A process oriented approach is required where the biogeochemical and hydrological cycles and their interactions are resolved at the appropriate scales.

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Many of these challenges are particularly pressing in developing countries and particularly in the emerging industrial superpowers China and India, and CIENS has an important mission to reach out to other parts of the globe to build competence on how to develop atmospheric sustainability.

## **STATUS**

Several CIENS partners are international leaders in atmospheric sustainability research and in applying the DPSIR philosophy in co-operation with international partners. The solution of acid rain and other trans-boundary, regional air-pollution problems in Europe are pioneering examples of application of the DPSIR philosophy, and CIENS-partners have been and are instrumental in this work.

**Drivers:** Within CIENS, NIBR has macroeconomic modelling expertise with focus on Norwegian municipalities/counties. CICERO has developed a global economic model for emissions related to economic development at a regional resolution and with links to a simple climate model. CICERO, met.no and NILU have competence on emissions. Economy-UiO has developed economical instruments and ideas which are used in integrated assessment models.

**Pressures:** Met.no, NILU, CICERO and MetOs-UiO make important contributions to the international research and assessment work on emission.

**State:** CIENS partners, in particular NILU, met.no and MetOs-UiO, and Chemistry-UiO are advanced in the description of the composition of the atmosphere both by measurements and by numerical model calculations. This includes chemistry, transport processes and fluxes between the atmosphere and the terrestrial and marine compartments of the earth system, and all scales from local to global. For the hydrological cycle met.no, NVE, NIVA, MetOs-UiO and Hydrology-UiO have specialized competence, both observation based and theory/model based.

**Impacts:** NIVA, NINA, NILU, CICERO, met.no, Chemistry-UiO, and Biology-UiO have considerable competence on the impacts of air pollution on health and crops including costs, and on ecosystems and the response on the natural fluxes between the terrestrial and marine ecosystems, and the atmosphere.

**Response natural and societal:** The CIENS partners, and in particular met.no, NILU, NIVA have a long tradition in contributing to appropriate decision- and policy- making to combat air pollution impacts. CICERO and to some extent met.no, has competence in abatement strategies, including co-benefits of climate measures (CICERO). Economy-UiO are doing research on issues related to CLRTAP.

“The source-receptor matrix” is here a central concept, where on an operational basis the trans-boundary fluxes of air pollution, derived from e.g. emissions of sulphur-, nitrogen- and volatile organic compounds, have been characterized in terms of their sources and receptors within Europe for several decades. These have formed the basis for negotiations of emission reductions within the Convention on the Long Range Transmission of Air Pollutants (CLRTAP) and the EU. The source-receptor matrix has in collaboration in particular with IIASA been combined with data for socio-economical drivers (emission cost curves) and data for vulnerability (critical levels and loads). Thus, cost-effective air pollution control strategies have been calculated and policy relevant conclusions have been derived and used in the negotiations for emission reduction protocols and other policy instruments.

Biology-UiO and NINA are advanced in some aspects of ecosystem adaptation to impacts of atmospheric pollution and fluxes.

**International Collaborative Partners:** The CIENS partners are strongly linked into international networks built up through decades of CLRTAP work, EU research framework programme participation, association with American and Asian work and international programmes like IGBP, IHDP, DIVERSITAS and WCRP.

The extensive network of collaborative partners will not be listed here, but we will highlight a few institutions being particularly relevant for the integrated DPSIR approach of CIENS:

A continued collaboration with IIASA is of particular importance to further understand how air pollution interacts with the macroeconomic mechanisms on national, continental or global scales. Here the IIASA research plan for 2006-2010 (“Atmospheric pollution and economic development program” APD 2005-2010 programme, see [www.iiasa.ac.at/nmo](http://www.iiasa.ac.at/nmo)) is very relevant.

Another collaborative partner is the Tyndall Centre at the University of East Anglia, which is a cross-disciplinary project organized centre with a particular focus on the integrated assessment of climate change abatement, but the methodology is also relevant for theme 2. CICERO has an ongoing collaboration with the Tyndall Centre ([www.tyndall.ac.uk](http://www.tyndall.ac.uk)).

A third centre for integrated assessment modelling in Europe directed at theme 2 – relevant issues, is the University of Stuttgart, where met.no has an established relationship. At the University of Stuttgart integrated assessment modelling is done on a spatial resolution which is regional/grid element resolved, rather than on a country basis, and therefore in principle it is possible to distinguish among abatement mechanisms within countries or regions and their cost effectiveness ([www.ier.uni-stuttgart.de](http://www.ier.uni-stuttgart.de)).

The cooperation with IES at the Joint Research Centre in Ispra is also worth noting, with its relevance for global atmospheric chemistry modelling, remote sensing and policy development.

## **RELEVANT INTERNATIONAL PROGRAMMES**

The Atmospheric Sustainability theme relates to several international programmes and joint efforts to understand fundamental problems arising in the coupling between earth system elements, between fluxes and impacts, and between drivers and pressures.

Of particular importance are the **IGBP** IGAC ( ILEAPS (Integrated land ecosystem-atmosphere processes study), SOLAS (Surface Ocean-Lower Atmosphere Study), and the IGBP land-atmosphere project ([www.igbp.kva.se](http://www.igbp.kva.se)); and **IHDP** with its seven Core Science Projects ([www.ihdp.uni-bonn.de](http://www.ihdp.uni-bonn.de)), Global Environmental Change and Human Security (GECHS), Institutional Dimensions of Global Environmental Change (IDGEC), Industrial Transformation (IT), Land-Use and Land-Cover Change (LUCC, co-sponsored with IGBP), Land-Ocean Interactions in the Coastal Zone (LOICZ) (co-sponsored with IGBP), Urbanization and Global Environmental Change, and Global Land Project (co-sponsored with IGBP).

World Climate Research Programme (**WCRP**) has a broad-based multi-disciplinary science strategy to investigate all physical aspects of climate and climate change. The Global Energy and Water Cycle Experiment (GEWEX) is the scientific focus in WCRP for studies of atmospheric and thermodynamic processes that determine the global hydrological cycle and water budget and their adjustment to global changes such as the increase in greenhouse gases. One of the main thrusts of GEWEX is the implementation of a series of atmospheric/hydrological regional process studies such as the GEWEX Continental-scale International Project (GCIP) embracing the whole Mississippi river basin, the GEWEX Asian Monsoon Experiment (GAME), or the Baltic Sea Experiment (BALTEX).

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Observational projects in order to satisfy specific and evolving scientific needs include the International Satellite Cloud Climatology Project (ISCCP), the International Satellite Land-Surface Climatology Project (ISLSCP), Global Water Vapour Project (GVaP), and the Global Precipitation Climatology Project (GPCP). Progress has also been made in the GEWEX Cloud System Study (GCSS) aiming to develop improved parameterizations and models of cloud systems used in climate and numerical weather prediction studies.

Another WCRP research activity playing an important role in better understanding the climate system is the Stratospheric Processes And their Role in Climate (SPARC) study, concentrating on the interaction of dynamical, radiative and chemical processes.

Atmospheric sustainability is a fundamental aspect of the stabilization of climate change, as discussed in IPCC (Intergovernmental Panel on Climate Change).

**GEOSS** (Global Earth Observation System of Systems). Theme 2 will in particular contribute to four of the social benefit themes: (2) Understanding environmental factors affecting human health and well-being; (5) Improving water resource management through better understanding of the water cycle; (6) Improving weather information, forecasting and warning; (8) Supporting sustainable agriculture and combating desertification

### **OPERATIONAL AIMS AND STRATEGIES TO ACHIEVE THEM RESEARCH QUALITY AND MULTI-FIELD ASPECTS**

Central to the CIENS ambition for the theme on atmospheric sustainability, is to make leading contributions to the research aims 1-6 presented under 'General Objectives' above.

**Objective** Pursue the elements of the 'atmospheric sustainability' theme (points 1-6 above) to enhance the combined value of the research efforts among the CIENS partners so that over the longer term, a coherent CIENS competence and methodology is developed which is suited to address the DPSIR-cycle related to atmospheric sustainability both on the local, regional/national and international/global scales.

**Strategy** The objective will be addressed on several levels in the sequence from basic to applied research. We recognize that in multidisciplinary research substantial attention is required to the coupling of disciplinary knowledge and methodologies, where often fundamental difficulties arise. Another related issue is the (lack of) relationship between scales when working multidisciplinary. Different disciplines or different institutions who work on different spatial scales: are they relevant to integrate? Research "in the interfaces" is needed.

*Interdisciplinarity and feedback* As the scientific understanding of individual environmental issues matures, some essential couplings and feedback mechanisms among them are detected. For instance:

- long range transport is a major contributor to averaged levels of particulate matter in cities;
- climate change and stratospheric ozone are strongly coupled;
- reduced emissions of particulate matter and precursors imposed to protect human health, will heat the earth system due to reduced reflectivity of solar radiation by aerosols;
- air pollution will change when climate changes even if emissions are stable;
- the presence of aerosols can change regional weather patterns and thus pollution transport.

To address the feedback mechanisms – or multi-field aspects - between the different environmental issues, there is an obvious need for interdisciplinary approaches. This encompasses the observational component as well as theoretical modelling and its data requirements. The disciplinary approach to legal regulations is also coming to an end. To cut emissions to protect climate, the stratospheric ozone layer, crops, terrestrial and aquatic

including marine ecosystems and public health, the earth system perspective is required to reach solutions which optimize the benefit of regulations and investments in technology replacements. With the vision to put this science in the lead, significant spin offs can be expected for weather prediction, in that the feedback from air pollution to weather can be significant.

*Interdisciplinarity and interface mismatch* The transformation of research from “within disciplines” to “between disciplines” involves boundary and interface problems which need careful attention. Examples: coupling of river runoff models with numerical weather prediction (NWP); coupling atmosphere and ocean or atmosphere and land-surface in climate; radiation budget changes are essential for calculating the feedback between changes in chemical composition and the climate physics and dynamics; coupling atmospheric chemistry models with NWP models to assess source-receptor relationships or to analyse past or future changes in composition as emissions or climate changes.

*Strengthening the scientific quality of interdisciplinarity* Multidisciplinary research has often been forced to produce results much before fundamental problems have been solved satisfactorily, impeding progress in quality and wasting significant resources on work of less than desirable quality. CIENS provides a unique opportunity to make a real contribution to the research into fundamental problems in the bridging of disciplines. CIENS will aim to uncover how there is a significant imbalance between strong pressure for quick applicable results and the undervalued development of fundamental understanding. This imbalance shifts intellectual and financial resources to applications rather than the scientific basis for the coupling of disciplines, and costly cross disciplinary applications are carried out with only a rudimentary understanding of the interface problems. This can lead to scientific advice that will bring unwise policy decisions. CIENS allows us to address the fundamental issues between disciplines.

*Strategic observational resources* The investigation of the science issues related to the challenges 1-6 listed above is dependent on observational data which to some extent exists. The CIENS partners, in particular met.no, NIVA and NILU host very significant observational national data series with strong and mature links to international observational data. Observational data are critical to the development of process understanding and quantification, model establishment, and the validation of models. Through the active participation in international programmes like IGBP, WCRP and EU research projects, the observational basis is continuously enhanced enabling improvements in modelling capabilities.

## **SCIENTIFIC PRODUCTION**

**Objective** Establish CIENS as a leading international research centre for atmospheric composition and fluxes.

**Strategy** To advance the work in CIENS on challenges 1-6 listed above, current and new projects will be used as a basis to prepare joint publications that promote the CIENS Theme 2 thinking. The CIENS partners are scientifically advanced and well recognized research institutions within atmospheric sustainability, and the DPSIR approach is widely used. To improve the quantification of the links between drivers and pressures macro-economical model development is required with an emphasis on environmental aspects in sectors of society, and with a spatial and temporal coverage and resolution which is compatible with the environmental problems addressed. With a broad CIENS partnership, review type publications will be prepared to demonstrate for external stakeholders and peers that CIENS is operational and to motivate further internal integration.

