Synthesis of Internal Consultations on the Natural Assets Knowledge-Action Network

1. Preamble

In order to achieve Future Earth's mission, which is for people to thrive in a sustainable and equitable world by 2025, all research activities/projects that Future Earth will endeavour to conduct will be based on the following three principles:

1) Inter-disciplinarity
2) Trans-disciplinarity
3) Solution-oriented

As such, all Knowledge-Action Networks, including the one on Natural Assets, will need to fulfil those principles.

2. Introduction

Human influence on natural systems is profound and increasing. This influence destabilizes, and reduces the resilience of natural systems, while creating complex, coupled socio-ecological systems that cross scales and change in complex, often unpredictable ways. Understanding the dynamics of these coupled socio-ecological systems will require a new kind of collaborative science — one that integrates different disciplines and allows us to map, predict, and respond to the feedbacks generated by the multi-scale changes affecting the planet.

While the discipline of sustainability science is growing roughly twice as fast as science in general, research integration across disciplines still comes with a significant cost, whether measured in terms of citation rates, or in terms of grant success rates[1]. The tools, capacities, evidence, and knowledge needed to support sustainable development are inherently interdisciplinary in nature and require collaborative team-based science built by experts from a wide range of scientific disciplines. This integrative knowledge is needed but not sufficient if society wants to build sustainable solutions "rapidly" implemented. To favour the uptake of this knowledge and implementation of sustainable solutions, Future Earth works with partners in society to co-develop the knowledge needed to support decision-makers and societal change at all scales and in diverse contexts. Both inter-disciplinary and trans-disciplinary approaches are at the heart of the Future Earth activities.

[1] Lindell Bromham, Russell Dinnage and Xia Hua. 2016. Interdisciplinary research has consistently lower funding success. Nature 534, 684–687.

Building on four global environmental change programmes[2], Future Earth was designed with the goal of generating integrated knowledge, tools, and capacities in support of more rapid, effective, and durable solutions to our largest sustainable development challenges. It is a boundary organization coordinating new, inter- and trans-disciplinary approaches to ensure that knowledge is generated in partnership with society and users of science. Future Earth is the largest coordinated effort to mobilize science in the service of sustainability, and is working toward the above-mentioned goals through the launch of eight Knowledge-Action Networks addressing major societal challenges.

3. Knowledge-Action Network on Natural Assets: overview

The Natural Assets Knowledge-Action Network aims at achieving a scientifically-based, sustainable and fair stewardship of terrestrial, freshwater and marine natural assets underpinning human well-being by understanding relationships between biodiversity, ecosystems and their benefits to societies, as well as developing effective management and governance approaches. It partially builds on different Fast-Track Initiatives initiated by Future Earth two years ago (Global Biodiversity Monitoring, Prediction & Reporting initiative, the Seed of the good Anthropocene initiative, the Scientific support for IPBES knowledge generation initiative and Linking Earth system and the socio-economic models to predict and manage changes in land use and biodiversity), and directly respond to some decision-making needs, especially those from the Convention on Biological Diversity (CBD), the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), and the Intergovernmental Panel on Climate Change (IPCC).

In January 2016, the Future Earth Natural Assets Knowledge-Action Network initiated an internal consultation process and call for expression of interest **to the Future Earth Community of Core Projects, Fast-Track Initiatives, Clusters, Science and Engagement Committees, regional centres and offices.** This was done to support a preliminary scoping process, build on the internal Future Earth Community expertise and to start the formation of the development team[3] of this Knowledge-Action Network. This document is therefore an attempt to synthesise the proposals submitted under the Natural Assets call for expression of interest, and summarizes the research priorities that were identified.

4. Themes of interest within the Natural Assets Knowledge-Action Network

The preliminary process (consultation of Future Earth Core Projects, FTIs/Clusters, and Regional centres) identified an overarching set of scientific needs and questions within several

[2] DIVERSITAS (international programme on biodiversity science), the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme (IHDP) and the World Climate Research Programme (WCRP).