### *A sustainable atmosphere*

The joint work with economists has advanced more on the response side than on the driver side. We will develop the theme to cover the relevant activities in the participating institutions to capitalize on the total CIENS competence. The collaborative links outside of CIENS to cover elements where the CIENS partners are weak today will be strengthened. This relates in particular to the modelling of economical development on the spatial and temporal scales relevant for atmospheric sustainability, and with a quantification of how the energy, transport, agriculture and industry sectors contribute to emissions changes.

It is required to develop commonalities in planning and information exchange within CIENS.

### **INTERNATIONALIZATION**

**Objective** Develop the ‘Sustainable atmosphere’-theme to put CIENS in the lead in international research.

**Strategy** Internationalisation is a major element in the research approach taken by the CIENS partners, and joining together will provide new opportunities to set the agenda and take the lead on specific issues.

- *Take up the GEOSS challenge* Specifically the CIENS partners define their research and development agendas to further develop their skills to meet the challenges as a part of a Norwegian response to GEOSS. As the alignment develops, CIENS will be able to influence internationally how to derive new research and products through the opportunity offered by GEOSS and its underlying international support and commitment.

The operational capabilities of some of the CIENS institutions like met.no are essential in this context, where the capability for real time data collection, data handling, product generation and dissemination through a variety of modern communications channels function very well and with a strong institutional and societal support (cfr. weather prediction).

- *Participation in EU Framework Programme 7 (FP7)* In CIENS the ambition is to take advantage of the CIENS platform in the opportunities provided through FP7.

A description of proposed contents of Framework Programme 7 was published in April 2005 by the CEC. The objective within the field of the environment (including Climate Change) will be on sustainable management of the environment and its resources through advancing knowledge on the interactions between the biosphere, ecosystems and human activities, and developing new technologies, tools and services, in order to address in an integrated way global environmental issues. Emphasis will be put on prediction of climate, ecological, earth and ocean systems changes; on tools and technologies for monitoring, prevention and mitigation of environmental pressures and risks including those related to health, as well as the conservation of the natural and man-made environment.

*Nordic collaboration* Strengthen the Nordic basis for international research by contributing to Nordic collaboration and efforts to establish a Nordic science region.

Traditionally several of the CIENS partners (NILU, NIVA, met.no, CICERO) have used the Nordic basis provided through the Air and Sea Group under the Nordic Council of Ministers to establish common research projects to underpin environmental policy within CLRTAP, EU, IPCC, HELCOM, OSPAR and AMAP. NILU and UiO with support from met.no are members of the Nordic Centre of Excellence on “Biosphere, aerosol, cloud, climate interactions” coordinated by University of Helsinki ([www.atm.helsinki.fi/BACCI](http://www.atm.helsinki.fi/BACCI)).

*Internationalisation beyond Scandinavia, EU or GEOSS* Develop further links to international partners in Europe and outside

Several of the CIENS partners under this theme have extensive international networks counting most of the leading institutions in Europe, and with many institutions in North America and Asia, and some in Africa, South America and Australia. An example is the IMPACTS (Integrated Monitoring Programme on Acidification of Chinese Terrestrial Systems) project where the Norwegian experience with monitoring of air pollution and its effects in an integrated way has been transferred to Chinese scientists and decision makers.

### **INTERACTING BASIC AND APPLIED RESEARCH**

**Objective** Couple basic and applied research in Theme 2.

**Strategy** In CIENS, theme 2 will be addressed at several levels in the sequence from basic to applied research, recognizing that in multidisciplinary research substantial attention is required for coupling disciplinary knowledge and methodologies. Often fundamental difficulties arise (e.g. the flux adjustments between the ocean and the atmosphere in GCMs).

Multidisciplinary research has often been forced to produce results much before fundamental problems have been solved satisfactorily, impeding progress in quality and wasting significant resources on work of a less than desirable standard. In CIENS attention can be paid to methodological problems on a fundamental level, at the same time as keeping up operational activities (e.g. at met.no operationality drives research activities).

### **RECRUITMENT, EDUCATION AND OUTREACH**

**Objective** Recruit, educate and reach out in an international context to develop the research basis for determining the bounds on human activity required for the composition of the atmosphere to be sustainable.

**Strategy** Take an active part in international exchange of students and researchers. Incorporate atmospheric sustainability themes in university courses and in public outreach activities.

### **INNOVATION**

**Objective** Develop signal parameters adequate for policy purposes; develop the methodology to generate the signal parameters.

**Strategy** Based on innovative methods for the fusion of observed and modelled data into custom designed products and decision making systems, CIENS will use the opportunities for innovation and commercialization related e.g. to the exploitation of remote sensing data, for the aviation industry, for oil exploration activities etc.

### **RESEARCH INITIATIVES AND PROJECTS**

Several joint applications from CIENS partners were sent to the Nordic Council of Ministers in June 2005, as well as to the Norwegian Research Council for PROFO (A "PROFO" proposal on "Catchment cycling of mercury in boreal ecosystems" was submitted in June 2005 by NIVA, NILU, UiO-Chemistry, IVL, Sweden, Trent University, Canada. A proposal involving NILU, met.no, NIVA and CICERO was sent to the programme "Kysten og Havet". To advance the work in CIENS on topics 1-6 listed under General Objectives above, current and new projects will be used as a basis to prepare joint publications that promote the CIENS Theme 2 thinking. "Ear marked" funding for developing co-operation on the interfaces is so far little explored, and may be particularly fruitful and potentially strengthen CIENS as a leading "institution" in symbiotic/interdisciplinary environmental research. With a broad CIENS partnership, review type publications will be prepared to demonstrate for external stakeholders and peers that CIENS is operational and to motivate further internal integration. This will provide a platform and an idea bank for later external funding proposals.

## ***Integrated River Basin and Coastal Zone Management***

**Kari Nygaard**, NIVA; **Bruce Hackett**, met.no; **Eyvind Aas**, MetOs UiO; **Josef Pacyna**, NILU; **Gunnar Halvorsen**, NINA; **Haakon Thaulow**, NIVA; **John S. Gray**, Biology-UiO; **Frode Olsgard**, NIVA; **Knut B. Stokke**, NIBR; **Morten Johnsrud**, NVE; **Nils Roar Sælthun**, Geosciences-UiO/NIVA; **Rolf D. Vogt**, Chemistry-UiO; **Sverre Husebye**, NVE; **Thorkel Askildsen**, TØI.

### ***Summary***

*How can we achieve sustainable management of our limited freshwater resources and vulnerable coastal zones? Within Integrated River Basin Management and Coastal Zone Management (IRBM and CZM) CIENS has high international-level competence within social and natural sciences on drivers, pressures, state and impacts, and feedbacks and responses related to river basins and coastal zones. Particular note should be given to the environmental monitoring and large-scale information systems managed by the CIENS partners. The expertise in CIENS will contribute to improved understanding of processes, solution of conflicts, and balancing of the stakeholders. CIENS intends to establish a centre of expertise in IRBM and CZM that will give scientifically sound advice to the authorities on e.g. implementation of EU's Water Framework Directive and the new EU Marine Strategy, as well as on national activities within integrated management of the river basins and coastal zones.*

### **VISION**

CIENS is recognized as the leading national and a well known international interdisciplinary research centre providing the scientific basis and tools for optimal and sustainable management of river basins and coastal zone.

### **OVERALL AIM**

CIENS will be a mediator for integration of scientific disciplines, including their data and methodologies, within the field of Integrated River Basin and Coastal Zone Management. CIENS will produce research regarding natural behaviour and management on the terrestrial/aquatic and freshwater/marine interactions in a cloud, catchments, coast and oceans continuum. CIENS will provide internationally attractive partnership in IRBM and CZM research and education, and be a provider of scientific understanding to the government, industry, public and NGOs on national and international IRBM and CZM.

### **DEFINITIONS AND DELIMITATIONS**

The theme "Integrated River Basin and Coastal Zone Management" (IRBM and CZM), is built on the two sub-themes: Integrated River Basin Management (IRBM) and Integrated Coastal Zone Management (ICZM), and the integration between these two themes. IRBM is an integral part of Integrated Water Resources Management (IWRM) and in this context it emphasizes the River Basin as the fundamental integration unit. There are no broadly accepted definitions of these terms, but neither is there any fundamental disagreement on how they should be understood. The Global Water Partnership (GWP) (Integrated Water Resources Management, Global Water Partnership Technical Advisory Committee Background Papers, No. 4, 2000) defines IWRM and IRBM as follows:

*“IWRM is a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.” (on IRBM): “The promotion of catchment and river basin management is an acknowledgement that these are logical planning units for IWRM from a natural system perspective. Catchment and basin level management is not only important as a means of integrating land use and water issues, but is also critical in managing the relationships between quantity and quality and between upstream and downstream water interests.”*

The EU Water Framework Directive (WFD) (DIRECTIVE 2000/60/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2000 establishing a framework for Community action in the field of water policy) bridges IWRM and ICZM and defines its area of authority to include coastal waters up to one nautical mile seaward from the coastal baseline. Further EUs Marine strategy will be an instrument to bridge oceans to the coastal waters.

With reference to the overall DPSIR philosophy as described in Section I, the different elements in relation to IRBM and CZM can be described as follows:

**Drivers:** Land-use change (urbanisation, industry, agriculture), energy demand, aquaculture, freshwater and marine fisheries.

**Pressures:** Pollution emissions/discharges, effects of land-use changes, long range transported pollutants, seepage from dumping grounds and other contaminated sites, introduction of non-indigenous species, dams and river regulation, coastal habitat changes.

**States:** Air quality, precipitation - amount and chemical quality, ice and snow cover, glaciers, frozen ground, ice on lakes and rivers, lake levels, river flow, erosion, sediments and inundations, floods and droughts, soil and soil water chemical and physical characteristics as well as pools of pollutants in the terrestrial environment, groundwater, water temperature, surface water chemical quality, sea level and state, salinity, currents, benthic and pelagic biological diversity.

**Impacts:** Economy, jobs and regional population patterns, ecosystem functioning (e.g. loss of fish stocks, plant communities and biodiversity in general), deterioration of drinking water reservoirs and value of nature for recreations purpose, enhanced leaching of contaminants from the terrestrial environment, marine deposits and polluted harbours etc.

**Responses (nature):** Changes in biodiversity; ecosystem changes dependent on responsiveness and resilience of the various ecosystems.

**Responses (society):** National and international conventions, licensing policies, basin management plans, restoration activities, wastewater treatment plants, flood protection measures. GHG (Greenhouse gases) tariffs and quotas, international trade agreements, and rural development policy.

A DPSIR based figure for IRBM and CZM is shown in annex.

## **GENERAL OBJECTIVES AND CHALLENGES**

The the water courses and the coastal zone are characterized by large variations in habitat diversity, ecology and biodiversity. They are very important economic zones, being sites for the marine and freshwater related primary economies of Norway: hydropower production, aquaculture, fisheries and oil and gas production, with a primary production value of approximately 25 000 mill EUR. The population is concentrated along the coast, and the inland population centres are located along the main rivers and lakes. Many interests collide

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here, and the main conflicts between resources utilization and environmental protection and between private and public uses are located at the coastal zone and the rivers.

**Scientific challenges:** The water courses and the coastal zone are facing large environmental challenges in terms of e.g. management of biodiversity, pollution, cultural heritage and land-use. These challenges extend over ecosystems, society drivers and management systems. Influence, usage and management of nature and culture can not be seen by means of simple boundaries linked to different types of pressures, but must be envisioned in a more integrated perspective. The spreading and effects of pollutants occurs across ecosystem borders, where it is important to understand the boundary line processes.

Knowledge of the underlying processes is vital to the understanding and modelling of the interactions within both the natural system and the human system, as well as between them. The assessment of the knowledge requirements within IRBM and CZM will reveal knowledge gaps that in turn will trigger relevant process studies.

Most cause-effect/dose-response relationships between interacting components of social, economic, and environmental systems in the DPSIR are only partly understood and modelled. The interactions between pressures and states are probably best understood, but even in this area there are large knowledge gaps. Essential scientific challenges are e.g.:

- Identification of critical thresholds and cascading effects in ecosystems.
- Development of effective environmental and social indicators of change.
- Identify the relative importance of climatic change compared with other drivers.
- Identify the importance of extreme events relative to normal variations.
- Identify the relative importance of long range transported substances.
- Migration of contaminants in the terrestrial and aquatic environment.
- Synergistic and antagonistic effects as well as multi-effects of drivers and pressures.
- Freshwater influence on marine systems.
- Human influences on river basin - coastal zone interactions.
- Cycling of carbon, nutrients, contaminants and sediments in coastal and shelf waters.

Enhanced understanding of these relations is vital for the correct prediction of the effect of various societal responses or scenarios.

Advances within these scientific challenges demand integrated monitoring data. Enhanced data compilation, assimilation, integration and management of databases as well as developing and coordinating integrated monitoring networks will be an essential fundament on which to base the research.. Furthermore, communication and development of tools between scientific disciplines is a field of research in itself and will be developed in CIENS. It is also necessary to develop toolboxes for decision- and policy makers; e.g. modelling of uncertainty and risk, predictive modelling and cost-benefit analyses, integrated information and decision support systems etc.

**Challenges within policy and decision making:** More transverse, integrated and trans-sector research can bring forward new and necessary knowledge on the framework directives and on what will be a sustainable usage of nature and culture. In order to achieve a sound basis of management knowledge, it is necessary that the whole chain of cause-effects relationships is studied. CIENS, with its broad angle of incidence, has what it takes to attend to this responsibility. With a strong bid CIENS will be able to contribute to an enhanced integration of research within humanistic-, social- and nature science.

CIENS aims at acting as a unifying partner for a fragmented administrative system and thereby enhance interaction between the different administrative levels and bodies covering the river basin/coast units. This interface will furthermore generate new cooperation arenas for the sector administrations, especially in the integration between basin management and coastal zone. . The conflicts of interest between commercial use, public access and recreational use, and environment protection are particularly strong in the river basins and the coastal zone, as the stakeholder community is widespread and diverse. Furthermore, public administration in the field of IRBM and CZM is often entwined with rural and regional development issues, which adds to the complexity.

CIENS activities will integrate uncertainty and risk assessments in decision-making (robust decision making) and accompanying assessment of vulnerability, preparedness and security.

CIENS will be instrumental in professional contribution to several international conventions and directives in progress. Many of the institutes are already supplier of data and knowledge in this field.

### STATUS

The CIENS group covers a broad field of scientific expertise, a broad range of national monitoring and hold a huge pool of monitoring data in databases. These data form a strong fundament for future research and development related to IRBM and CZM, and enable an integrated approach to knowledge based management. CIENS has as particular competence in environmental monitoring and impact studies, environmental risk analysis, and prediction and foresight/scenario analysis.

The competence within CIENS partners in a DPSIR perspective is particularly high in the following areas:

**Drivers:** NIBR, TØI and CICERO provide important input on issues like land-use change (urbanisation, industry, and agriculture), and transportation. NVE has expertise in drivers related to hydropower.

**Pressures:** NIVA, NILU, NINA, NVE, MetOs-UiO, Hydrology-UiO, and Chemistry-UiO have expertise and extensive networks on pollution emissions/discharges, effects of land-use changes, long range transported pollutants, seepage from dumping grounds and other contaminated sites, introduction of non-indigenous species, dams and river regulation, coastal habitat changes.

**States:** MetOs-UiO; Met.No, NILU, NIVA, NVE, NINA, and Chemistry-UiO and Hydrology-UiO are all strong on environmental monitoring and assessments (air, water, soil). NVE operates the national network and data management systems for hydrology, and data includes river flow, soil and groundwater, snow, glaciers sediments and reservoir water levels. All partners have strong and specialized competence on state and impact research.

**Impacts:** NIVA, Chemistry-UiO, and Biology-UiO hold expertise within ecosystem functioning (e.g. loss of fish stocks, plant communities and biodiversity in general), deterioration of drinking water reservoirs, enhanced leaching of contaminants from the terrestrial environment etc.

**Responses:** NIBR, CICERO, Economy-UiO, and Political Sciences-UiO have competence on social responses like GHG tariffs and quotas, international trade agreements, rural development policy, international conventions, licensing policies, basin management plans, restoration activities, flood protection.

**Important partners for CIENS in Norway:** Institute for Marine Research (Havforskningsinstituttet, IMR), Norwegian University of Life Sciences (UMB), Norwegian Geological Survey (NGU), Norwegian Geotechnical Institute (NGI), NTNU, Sintef,

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Norwegian Computing Centre (NR), NORUT IT, Norwegian Institute of Land Inventory (NIJOS), Jordforsk, Norwegian Forest Research Institute (Skogforsk), Nansen Environmental and Remote Sensing Center (NERSC).

**Important international partners for CIENS:** Centre for Ecology and Hydrology (CEH, UK); National Environmental Research Institute (NERI, DK); SMHI, National Energy Authorities on Iceland, Global Runoff Data Centre (GRDC), World Glacier Monitoring Service (WGMS), US Geological Survey (USGS); Institut français de recherche pour l'exploitation de la mer (IFREMER, F); Rijksinstituut voor Integraal Zoetwaterbeheer en Afvalwaterbehandeling (RIZA, NL) The Netherlands Centre for River Studies (NCR); Rijksinstituut voor Kust en Zee (RIKZ, NL); Suomen ympäristökeskus (SYKE, FIN); Plymouth Marine Laboratory (PML, UK); Met Office (UKMO, UK); Netherlands Institute of Ecology (NIOO-KNAW); Centre for Social and Economic Research on the Global Environment (CSERGE) at University of East Anglia (UK); University of Plymouth (UK); Institute of Environmental Studies Vrije, University of Amsterdam (NL); Gdansk University of Technology (P).

## RELEVANT INTERNATIONAL PROGRAMMES

A large number of research and management programs are relevant for IRBM and CZM.

**EU Research Programmes.** EU-research had IRBM and CZM as priorities both in Framework Programmes 4, 5 and 6. All CIENS partners are involved in EU Research Projects. There are also INTEREG projects and activities within this field such as ESPON (European Spatial Planning Observation Network). This programme is conducted under the aegis of INTERREG III and aims to encouraging international collaboration within the EU. NIBR is ESPON Contact Point for Norway, and is lead partner for ESPON Activity 2.1.5 "Territorial Impacts of European Fisheries Policy (CFP)". IRBM and CZM in European regions is one central issue in this project.

**European Environmental Agency (EEA):** European Topic Centre on Water (EEA supporting activity). NIVA is a consortium partner.

**Global Monitoring for Environment and Security (GMES).** The EU Commission (EC) and the European Space Agency (ESA) have initiated the establishment of GMES. GMES is regarded as a European Contribution to GEOSS (Global Earth Observation System of Systems). Norway is a partner through the EEA. CIENS members are participating in GMES implementation projects funded by both the EC and ESA.

**ELOISE** (European Land Ocean Interactions Studies) and OSPAR monitoring (North Sea pollution emissions). ELOISE is an umbrella activity with secretariat at NILU. NILU and NIVA are active partners in OSPAR monitoring.

**ICSU - International Council of Science.** Integrated Water Resources Management is addressed by the International Commission on Water Resources Systems (ICWRS) and in the Global Water System Project (GWPS), jointly organised by WCRP, IGBP, IHDP, ICWRS, IAHS, ICCE, ICSW SSC and DIVERSITAS.

**UNESCO:** is relevant through the Intergovernmental Oceanographic Commission (IOC) and International Hydrological Program (IHP), Integrated Coastal Area Management (ICAM), Hydrology for Environment, Life and Policy (HELP), Flow Regimes from International Experimental and Network Data (FRIEND), Global Observation Networks (GOOS

oceanographic, GTOS terrestrial), EuroGOOS, GOOS-Coastal, GTN-C (Coastal) and GTN-H (Hydrology).

**Arctic HYCOS:** is the arctic component of the WMO global Hydrological Cycle Observing System (HYCOS).

**ICES - International Council for the Exploration of the Sea.** Norway has a central position in ICES through the Institute of Marine Research, NINA and NIVAs participation in expert working groups.

**NOOS - Northwest Shelf Operational Oceanography System.** CIENS partners are members (met.no, NIVA) of this network, which aims to coordinate and advance marine forecasting in the shelf and coastal seas of northern Europe.

### **OPERATIONAL AIMS AND STRATEGIES TO ACHIEVE THEM RESEARCH QUALITY AND MULTIDISCIPLINARY ASPECTS**

**Objective** IBRM and CZM is a multidisciplinary research field both by definition and international practice. The operational aim is to actively utilize the advantage of CIENS interdisciplinary to boost research quality in this field. The prime indicator of success will be regular publications by the partners in relevant journals with high impact.

**Strategy:** A key strategy would be to develop a national centre of expertise in IRBM and CZM focussing on issues including contribution to harmonization of monitoring, databases and monitoring methods, standards and Quality Assurance issues. Such activity should be a part of a joint CIENS GEOSS activity.

For the developing of capability and capacity it is recommended that “Greater Oslo fjord Area” is selected as a “laboratory” for initial IRBM AND CZM projects and education.

In this context the “Greater Oslo fjord Area” also includes the river basins with its outlets to and near the fjord (Glomma, Drammenselva). This is a densely populated, high pressure sub-national region with international connections, and interesting biology and geology. Enhanced data compilation, assimilation, integration and management of the numerous ongoing monitoring programmes and existing databases within this region represent a great potential for advances within environmental science. The region is also close to CIENS and is easily accessible for fieldwork and data collection. These river basins and coastal zones are the most intensely used in Norway. Moreover, most economic drivers on the national scale are represented within these river basins and this coastal zone. The area could be both a laboratory for international research and a research site in international projects. A long-range goal would be to establish a coastal observatory for the Oslofjord and Skagerrak. Gained knowledge will later be used in other areas in Norway and abroad.

It is aimed to arrange an international workshop in 2007 with the aim of assessing the state-of-the-art in IRBM and CZM-related research with respect to the aims of the CIENS group.

### **INTERNATIONALIZATION**

**Objective** IWRM and ICZM are prioritized areas internationally, e.g. in UN's Millennium Declaration. CIENS therefore aims at developing and strengthening its role as an attractive research partner and knowledge provider internationally.

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**Strategy** CIENS will strive to be the central national research and advisory partner on the EU directives and conventions that are relevant to IWRM and ICZM.: i.e. Water Framework Directive, the Nitrate Directive, the EU Marine strategy (in legislation), the Habitat Directive and the Directive on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), CLRTAP, OSPAR, HELCOM and the Biodiversity conventions. A special focus will be on the Water Framework Directive and the upcoming EU Marine Strategy.

In the EU Marine Strategy (COM2002, 539 final) the objectives are to promote sustainable use of the seas and conservation of marine ecosystems, including sea-beds, estuarine and coastal areas paying attention to sites holding a high biodiversity value. This implies full implementation of the Habitats Directive, which Norway has not implemented. Special Areas of Conservation are seen as a major part of achieving nature protection yet integrating sectorial activities that impact on the marine environment. For Norway to achieve the objectives will require research of an interdisciplinary nature that CIENS is fully capable of supplying, yet recognizing that there is a need to fully utilize competence of all relevant marine research institutions.