[3] The primary role of the Development Team (DT) is to drive the development of the Knowledge-Action Network (KAN) for a short duration (most likely under 12 months) during which time its main function will be to lead the planning and execution of the KAN scoping phase. The scoping phase is intended for co-developing a Research and Engagement Plan, identifying a steering group, and developing a funding strategy. The DT will operate over this limited time period until a Steering Committee is appointed.

broader themes. It is worth mentioning that several of the themes and research questions addressed under this specific Knowledge-Action Network, will also be relevant to other Knowledge-Action Networks, which should prompt collaborations. If you want more information on a specific topic you will find the detailed responses to the call for interest in Appendix.

The broad themes include:

1. **Biodiversity, ecosystem functions and ecosystem services**

   1.1 Biodiversity and ecosystem valuation across scales, including the development of more robust systems to evaluate, translate, and connect changes in natural asset stocks and flows to measure commonly used assets and to assess the health of systems. Ecosystem services range from provisioning services (e.g. food, fiber, fuel, chemicals obtained from ecosystems), regulating services (the regulation of ecosystem processes such as air quality, climate and water regulation), cultural services (spiritual enrichment, cognitive development and recreation), to supporting services (e.g. soil formation, nutrient and water cycling), all of which provide transboundary services across scales. Fundamental research in this would aid decision processes at local, national, and regional scales, and results would interface with science policy interface such as the Convention on Biological Diversity (CBD), the Ramsar convention, and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) and contribute towards achieving multiple UN Sustainable Development Goals.

   Examples of key research needs and questions:
   - How to assess and integrate different types of values (use and non-use) of natural assets (response to identified IPBES needs)
   - How to systematic assess natural capital replaceability (through the infusion of industrial, technological or social capital); (Appendix I)
   - Development of methods for the dynamic valuation of the many services simultaneous provided by an ecosystem to assess changes in these services resulting from a given change in the ecosystem management.
   - What are the economic consequences of biodiversity loss, and what are potential alternatives for local population?
   - What are the social costs associated with biodiversity and ecosystem services change?
   - Role of ecosystem services in adaptation to global change and carbon sequestration

This theme is related to the following proposals: Appendix E, F and I.

1.2 Global biodiversity change, ecosystem monitoring and ecosystem health indicators

Understanding the causes and consequences of ongoing changes in biodiversity is at the core of a sustainable use of the planet, but dependent on innovative approaches and a collaboration between researchers and multiple stakeholders.

Following up on the work of the Cluster on 'Global Biodiversity Monitoring, Prediction and Reporting', developing a forum for academia, practice, and policy to address - in relation to changing biodiversity and ecosystem functions - the advancement of theory and concepts, the observational and experimental testing of hypotheses, and the development and use of new technologies for information capture. Activities may often focus on specific systems or approaches best suited for enabling general inference about patterns, causes and consequences of global biodiversity change. It also aims at collaborating closely with the Group of Earth Observations (GEO) Biodiversity Observation Network (GEO BON) efforts addressing the global capture of essential biodiversity variables that will deliver important observational evidence, support the ongoing and future assessment and interpretation of biodiversity change for ecosystem functions and services (e.g. in the context of IPBES). Research communities under this theme would create a very strong link to the communities and work being carried within GEO BON, the Biodiversity Observation Network of GEO. GEO BON, one of GEO nine Societal-Benefit-Areas, is building up the pathway to link biodiversity data and metadata to the Global Earth Observation System of Systems (GEOSS). As such, putting all these pieces of knowledge and information together into a global framework that can help us understand the biosphere as a system and how and why it is changing would facilitate the harmonization of existing biodiversity monitoring initiatives, especially through GEO BON's Essential Biodiversity Variables (EBVs) and the "BONBon in a BOX" project.