CIENS activities will contribute to further development and modification of current research policies on coastal zone, particularly the policies defined within the IGBP/IHDP Land-Ocean Interactions in the Coastal Zone (LOICZ) program. NILU was represented in the former SSC and is asked to chair the SSC from 2006.

CIENS will also contribute to research activities emerging from the EU Water Framework directive, such as improved methods for characterisation, monitoring, river basin planning, socio-economic impacts of the implementation etc.

CIENS has great potential for becoming a desired partner for institutions in the new EU member countries when applying for EEA funded projects in this field, particularly within research cooperation.

CIENS is to a certain extent directly engaged in the Global Observation Network through membership in EuroGOOS (met.no), but strongly engaged in the underlying operational monitoring through WMO within meteorology (met.no) and hydrology (NVE).

CIENS aspires to become a national node for GEOSS, and aims to establish contact and cooperation with GWPS and LOICZ. Remote sensing in CIENS (for instance NIVA's Ships of opportunity) would be a valuable contribution to GMES.

### **INTERACTION BETWEEN BASIC AND APPLIED RESEARCH**

**Objective:** To increase the total project portfolio for CIENS partners within basic and applied research.

**Strategy** IWRM and ICZM are in themselves bridging activities between basic, applied research, and management, and CIENS aims at supplementing and partly replacing traditional sector oriented management with knowledge based integrating methodologies. The operational aim is to see scientifically based methods applied in decision making.

### **RECRUITMENT AND EDUCATION**

**Objective** In co-operation with relevant UiO-departments, CIENS aims at contributing to educational programmes at all academic levels. Integrated Water Resource Management

and Integrated Coastal Zone Management are internationally recognized and well suited for interdisciplinary educational programmes.

**Strategy** The establishing of an international M. Sc. in Integrated River Basin and Coastal Zone Management will be investigated. Other possibilities are International Summer schools in associated topics, International courses within the Erasmus and Erasmus mundus system, and Nordic training courses and graduate schools within the Nordforsk system. Recruitment of Ph.D. candidates in co-operative projects with UiO is emphasized. The participation of the University of Oslo in CIENS is essential, and the education activities will be part of the UiO system. Education in IRBM AND CZM, including water resources, EU's Water Framework Directive and EUs Marine Strategy, could offer Master and later PhD studies based on several existing bachelor programmes at UiO, where CIENS-partners should contribute.

An example of education modules in selected topics in research and management is found on the web-page ELOISE: ([www.eloisegroup.org](http://www.eloisegroup.org)).

## **PUBLIC DISSEMINATION OF KNOWLEDGE**

**Objective** CIENS aim to disseminate knowledge on IRBM and CZM to a broad public in Norway.

**Strategy** Many activities, e.g. in monitoring and status reporting, include visualization, graphic interfaces and extensive use of geographical information technologies, and are as such well suited for presentation at the CIENS Resource Centre and on the web pages of the participating institutions.

Dissemination encompasses extending the web-portal [www.senorge.no](http://www.senorge.no) to accommodate data from all CIENS partners and access to real time environmental monitoring such as stream flow. An Information Portal "Oslofjorden Online" will disseminate information from the research activities in the Greater Oslofjord Region.

## **INNOVATION AND COMMERCIALISATION**

**Objective** In cooperation with the innovation programs at the Oslo Research Park and the University of Oslo, CIENS aims to initiate products having a commercial potential

**Strategy** Research within IRBM and CZM as management methodologies and methods has limited potential for commercialization in itself. However, as monitoring is an important part of these activities, the development of new observation and sensor technologies, new observation platforms, data assimilation and modelling and decision maker interfacing techniques has innovation potential. A long-term goal for the group is the establishment of a coastal observatory for the Oslofjord and Skagerrak. This builds on existing observing and monitoring systems, giving a focus to further research and observational innovation.

## **RELATIONS TO DEVELOPING COUNTRIES INCL. CHINA**

**Objective** Developing countries are facing huge challenges in air pollution, water shortage, water pollution, deforestation, soil erosion and desertification. In order to implement the most cost-efficient mitigation measures we need to adapt our existing knowledge and understanding of the links between drivers, pressures, states impacts and responses to the environmental and social conditions in the developing countries. Through project work within IRBM and CZM, CIENS aims to contribute to the international portfolio of "Best Practice" examples for reorganization of administration and management in

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developing countries. Elements of IWRM and ICZM are often included in project tenders on Institutional Strengthening.

**Strategy** To achieve objectives Cross-CIENS expert teams for international work, and competitive bidding on relevant calls and tenders, could be established. It could be beneficial to establish bilateral research projects with scientists in developing countries aimed at adapting existing environmental and social simulation and prediction models to local conditions. In China this can be facilitated through a Sino-Norwegian centre established under the Chinese Academy of Science.

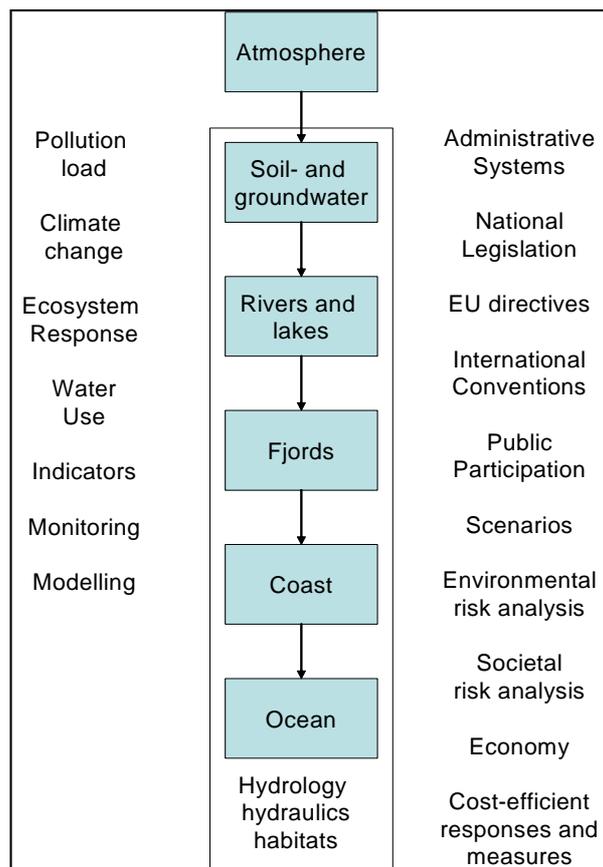
Courses for decision makers, with main part in developing countries with visits and excursion to developed countries, are important tools for knowledge transfer. The courses should be integrated as part of “Continued Learning and Distant Education” of the University of Oslo and offer formalized diplomas.

Knowledge can efficiently be transferred through international B.Sc., M.Sc. and PhD programmes mainly based on teacher exchange, not student exchange. A pilot project between University of Oslo and University of Costa Rica is under establishment.

## RESEARCH INITIATIVES AND PROJECTS

A suitable framework for cooperative, crosscutting research on IWRM and IRBM in the CIENS partnership is the “Cloud, Catchment, Coast, Ocean” concept, which follows the water flow through the different systems and habitats (see illustration). The centrepiece of this approach is to trace water parcels and thus to model the terrestrial history of water in the catchments, the water course and the marine system, enabling description of the water distribution and the interactions between the water, the soil system, the chemical loads and the biological system to any time. A schematic layout is given in the figure, indicating the major system components and main natural science and social science research themes.

Taking the Oslo base in consideration, a natural choice for pilot and demonstration research area is the Oslo fjord and Skagerrak marine systems with its upland, including the three major rivers Glomma, Drammensvassdraget and Numedalslågen. Most drivers and pressures and user conflicts are present in this area, with the exception of aquaculture. This river basins and coastal zones are the most intensely used in Norway.



**Illustration:** Cross-cutting Cloud – Catchment – Coast – Ocean project concepts following the fresh water pathway. Illustration of some key processes, disciplines and tools to achieve sustainable fresh water resources and coastal zones management.

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The CIENS partners have important field research facilities in this area: The Solbergstrand Marine Research Station, Drøbak Biological Research station and the UiO Research Vessels, and on the terrestrial side the Finse Research Station, Gardermoen groundwater research area and the Aursunden large scale hydrological site.

Possible funding: EU 7<sup>th</sup> Framework Programme, Norwegian Research Council Programme “Havet og Kysten”, etc. A CIENS IRBM AND CZM seminar to further develop i.e. project proposals is proposed for early 2006.

## **Urban Sustainability**

### **Towns, cities and the environment**

**Vibeke Nenseth**, NIBR; **Alena Bartonova**, NILU; **Lars Erikstad**, NINA; **Leonor Tarrason**, met.no; **Marika Kolbenstvedt**, TØI; **Oddvar Lindholm**, NIVA/UMB; **Per Gunnar Røe**, Sociology & Human Geography-UiO; **Per Kristen Mydske**, Political Sciences-UiO

### **Summary**

*What are the conditions for a long-term and balanced development across environmental, economic, and social concerns (i.e. sustainable development) of towns and cities in a local and global perspective? CIENS offers unique interdisciplinary research competence on interactions between societal, political and economic drivers on the one hand and environmental impacts and responses on the other, in an urban context. In particular, environmental qualities and a sound urban structure are addressed, such as the technical, blue-green, and social infrastructure. Urban sustainability necessitates the political and scientific involvement of a multitude of actors, as well as innovative perspectives and processes. CIENS' interdisciplinary and cross-institutional endeavour for high-quality research aims at providing comprehensive tools and policy instruments for improved planning and implementation of sustainable development in urban regions. Risks and potentials created by urbanization in developing countries will be given special attention.*

### **VISION**

As the leading Norwegian research group on Urban Sustainability, CIENS offers innovative and integrative perspectives and an important knowledge basis for urban planning and governance in Norway, in cross-national comparisons and in developing countries.

### **OVERALL AIM**

CIENS will develop interdisciplinary and applicable knowledge on the prevailing potentials and risks in urban contexts, integrating both physical-ecological and political-societal aspects – both causes and consequences. The territorial approach, addressing all environmental problems in one place – the urban space - instead of traditional approaches to one and the same problem all places, is essential for the comprehension of sustainability, the particularly complex and dynamic societal and environmental interaction in urban areas.

### **DEFINITIONS AND DELIMITATIONS**

Urban sustainability deals with a long-term, balanced development across ecological, economic and social concerns. Studying urban sustainability requires analytical tools - both for the theoretical comprehension, the empirical documentation and political solutions. The sustainability concept addresses the intersections between the ecological, the economic, political and socio-cultural aspects of the urban development, i.e. the mutual influences between urban ecology, urban economy, urban governance and urban welfare.

Physically, the term ‘urban’ denotes structures decided of a particular density (population/built land) and mobility, within certain distances and with specific concentrations of private and public services. Urbanisation represents both a physical and social transformation.

‘Urban Sustainability Scenarios’ might be put forward in terms of the matrix above with systematic combinations of positive (light gray) and negative (darker) development trends

along the environmental, economic and social dimensions of sustainability: As the 'sustainable' scenario would be the ultimate goal; the developing/developed countries divide represents the huge problems of equity globally, and the socially divided, often gentrified, city an "unfair" challenge in a local context. Expansive urban renewal programmes represent an "expensive" challenge, and broad prosperity with high level of material consumption the "environmentally damaging" trend. The right-hand side of the matrix represents the huge problems of grave imbalances in nature, society and economy.

		<i>scenarios</i>							
		"sustainable"	"unfair"	"expensive"	environ. damaging	"eco-centric"	"money-centric"	"therapeutic"	"nightmare"
<i>dimensions</i>	Environment								
	Economy								
	Social equity								

We will particularly focus the *urban structure*, i.e. the physical and social arrangement of urban areas. The urban structure is societally and politically constructed and is itself an important development factor. The urban landscape is shaped by the centre structure, the (historical) built environment; the technical, blue-green (e.g. green space and corridors, rivers and waterways) and social infra-structure (social, cultural, educational arenas and institutions). The urban structure and landscape are strongly related to the environmental and socio-cultural qualities and challenges in towns, cities and villages (urban communities/neighbourhoods). Optimal policy measures would be pro-active and address the urban drivers – and thus become drivers themselves (i.e. urban planning).

The interactive relationships (Drivers - Pressures - State (*Urban structure*) - Impact - Responses), i.e. the DPSIR-"butterfly" for urban sustainability thus consists of:

**Drivers:** demography; regional economy/business structure; transport and mobility; technology; changes in values and attitudes; urban housing, lifestyle, consumption etc.

**Pressures:** social and environmental stressors; urban land take, sprawl, congestion, pollution (traffic, waste, emissions, noise), etc.

**State:** state changes in urban structure and in urban environmental qualities (air, water, biodiversity)

**Impacts:** environmental and distributional impacts for quality of life, health, safety, recreation etc. in an urban context

**Responses:** *Societal:* urban planning and governance, political, institutional, technological, communicative, actions/policies, etc.

*Natural:* ecological processes, biodiversity in the green structure, etc.

## GENERAL OBJECTIVES

Urban structures are expanding, globally and locally. The urgent challenges of sustainability are particularly salient in an urban context. Although urbanisation is not necessarily connected to environmental deterioration any more, urban burdens are unequally dispersed, not least globally. Urban development is paced and staged by a multitude of urban actors,

### *Urban Sustainability*

enterprises, people, planners and politicians, through interactive and more or less participatory processes. Seeing policy development in light of broad policy networks represents the policy shift from governing to *governance*, where facilitating measures and local responsibility are considered to be more important policy strategies than hierarchical command and control.

CIENS aims to enhance the creativity and excellence at the frontier of knowledge on urban sustainability. An overarching challenge is to analyse the policy gap between intentions and realities in urban policy-making and planning; in search of improved urban governance and new policy measures (concerted planning, foresight analyses; integrative strategies, public-private co-operation, subsidiarity, e.g.) Of special attention will be the particular risks (natural and man-made catastrophes and extreme events) in urban regions; emphasising reversibility, precautionarity and preparedness.

CIENS group on urban sustainability will explore the dynamic relations between social and economic welfare, physical structures and environmental qualities, over time, to forecast future critical factors. We will investigate how (the technical, blue-green and social) urban structure matters, when it comes to the urban ecology, the urban economy, and the urban well-being. The significance of a sound urban structure as a necessary condition for urban sustainability will be particularly addressed. The multi-faceted shaping and paradox of urban growth (exurbanisation and reurbanisation) needs attention - both too fast growth as well as the problem of “shrinking cities”, in a regional, national or global context.

Urban sustainability in developing countries will be an important research issue. The rapidly shifting patterns of risks of environmental and resource conflicts that potentially undermine health and social standards are main challenges. As a nation of high aid-profile Norway contributes strongly to the research and development to achieve the UNs eight Millennium Development Goals, where ensuring environmentally sustainable development is one (safe water supply and sanitary systems for 1,5 billion people within 2015 is an important indicator e.g.). Another huge problem particularly related to urbanised environments is traffic accidents, which WHO (UNs World Health Organization) has predicted to be the third largest health problem of the world towards the year 2020.

Theoretically, the interdisciplinary research at CIENS is particularly promising when it comes to knowledge development due to innovation proneness when alternative scientific arguments and ideas are confronted in the struggle for the (currently) most valid theories and comprehensions on urban sustainability.

## STATUS

CIENS' particular competence is the multi-perspective approach to the whole entity of the problem complex of urban sustainability, from drivers to responses.

**Drivers, Social Impacts and Response.** The social science researchers at NIBR, TØI, CICERO, Political Science-UiO, Sociology and Human Geography-UiO, and Economy-UiO have methodological and basic competence in the *drivers*: the social and political conditions for sustainable urbanisation, cities as regional development actors; the urban structure's social *impacts*, and urban governance and *planning* challenges (response).

**Pressures, State and Natural Impacts** The scientists at NILU, NINA, NIVA, met.no, Hydrology-UiO, and Biology-UiO together hold strong competence in changes in urban environmental *state* or qualities (in air, urban rivers, lakes and fjords; biodiversity in parks, suburban forests and agricultural land), the environmental *pressures* (land use, emissions, noise, deterioration of technical infrastructure) and environmental *impacts* in urban contexts.

Apart from CIENS researchers' specialised or casuistic competence within single aspects of urban sustainability, the problem complex invites particularly to the kind of interdisciplinary research that CIENS' unequivocal innovative character represents.

*An integrated sustainability perspective* is particularly applicable in an urban context, regarding the multitude of political, social and economic actors, and the amount and intensity of interaction. Cross-disciplinary research on sustainable development in general and urban sustainability in particular has since long been in strong demand. Collaborative efforts among the environmental research institutes in Norway ("Envira" and university centres for environment and development) break the divided research tradition towards environmental problems (studying air, water, nature, urban development separately). The sector approach in environmental research is, however, not a particular Norwegian peculiarity. Up to now the EU environmental research has been quite similarly divided. In 2004 a thematic Strategy (the 7<sup>th</sup>) was launched, an integrative, territorial (spatial) approach, precisely with the urban contextualisation – i.e. "Towards a Thematic Strategy on the Urban Environment".

The CIENS partners (CICERO, NIBR, NILU, NINA, NIVA) participate in the Norwegian branch of EIONET ("European Environment Information and Observation Network"): the collaborative network of the European Environment Agency and its Member Countries, connecting National Focal Points in the EU and accession countries, European Topic Centres, National Reference Centres, and Main Component Elements. These organisations jointly provide the information that is used for making decisions for improving the state of environment in Europe and making EU policies more effective.

The interdisciplinary and cross-institutional competence between researchers in CIENS has been developed by several projects addressing common research themes (e.g. urban environment, development of urban sustainability indicators, outdoor recreation, cultural heritage) and common methodology (Environmental Impact Assessment and Strategic Environmental Assessment). At present the cooperative work culminates by the founding of CIENS. Across and within the CIENS institutes there is extensive international contact, in research networks and concerted actions and co-operative projects on issues highly relevant for urban sustainability.

## RELEVANT INTERNATIONAL PROGRAMMES

CIENS partners are all active participants in international research cooperation, bilateral and multilateral, in Nordic, in wider European consortiums, and in collaboration with researchers in developing countries. They have been involved in all the last EU Framework programmes (FP), in particular in the 5<sup>th</sup> and 6<sup>th</sup>. (e.g. the sub-programmes "City of Tomorrow" and "Sustainable surface transport").

CIENS partners are participating in the European Spatial Planning Observation Network (ESPON) for research and studies on a better balance and polycentric development of the European territory (NIBR acts as the ESPON contact point in Norway). "The ESPON 2006 programme – Research on the spatial development of enlarging European Union" is structured around thematic projects, policy-impact projects, co-ordinating and cross-thematic projects and scientific briefing and networking – in all spatially relevant research, as for instance in urban and metropolitan areas.

CIENS partners are also actively involved in an intergovernmental framework for European Co-operation in the field of Scientific and Technical Research, COST actions that has been evaluated as having "... *its strength in non-competitive research, in pre-normative cooperation and in solving environmental and cross-border problems and problems of public utility. It has been successfully used to maximise European synergy and added value in*

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*research cooperation and it is a useful tool to further European integration, in particular concerning Central and Eastern European countries”.*

The challenges linked to sustainable development require an international global perspective. CIENS partners are strongly involved in numerous research projects within the programmes of the World Bank and The Norwegian Agency for development cooperation (NORAD), several with urban issues and urban-rural relationships in focus.

In the recently launched White Paper to the Parliament on Research Policy the internationalisation of the Norwegian research has been put forward as an important goal. Thus the expectations of more international funding have to be supported by matching national funding in order to further improve the internationalisation endeavours for Norwegian environmental and sustainability research in general and urban environment and sustainability issues in particular

## **OPERATIONAL AIMS AND STRATEGIES TO ACHIEVE THEM**

### **RESEARCH QUALITY AND MULTI-FIELD ASPECTS**

**Objective** CIENS’ interdisciplinary and cross-institutional endeavour aims at delivering comprehensive planning tools and mixed policy instruments for an improved planning and implementation of sustainable development in urban regions.

**Strategy** The Urban Sustainability group suggests developing at CIENS a *scientific infrastructure*, i.e. an information basis for Urban Sustainability studies, by constructing an integrated knowledge bank/base, covering topics within urban sustainability using physical or virtual pooling or coupling of databases, indicator sets and other information sources and facilities relevant to urban sustainability topics

Urban planning is particularly knowledge-intensive. CIENS’ main contribution will be to deliver research (results) on a (continuously) mapping of urban sustainable development by current presentations, monitoring, descriptions and further development of (sets of) urban sustainability *indicators*. Urban sustainability indicators (*Barometer of Urban Sustainability*) to be used in municipal, metropolitan and regional planning will be updated regularly.

Methodologically, we will explore different “model towns”, best cases/practices or scenarios of urban sustainability, chosen among various criteria: (size, topography, centre/periphery, coast/inland; industrial structure, smart-growth; particular policy-solutions e.g.). Oslo could be selected as one “best case” among others, due to e.g. CIENS’ location, to “The European Sustainable City Award” in 2003, and the large and easily accessible “data bank” on Oslo within the CIENS institutes. We will in particular emphasize the knowledge mediation and policy mechanisms to transfer knowledge and experiences from some few chosen model towns in Norway from today’s situation to a firm sustainable status concerning air, water, green and technical infrastructure, and the urban structure in general. Presentations of ‘model towns’ and urban scenarios will be regularly reported in reports and scientific articles.

CIENS researchers’ participation in policy *networks* with policy-makers, planners, developers and citizens represents an important access to empirical fieldwork as well as a channel for research mediation. Close interaction between researchers and practitioners ensures the policy relevance of the CIENS research. By holding a reflexive, meta-approach (“research on research”) the Urban Sustainability group will also conduct research on the *knowledge-policy* linkages in an urban governance perspective. The research on the utilisation of CIENS’ research in urban planning and policy-making will be an important contribution to further improve the quality and relevance of the CIENS research within the urban field.

**INTERNATIONALIZATION**

**Objective** CIENS' group on Urban Sustainability aims to be an internationally attractive and competitive research milieu at the research frontier, in a Nordic, European, and North-South-perspective.

**Strategy** CIENS partners have started coordinative work for the EUs 7<sup>th</sup> Framework Programme, FP (with its overarching aim of contributing to sustainable development), in order to take part in consortiums and proposals, in particular within the theme on Environment and Climate change (one of the nine high level themes). Special emphasis has been put to the role of urban research in the 7<sup>th</sup> FP, with a (preliminary) identification of five key areas: urban/suburban relations; environmental impact and industrial ecology; labour market and quality of life; integrated approach and decision making; and regional cooperation and competition.

CIENS partners will contribute in strengthening the Scandinavian and Nordic co-operation on urban issues, urban sustainability indicators and urban planning and governance, by further research networking and common comparative research proposals in the Nordic context, particularly addressing the Nordic Council of Ministers for further funding.

For the developing of CIENS into the Norwegian contact for the "Global Earth Observation Initiative" (GEOSS) the research on urban sustainability will contribute to the, among others, goal of an improved understanding of the environmental factors affecting human health and well-being, factors that are particularly salient in an urban context.

Relevant for the urban sustainability research is the International Human Dimensions Programme on Global Environmental Change (IHDP) which has recently launched a new core project on "Urbanization and Global Environmental Change". The Science plan for this new core project emphasises the ways global environmental change affects urban systems and the interactions – vulnerability and coping strategies - within the urban systems.

**INTERACTING BASIC AND APPLIED RESEARCH**

**Objective** The CIENS cooperation has already improved - and will furthermore strengthen - the integration between basic and applied research.

**Strategy** CIENS' research on urban sustainability will contribute to an active collaboration in project proposals and project organisation between university researchers and researchers from the sector institutes, e.g. applying for CoE (Center of Excellence) status on Urban Sustainability and Mobility.

We want also to employ more 20 % part-time positions (II-positions) at the University/the sector institutes, respectively, addressing urban sustainability in particular.

**TRANSFER OF KNOWLEDGE TO DEVELOPING COUNTRIES**

**Objective** The urban sustainability group will actively contribute in exchange and transfer knowledge internationally and in research collaboration, in particular with developing and transitional countries.

**Strategy** The group will take part in new initiatives and build upon established partnerships and ongoing international projects with cross-national comparisons or with close cooperation with local research institutes and authorities, focusing the broad field of sustainability and in particular the relationships between urban livelihood, environmental degradation, congestion and inadequate provision of urban infrastructure.

## **RESEARCH INITIATIVES AND PROJECTS**

A pre-supposition for further international funding is a solid national foundation. The Urban Sustainability group will have a two-step strategy depending on (level of) further funding. (1) In a first consolidating stage, the urban sustainability group will clarify and specify the research programme, identify work packages and methodological approaches. (2) In a next stage, the interdisciplinary 'model case' project will be developed, with the theoretical and empirical examination of how to transform contemporary towns into sustainable towns, by use of the scientific infrastructure, knowledge and data bases and sets of indicators developed in CIENS.

The urban sustainability group - across the university and institute border - will also apply for further national funding for research project on development and current up-dating of urban sustainability barometers (e.g. Norwegian association of Local and Regional Authorities, Ministry of the Environment, Ministry of Local Government and Regional development) and will develop more theoretical research proposals examining the interdisciplinarity in the CIENS collaboration on urban sustainability (analysing the knowledge-policy linkages, the level of interdisciplinarity challenges and results (Norwegian Research Council).

The urban sustainability group has recently (October 2005) initiated – together with the group on sustainable mobility – a proposal for a Centre of Excellence on Urban sustainability and mobility

In the forthcoming EUs 7 FP, “environment” is one of the main research areas, and “the role of urban research” is expected to be significantly present. Urban problems seem to be specifically noticed in under-categories, such as Environment and Health; Sustainable management of resources; Environmental technologies, e.g. CIENS will strongly pay attention and be prepared to join international cooperation for concerted actions and project proposal within the 7<sup>th</sup> FP on urban sustainability issues.

## **Sustainable mobility**

**Claus Hedegaard Sørensen, TØI; Petter Næss, NIBR; Gunnar Eskeland, CICERO; Sjur Kasa, CICERO/TIK-UiO; Egil Bendiksen, NINA; Steinar Larssen, NILU; Torleif Bækken, NIVA; Leonor Tarrason, met.no**

### **Summary**

*What policies can cities and countries adopt for themselves, and agree to between themselves, to develop and ensure mobility benefits while environmental and social goals are given increased priority? Access and productive relations depend on mobility, and therefore on transport of goods and people, while also involving environmental and other governance challenges locally, nationally and globally. Societal responses to environmental and social pressures and impacts place demands on interdisciplinary research, both in terms of descriptive and analytic systemic aspects and in terms of recommendations on institutional change and policy. The strength of CIENS is the representation of more academic disciplines than normally seen in transport research. CIENS has and will continue to have competence in all aspects of the DPSIR-chain, but will develop an interdisciplinary focus around societal responses. The vision is that the unique, interdisciplinary competence gathered in CIENS will result in high quality research, combining analysis of mobility benefits with environmental, social and economic aspects.*

### **VISION**

CIENS performs high quality research in the field of sustainable mobility, combining analysis of mobility benefits with environmental, social and economic aspects.

### **OVERALL AIM**

CIENS builds an interdisciplinary team across professions to contribute to, first, a thorough and broad understanding of social, technical, institutional and economic drivers of mobility; second, analyses of the resulting pressure on and state of environment as well as social and environmental impacts; and third, analyses of the conditions for, recommendations for and actual societal responses.

### **DEFINITIONS AND DELIMITATIONS**

The research takes its point of departure in the following definition of sustainable mobility (further detailed in annex 5.1):

Sustainable mobility is mobility in accordance with the principles of sustainable development. That is, a volume of physical mobility, a modal-split and a transport technology, moving significant steps towards a situation where mobility in society:

- allows the basic mobility needs of individuals and societies to be met, offers choice among environmentally sustainable transport modes, operates efficiently and supports an economy meeting the population's essential needs (the economic dimension),
- takes care of ecosystem integrity and limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise (the environmental dimension), and
- is affordable, safe and consistent with human health as well as with equity within generations, both at a global, regional and local scale (the social dimension).

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Regarding the DPSIR framework, we understand each element in the framework as illustrated below.

**Drivers:** Economic activity (Gross Domestic Product - GDP), disposable income, market price of transport, numbers of households, work and settlement patterns, distribution and trade patterns, leisure activities, the transport infrastructure system, as well as public decision making and market processes which influence transport. The consequence of all these drivers is passenger and freight transport.

**Pressures:** CO<sub>2</sub> and other greenhouse gas emissions, NO<sub>x</sub>, CO, particulates, VOC's, noise emissions and use of materials; depletion of non-renewable energy resources (notably oil); land take for transport infrastructure; and vehicle stock and related wastes.

**State:** Air, water, soil quality; state of climate; noise levels and exposures; settlements and biodiversity fragmentation.

**Impact:** Health (e.g. accidents and respiratory diseases); biodiversity and ecosystems loss; loss of productive soil; loss of urban qualities and cultural heritage; congestion; lack of mobility.

**Nature's responses:** Changes in interspecies competition and increasing alien species distribution in marine, freshwater and terrestrial ecosystems.

**Societal responses:** Regulation, taxes, investment, land use and transport infrastructure planning and information which intend to influence the volume, the modal split as well as other system characteristics (e.g. capacity utilization and speed limits) and the technical solutions in transport.

Some phenomena can be subsumed under several of the elements in the framework. Hence, we here classify congestion as an impact, but it also functions as a driver for construction of transport infrastructure. Stakeholders in the public sector, in the market and in civil society can be important drivers, as well as important promoters and decision-makers regarding responses. Hence, the framework describes a dynamic system.

## **GENERAL OBJECTIVES**

Access and productive relations depend on mobility, and therefore on transport of goods and people, but it also involves environmental and other governance challenges locally, regionally and globally (detailed in annex 5.2).

CIENS research within the field will have three foci:

- Analyses of the social, technical, institutional and economic conditions that drive the changes of the transportation system (drivers of change).
- Analyses of pressure, state and impact regarding air pollution, climate, noise, water and biodiversity, as well as social and economic impacts (pressure, state, impact).
- Analyses of the conditions for, recommendations for and actual societal responses. It also implies studies of institutional conditions, policy-making processes and implementation, the impact of knowledge, as well as target group response (societal response).

The need for research in societal response is stressed in for example the International Human Dimensions Programme on Global Environmental Change (IHDP). Hence in CIENS, societal response will be a focal point within the research in sustainable mobility, which means that research in drivers of change as well as pressure, state and impact will be analysed from the perspective of societal response. Regarding research on pressure, state and impact, the

research in sustainable mobility to a considerable extent will draw upon research within the other themes in CIENS.

CIENS research on sustainable mobility is motivated by the environmental and other challenges related to the transportation sector as a whole. Air-, maritime- and land transport have different but important impacts in environmental media locally, nationally and globally. The objective of the sustainable mobility research programme is research on the DPSIR chain for all modes of transport. Nevertheless, an emphasis on road transport and its alternatives, in particular on the urban scene, is envisaged, at least in the program's initial phases.

## **STATUS**

Research in sustainable mobility can hardly be studied from only one academic discipline. To take the entire DPSIR-chain into consideration it is necessary to combine different academic disciplines. Hence, a research environment as CIENS is suitable for research in sustainable mobility. The comparative advantage of CIENS is the representation of more professional competences than normally seen in transport research, in Norway as well as internationally.

CIENS' competences in the field of sustainable mobility can be illustrated in connection to each element in the DPSIR framework:

**Drivers:** CIENS includes the main part of Norwegian research in the field. TØI has an international standing in the field.

**Pressures:** CIENS partners produce important contributions in the field, especially NILU, CICERO, and MetOs UiO.

**State:** CIENS gathers the main part of Norwegian research in the field. CICERO, TØI, NILU, MetOs UiO and met.no make important contributions in the field.

**Impact:** CIENS gathers the main part of Norwegian research in the field. NIBR, NIVA and Hydrology at UiO produce important contributions in the field. TØI has an international standing in the field.

**Nature's responses:** Individual researchers at NINA and NIVA make important contributions in the field.

**Societal responses:** CIENS includes the main part of Norwegian research in the field. NIBR, CICERO and Political Sciences at UiO make important contributions. TØI has an international standing in the field.

Hence, CIENS gathers academic disciplines and competences relevant for comprehensive research in sustainable mobility. The challenge is to build a high-quality, interdisciplinary research environment based on the competences in CIENS, and hence take advantage of the unique representation of academic knowledge.

In analysing mobility, the CIENS research team will be able to build on a large body of accumulated scientific knowledge, on the methodological as well as on the substantive side. Mobility has been the object of intensive, international research efforts since the 1970s, and increasingly sophisticated research methodologies and theories have been developed (e.g. stated preference techniques). Many of these research projects have been aimed at the very purpose of identifying drivers of change and/or possible societal response variables relevant for sustainability (see annex 5.3).

Through international research projects and networks CIENS currently collaborates with a huge amount of research institutions in- and outside Europe. In particular we want to stress

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the close collaboration with the IMPACT consortium led by Lund University, Sweden, which has received funding for several years of research into sustainable mobility, and with Aalborg University, Denmark. TØI is a partner in the IMPACT consortium, and NIBR has particular close research collaboration on sustainable mobility with Aalborg University.

Furthermore, MetOs-UiO, CICERO and NILU are heavily involved in an integrated project about the climate impacts of air, sea and land traffic on the global climate. The project is funded until 2010 by the European Commission within the 6th research framework programme and has 35 participants and 4 associated members from 16 European countries and the U.S.

## **RELEVANT INTERNATIONAL PROGRAMMES**

CIENS' priorities regarding research in sustainable mobility are in accordance with the International Human Dimensions Programme on Global Environmental Change (IHDP) and with the EU Commissions white paper on transport.

The EU focus on sustainable mobility is stressed in the new proposal for the seventh framework programme on research (2007-2013) in which transport is an independent theme. Within this theme, "the greening of air transport", "the greening of surface transport" and "ensuing sustainable urban mobility" are among the elements.

In connection to a Norwegian responsibility for a Global Earth Observation System of Systems (GEOSS), the TØI -socio-environmental database related to the human impacts of transportation noise, vehicular air pollution, and vibrations from heavy vehicles and trains, may be made available.

## **OPERATIONAL AIMS AND STRATEGIES TO ACHIEVE THEM**

### **RESEARCH QUALITY AND MULTI-FIELD ASPECTS**

**Objectives.** The aims are a) to develop a research environment that facilitates bridging between different disciplines and traditions, b) to produce one scientific article for each 3/4 man-labour year of common research, and c) to propose a large-scale, interdisciplinary research programme in sustainable mobility.

**Strategy.** The research topics of sustainable mobility are not rooted in any single discipline but involve several different disciplines representing different research concerns and traditions. Bridging between these different disciplines and traditions is crucial in order to be able to conduct cutting-edge inquiry. Developing an understanding of the world which can facilitate the combining of insights emerging from different disciplines is therefore a key challenge. Such efforts also necessitate methodological reflections.

The number of CIENS publications in sustainable mobility will depend on the amount of common research projects. As will appear later common research projects are expected, and for each 3/4 man-labour year we expect to produce one scientific article.

In Sweden, MISTRA (The Foundation for Strategic Environmental Research) funds a large-scale research programme on sustainable mobility. MISTRA in particular stresses that the aim is "research that builds bridges" – both between different research disciplines and between research and practitioners, be it the public sector or industry and commerce. CIENS will argue for a research programme along the same lines to be established in Norway addressing how a rich, democratic welfare state strongly linked to the international markets can handle the great challenges connected to a rapidly increasing demand for mobility. Such a research programme should be a follow up to the Swedish MISTRA initiative and set the research agenda for some of the most important challenges of globalisation.

## **INTERNATIONALISATION**

**Objectives.** CIENS aims a) to take part in consortiums applying for funding in EU's 7<sup>th</sup> Framework Programme, FP, b) to demonstrate research in sustainable mobility on countries in Europe as well as on developing countries, and c) to have a specific budget funding visiting scientists within the field of sustainable mobility.

**Strategy.** Regarding funding from the EU's 7<sup>th</sup> FP running from 2007-2013, it seems that the new 7<sup>th</sup> framework programme will contain nine thematic areas, and among these are: energy, environment and transport. So far, the description of transport seems especially suited for interdisciplinary research in sustainable mobility.

A prerequisite for CIENS to apply is participation in consortiums with institutes from large parts of Europe and abroad. In this effort CIENS expects to draw upon existing consortiums and research networks in which the partners in CIENS participate.

If basic funding is received for CIENS research in sustainable mobility, part of the money will be used for internationally acknowledged visiting scientists within the field of sustainable mobility

## **INTERACTION BETWEEN BASIC AND APPLIED RESEARCH**

**Objectives.** CIENS aims a) to provide the conditions for more CIENS researchers having positions at both Oslo University and the applied research units, and b) that all applications for research in sustainable mobility should include Oslo University and at least one of the involved applied research units.

**Strategy.** Within the framework of CIENS, an application has been sent to the Research Council of Norway for nomination as a Centre of Excellence in the field of urban sustainability and mobility. The centre will involve the university as well as applied research units, and hence provide conditions for active collaboration.

Besides this initiative, CIENS partners will provide the conditions for researchers being employed at the university as well as at applied research units, e.g. in the form of adjunct professors. It will be an efficient way of integration basic and applied research.

To ensure integration and to strengthen the comparative advantage of CIENS research in sustainable mobility, the ambition is that applications for funding of common research involve the university as well as the applied research units.

## **RESEARCH INITIATIVES AND PROJECTS**

Examples of relevant research projects in sustainable mobility for which CIENS aims to search funding are the following:

**The interaction between urban structure and transport** (drivers) (detailed in annex 5.3). It is important to go deeper into the relationships between land use and transport through a further exploration of the causal mechanisms by which different aspects of urban structure influences travel both at individual and aggregate level.

**Future vehicle and transport energy carriers** (drivers) (detailed in annex 5.5). Vehicles are dominant energy consumers in transport Well to Wheel chains. Broad expertise to choose the right paths is needed for future successful research and industrial development. Sustainable energy resources, potential for hydrogen as an energy carrier, energy storage, emissions, and economy must by evaluated thoroughly.

**International transport and travel** (drivers) (detailed in annex 5.6). Important are among others studies of the mobility need in knowledge organizations with a view to identify the

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amount and characteristics of long-distance work-related mobility among the employees in these organizations. Such studies will include the potential of information and communication technology to reduce the amount of travel in these organizations.

**Environmental Impact Assessments** (pressure, state, impact) (detailed in annex 5.7). The links between transport policies and environment are strong, and in particular infrastructure development has large and complex impacts on nature. A research programme on EIA involving several institutes in CIENS has revealed important multidisciplinary fields of research.

**The choice of transportation modes of large developing countries** (societal response) (detailed in annex 5.8) The choice of transportation modes of large developing countries experiencing rapid growth will have substantial and complex global effects on poverty, security and the environment. Hence, studying social and political factors that influence such choices is important.

**The role of knowledge about urban structure and travel** (societal response) (detailed in annex 5.9). The challenge of sustainable mobility has been dealt with differently in urban planning and urban development across national contexts. What are the causes of these differences (and similarities), and which impacts do formal knowledge and decision-making tools have?

**Organisational reforms and environmental policy integration** (societal response) (detailed in annex 5.10). Two tendencies affect public as well as private organisations in the transport sector, viz New Public Management reforms and the principle of environmental policy integration. It is important to study how the reforms affect the possibilities of environmental policy integration in transport.

Funding of such research projects are possible through research applications to e.g. The Research Council of Norway, EU's 7<sup>th</sup> framework programme, Volvo Research and Education Foundation, The Norwegian/EEA Financing Mechanisms, The World Bank, Volkswagen. During 2005, common research applications were send to The Research Council of Norway (CoE) and the Norwegian Ministry of Transport and Communications (POT – 'Program for overordnet transportforskning).

## **Ecosystem Products and Services for Sustainable Development**

**Bror Jonsson, NINA; David Barton, NIVA; Sissel Hovik, NIBR; Roland Kallenborn and Ole-Anders Braathen, NILU; Knut Veisten, TØI, Asbjørn Vøllestad, Biology-UiO**

### **Summary**

*Do we need all species of plants, animals and microbes? The extent to which all species are needed is still a mystery, but when symbiotically functioning together in balance with the physical environment, they constitute the basis for life on earth, including economic production for humans. Sustainable development requires knowledge of nature's ability to deliver products and services to humans in an economic way. CIENS develops such knowledge in relation to socio-economic and cultural/social conditions associated with drivers and pressures for environmental change, ecosystem impacts and responses by the ecosystems and society to it. In line with the Biodiversity Convention and themes of the Millennium Ecosystem Assessment, CIENS builds a dynamic and integrated approach to biodiversity through interdisciplinary research. CIENS research emphasizes implications for ecosystem functions and services, and incentive systems as in the proposed Biodiversity Act. These include principles such as: precautionary, polluter pays, aggregate environmental damage, environmental liability, and compensation for foregone opportunities and land-use rights.*

### **VISION**

To be recognized as a (natural and social) science centre with high international thematic, theoretical, and methodological competence which will set the national agenda on interdisciplinary ecosystem research and ecosystem management for Norwegian authorities.

### **OVERALL AIM**

To advance the scientific knowledge on the structure and functions of selected ecosystems in relation to socio-economic and cultural practices linked to drivers and pressures on the ecosystem, and natural and society responses, as a basis for rational, long-term management of ecosystems.

### **DEFINITIONS AND DELIMITATIONS**

Biodiversity encompasses multiple levels of biological organization with the three attributes: composition, structure and function. It is organized at four levels: landscape, ecosystem-community, population-species, and genetics.

The composition comprises a list of the species and measures of species and genetic diversity. Structure is the physical pattern of the system from habitat complexity to patterns of patches and other elements of the system. Functioning involves ecological and evolutionary processes including gene flow, disturbances, nutrient cycling, hydrological processes and flow rates. For instance, the biodiversity of a fjord can be studied from different points of view, namely genetic (e.g. allelic diversity, effective population size and genetic mechanisms), populations (e.g. abundance, dispersion, demographic processes), communities (e.g. identity, environmental impacts, productivity, trophic relationships) or system (e.g. identity of the system, heterogeneity, patch sizes, spatial linkages, disturbance processes and uses). The system includes abiotic characteristics and the uses of its

### *Ecosystem Products and Services*

components (communities). Ecosystem products are organisms which can be harvested such as berries, mushrooms, game animals and fish. Ecosystem services are the aspects of ecosystem functions such as the hydrological cycle with its provisioning of water, with direct utility for society without the use of man-made technology or indirectly as natural processes that replace or avoid the need for man-made technologies.

The definition and delimitation of the individual components of the DPSIR framework depend on the scale of analysis:

**Drivers.** Natural factors such as climate change or contextual factors such as human systems of resource extraction, production, consumption and waste generation processes, values, conceptions and preferences, influencing ecosystem services and functions. The ecosystem drivers are usually exogenous to the systems under study.

**Pressures.** Proximate (endogenous) causes of ecosystem change generated by human uses of ecosystems products and services such as pollutants, introductions of new species/genes and harvesting.

**State.** The condition of the biodiversity of the system, with its composition, structure and functions.

**Impacts.** Effects on ecosystems related to society uses of ecosystem products and services.

**Responses of the system.** Changed ecosystem functions in response to the pressures.

**Responses of society.** Adaptation in the human society in response to changed state/impact, or mitigation efforts, with new techniques and technologies.

## **GENERAL OBJECTIVES**

Exactly how the numerous species work together to deliver all ecosystem services needed, is still largely unknown. But we do know that drivers formed by the human society, such as changes in the population size and economy, together with natural ecosystem drivers, more quickly than ever alter ecosystem structures and functions. These changes influence nature's opportunity to deliver services relevant for the human society. With adequate responses of the society, it is to a certain degree, possible to restructure the responses of the system in a desirable direction. By political decisions, management regulation and lack of knowledge about the consequences of our actions, it is also possible to cause unwanted system responses.

We will therefore build a dynamic and integrated approach to biodiversity. Evolutionary and ecological dynamics affect biodiversity, as do deliberate and unintentional human actions. Altered biological diversity influences human societies, which have to adapt to or reverse the changes. To understand and predict this cycle of interactions require a major interdisciplinary effort involving integration across traditional disciplines. By taking this approach, we will influence the agenda for prioritized scientific tasks of the international community. The diverse background and training of the scientists at CIENS, give the centre a comparative advantage in multi-disciplinary research on environmental problems.

CIENS research in ecosystem services aims to strike the necessary balance between scientifically rigorous, accurate and reliable analysis of complex and dynamic systems, while providing adequate succinct policy recommendations, and sufficient simplified results for public interest/dissemination.

## **STATUS**

**Drivers.** NIBR, NILU, NINA, NIVA, and Economy-UiO are studying drivers impacting ecosystem products and functions.

**Pressures.** NIBR, NILU, NINA, NIVA, and Biology UiO are studying ecosystem pressures such as pollutants, introductions of new species/genes and harvesting.

**State.** NINA and Biology UiO are competent in describing the state of biodiversity in the major terrestrial and aquatic ecosystems.

**Impacts.** NINA, NIVA and Biology UiO study impacts of human use of ecosystem products and services.

**Responses of the system.** NINA, NIVA and Biology UiO are working with responses from terrestrial and aquatic ecosystems of human use.

**Responses of society.** NIBR, NILU, NINA, NIVA, TØI, Economy UiO, and Political Sciences UiO study responses of the human society caused by ecosystem changes.

Knowledge about the diversity of life, understanding relationships between biodiversity and ecosystem functioning and finding ways to support conservation and sustainable use of biodiversity are challenges for the CIENS institutes. The institutes exhibit extensive qualifications in natural, social and economic sciences and on cross-cutting issues related to ecology, conservation and restoration biology, environmental chemistry and pollution, meteorology, environmental economics, tourism and use, resource management and administration. The recent loss of biodiversity can impact the functioning of natural ecosystems essential for human well-being, and many of the processes that underlie the delivery of ecosystem goods and services are poorly understood.

The institutes comprise expertise on the ecology of natural systems with their plants and animals relevant for studying environmental drivers, pressures, and impacts on ecosystem functions, modeling and scenario assessment responses from the system and society. They are also strong in pollution ecology, modeling of aquatic systems, economic valuation of ecosystem attributes and services, economic feasibility analysis of measures to conserve or restore ecosystem services, and uncertainty analysis in integrated modelling of land-water interactions as a basis for economic risk analysis in watershed management. The capacity of the institutes also encompasses peoples' perceptions of environmental performances, landscape changes analyses of sustainable tourism management of nature areas. In addition to this, the capacity covers important socio-economic drivers and pressures, processes of policy formulation and implementation within the fields of environmental policies, land use and resource management.

The University of Oslo is a CIENS partner. It is the largest university in Scandinavia in terms of staff and students with expertise in most fields. This means that education and student training will be integrated with the knowledge building at CIENS.

Important collaborating partners for the CIENS institutes are Institute of Marine Research, Flødevigen, on ecological studies in Oslo Fjord, Jordforsk (Bioforsk) in modelling of land use and vegetation cover's consequences for run-off, and nutrient and pesticide loading of aquatic ecosystems, and Institute of Resource Studies (IØR) at University of Life Sciences (Ås) in econometrics and micro-economic modelling of resource users. Important international partners are chiefly those of the EU-networks such as those of ALTER-net seeking excellence in biodiversity research.

## **RELEVANT INTERNATIONAL PROGRAMMES**

**DIVERSITAS** is an international programme of biodiversity science concerned with the understanding of relationships between biodiversity and ecosystem functioning and services, seen as one of the chief challenges of our time. Recent research demonstrates that the loss of biodiversity can impact the functioning of both natural and managed ecosystems. These

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results raise concerns about the capacity of impoverished ecosystems to deliver ecological goods and services, which are essential to human well-being. Yet many of the processes that underlie the delivery of ecosystem goods and services remain poorly understood and underevaluated.

Diversitas has formulated three main issues, Bio-discovery, Eco-services and Bio-sustainability. Bio-discovery was formed because knowledge about the diversity of life on our planet remains limited and fragmentary: as many as 80% of existing species are undiscovered and/or undescribed. Foci of the programme are an assessment of the current biodiversity, the monitoring of biodiversity change, and the understanding and predicting biodiversity change. This assessment of the current level of biodiversity will develop a system for monitoring, observing and understanding biodiversity.

Eco-services will expand the knowledge on biodiversity and ecosystem functioning at different scales and over a greater breadth of the biological changes in ecosystem structure and functioning, and the delivery of ecosystem services. New knowledge will be developed to guide policy makers and regulators in their efforts to support sustainable use of biodiversity, to evaluate the current conservation measures, and in studying the social pressures and economic drivers of biodiversity loss. To reach this goal there is a need for research on relationships between biodiversity and ecosystem functioning, the link between these and the provision of services, and on human responses to change in ecosystem services.

Bio-sustainability encourages to more sustainable use of biodiversity as a guide policy and decision making, and to establish a more complete understanding of the ecological economic and social aspects involved. Despite the best efforts of international conventions, directives, national and local policies and regulatory tools, DIVERSITAS perceives it to be a pressing need for strengthening of the scientific foundations for appropriate future social actions aimed at maintaining an acceptable level of biodiversity on our planet.

**The EU 7<sup>th</sup> Framework Programme (FP)** is relevant for the present research theme. Several of the CIENS institutes are at present involved in EU-networks and projects (6<sup>th</sup> FWP), perhaps with ALTER-net transferring excellence in biodiversity research among its partners, as the most relevant. CIENS will build on its present European networks and projects when applying for continuation of their research commitments on biodiversity and ecosystem ecology under future FWP.

**GEOSS**, and in particular points 7 to 9 among their research priorities: Improving the management and protection of terrestrial, coastal and marine ecosystems; supporting sustainable agriculture; and understanding, monitoring and conserving biodiversity, is of high relevance for the present research theme.

### **OPERATIONAL AIMS AND STRATEGIES TO ACHIEVE THEM RESEARCH QUALITY AND MULTI-FIELD ASPECTS**

**Objective.** To regularly publish scientific publications in international, peer reviewed journals, with emphasis on cross-sectorial research.

**Strategy.** To disseminate the results in high quality scientific journals, with high impact and broad readership. The publishing of the results in peer-reviewed, international journals gives a control of adequacy of the methods used and the relevance of the content in relation to international standard within the field. By seeking out journals with the broadest possible readership, we secure a wide dissemination of our findings and ideas. At present, mean

number of international publications per CIENS scientist is less than one, and to enhance our scientific position, there is a need for increasing this mean.

The Norwegian White paper on Environmental Policy (2004-2005) is concerned about threats to ecosystem functions, and has called for the development of cross-sectorial environmental research (St. meld. nr. 21) The establishment of an advisory board for this programme with representatives from the appropriate authorities and the scientific community would be advantageous when discussing adjustments in research priorities and use of intrinsic funds. The focal problems should be defined according to their relevance for human management of ecosystems, and solved interdisciplinary through the perspective of the DPSIR philosophy (e.g. interaction on methods). The various institutes will be responsible for different parts in accordance with their competence and capacity.

### **INTERNATIONALIZATION AND EXCHANGE OF KNOWLEDGE**

**Objective.** To become a leading national and international institute on multi-disciplinary, cross-sectorial biodiversity research.

**Strategy.** Through publications and contributions at international conferences, symposia and workshops, we will participate in setting research priorities and standards for international ecosystem research. The strength of CIENS is the high standard of its scientists in a wide range of disciplines from ecology to economy and social sciences with the possibility to address problems cutting across disciplines.

The Biodiversity Convention and themes within the Millenium Ecosystem Assessment are driving forces for policy-driven ecosystem research. The Millenium Ecosystem Assessment underlines the importance of assessment and quantification of ecosystem services and their valuation to promote sustainable development. Capacity building within this field is a prerequisite for effective mitigation of degraded ecosystems, and the Norwegian White paper on Research (2004-2005) supports increased co-operation between the CIENS institutes to promote their competitiveness in responding to the international research agenda (St. meld. nr. 20). Our approach is similar to that of DIVERSITAS, “to build a dynamic and integrated approach to biodiversity”. Evolutionary and ecological dynamics affect the biodiversity, as do deliberate as well as unintentional human actions. Altered biological diversity influences human societies, which have to adapt to or reverse the changes. To understand and predict this cycle of interactions, we see that integration across traditional disciplines is highly needed. By taking this approach, we aim to influence the agenda for prioritized scientific tasks of the international community. The diverse background and training of the scientist at CIENS give the centre a comparative advantage in multi-disciplinary research on environmental problems.

We will strengthen our research co-operation among Nordic countries, and participate in European networks built for applications to the 7th Framework Programme (FWP) of EU on biodiversity research. Furthermore, several CIENS scientists co-operate with scientists in North America. We encourage expanding such links by facilitating scientist exchange with leading institutes elsewhere. This can be done by making funds available for the support of visiting international scientists, as well as for CIENS scientists to go abroad on sabbatical leaves similar to what university professors do.

### **TRANSFER OF KNOWLEDGE TO DEVELOPING COUNTRIES**

**Objective.** To transfer established biodiversity knowledge to developing countries.

### *Ecosystem Products and Services*

**Strategy.** We will explore the possibility of engagements from NORAD, and other agencies such as the World Bank, the Inter-American Development Bank, and the Asian Development Bank. We will stimulate to project applications involving knowledge exchange with developing countries that have experimented with other principles for biodiversity conservation (e.g. use-oriented) and innovative incentives for ecosystem services. Furthermore, we will explore research collaboration opportunities with Eastern Europe including the Baltic States, North-Western Russia, and Barents Sea. Of particular importance will be collaborations in applied research on environmental and conservation policies in EU enlargement countries, taking advantage of Norwegian research on integration of EU's environmental legislation with established Norwegian environmental legislation and management practices (i.e. local adaptation of the EU Water Framework Directive, proposed Nature Diversity Act vis a vis EUs Habitat Directive).

### **RESEARCH INITIATIVES AND PROJECTS**

By use of the DPSIR-model, we will initiate cross-sectorial studies in Norway and other countries, in terrestrial and aquatic ecosystems. In particular, we would like to focus on the Greater Oslo Fjord and its catchments which include alpine and boreal habitats covering most of south-eastern Norway (detailed in annex). Reasons for this choice are the proximity to Oslo and its relevance for a large part of the Norwegian population, urban-rural; land and water use conflicts which are among the most pronounced ones in the country; the multiplicity of resource use conflicts are similar to those in countries we wish to cooperate with (i.e. in continental Europe); the economic importance of the region for the nation; biological knowledge of near-coastal, marine ecosystems and littoral processes, still sparsely investigated compared to the commercial resources of the high seas.

In the short term (2 years), we would like to establish a co-operative network for the programme, and review the existing knowledge within the field (surveillance data, case studies, etc). In modern societies constitutes disturbance and pollution associated with use a greater problem than those caused by the production of the items, and in the longer term (5-10 years), we will carry out research on ecosystem effects of noise and chemical pollution due to traffic on land, water and in the air, alternative area use, users conflicts associated with traffic on land and water. In case of strongly limited funds, the money will be used to build, coordinate and maintain the network and apply for extra funding, and the science will largely be performed by MSc and PhD students. If a more generous financial support is available, stronger scientist involvement from the CIENS institutes directly into the research projects will be possible, and broader ecosystem-based studies will be carried out.

Major issues related to our priority topics are knowledge about the most important natural and anthropogenic drivers behind the transport sector, their variation at different spatial and temporal scales, the identification of critical ecosystem components influenced by transport, and the linkage between these ecosystem components and other biotic community structures. Furthermore, we will study the value of nature's services and products, and how this value is associated with transport. We will also register institutions (traditional and formal use and property rights, formal and informal organizations) governing the use of ecosystem products and services in Oslo Fjord, and how these institutions condition the alternatives available for management of the ecosystems, including preventive, mitigatory, and restorative technological measures, economic incentives and potential cooperative agreements between the users of the fjord ecosystem. Furthermore, we would like to study ecosystem management and policy responses and how society strive to implement its objectives for nature's products and services through various management policies and actions in relation to

the fjord and model based scenario assessment for the development of future environmental management. (A more complete list of questions is given in annex.)

The majority of the CIENS institutes, and Jordforsk, applied jointly for a five year strategic programme in 2005: "Valuation of ecosystem services in watershed management (detailed in annex). The programme has as a case study the River Glomma. In association with this programme, the institutes will apply for additional research activity from the Norwegian Research Council, and seek long-term research exchange agreements with research centres in developing countries implementing payment systems for environmental services (PES). PES is a current research priority of multi-lateral funding organisations such as the World Bank.

The research initiatives suggested here will only be successful if a number of basic questions are addressed. There is a need to better understand the structure of the ecosystem used, including the complex interplay between the various components in the system. Since the ecosystem contains terrestrial, littoral, pelagic, and profundal components, complex models may have to be constructed for understanding the interactions. Developing and testing such models for validation is a scientific challenge. Furthermore, behavioral and physiological (and toxicological) responses to the various ecosystem effects have to be studied and quantified. For example, the biological effect of noise (in water) is only beginning to be understood - and here UiO may be a key player in the future.

We will seek economic support from relevant programmes of the Norwegian Research Council (Ocean and Coast, subsequent pollution research programme), relevant public authorities and industry and support from the 7<sup>th</sup> Framework Programme of EU.

**CIENS**

 **SACRE**

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