This research theme would also target the need for improved indicators for forecasting non-linear, often irreversible, changes in ecosystem functions and services, building up on the work done by the FTI "Scientific support for IPBES knowledge generation initiative" .

Example of key research needs and questions:

- Gather, structure and synthesize existing knowledge on ecosystem monitoring in new ways (including the use of citizen science, knowledge platforms, and integrative collaborative efforts with strong links to work being carried under the Global Earth Observation System of Systems (GEOSS), and especially the Group of Earth Observations Biodiversity Observation Network (GEO BON)) - see below for more details; (Appendix I):
    - What is the effect of landscape heterogeneity and spatiotemporal scale on how biodiversity affects ecosystem function?
    - What guidance can new sensors (eDNA, GPS- animal tracking, in situ and remote sensing) offer for capturing global biological connectivity and its role for the spread of invasive, agricultural pests, and human diseases?
    - Toward a smart measurement of the pulse of the planet: technological and modeling innovations for capturing biodiversity and ecosystem change and their interrelationship.
- Development of a robust set of physical, biological, and socio-economic climate indicators for use in predicting changes in the flow of ocean-based ecosystem

services. There is now a wealth of ecosystem and biodiversity indicators proposed by the scientific community and frameworks have been developed for the selection of indicators. These indicator sets are mostly based on ecological theory and data availability, and favour sets of indicators that are widely available if not global in their coverage. However the FTI "Scientific support for IPBES knowledge generation initiative" has identified large gaps in these sets of indicators, especially to address the socio-economic drivers of ecosystem change, impacts of management & conservation policies on ecosystems and marine indicators (e.g. to differentiate between fishing effects and other ecosystem drivers). This work would allow rapid advances in scenario modelling.

- Research, assessment, and monitoring for the planet's most sensitive and global-change exposed ecosystems, their biodiversity, and associated livelihoods.

This theme is related to the following proposals: Appendix G and I

1.3 Changing dependencies between natural assets, ecosystem services and human health, emphasizing the development of place-based methods for predicting impacts of changes in the quality and quantity of essential ecosystem services, and supporting biodiversity, on key global health parameters, including age and cause-specific mortality, morbidity and debilitation. Additional areas of particular concern include the integration of ecosystem service-human health models into models of climate change, water and food scarcity, and the complex health-related feedbacks resulting from changes in essential services. Health-related variables of particular interest include the spread and control of disease, changes in human nutrition, and key causes of childhood mortality.

Example of key research needs and questions:

- Which configuration of biodiversity levels (composition, functions, etc.) is important for human well-being considering socio-economical and geographical specificities?
- What is the role of animal movement in an ecosystem for disease spread, food security and maintenance of biodiversity?

This theme is related to the following proposals: Appendix A and I

2. Governance and fair stewardship of natural assets, which ranges from the broader approach to improve governance of ecosystems towards ecological sustainability, to applying knowledge on changing species distribution and interaction for better forest management. For instance, there is a need to consolidate network interactions on the management of natural assets, e.g. land cover and land use, coastal development and ocean productivity, biodiversity, agriculture and fisheries, land reclamation and development.

Example of key research needs and questions:

- Assessing current governance mechanisms that can contribute to social-ecological sustainability across sectors and identifying best practices for the governance of ecosystem services; (Appendix H)
- Assessing trade-offs and conflicts between different sectors (e.g. tourism, forestry, conservation, agriculture). This will lead to identifying sustainable systems-based cross-sectoral governance and management practices, and will contribute to the work programme of CBD on mainstreaming biodiversity in other sectors; (Appendix B and C)
- Assessing current ocean & freshwater regulations, governance systems needed to address the growing food-related harvest pressure, including the international *versus* national aspect and transboundary management of fisheries resources. (Appendix B, C and G)
- Assessing governance mechanisms of ecosystems that insure a transition towards ecological sustainability. This theme will build on the FTI Seeds of Good anthropocene (Appendix A).

This theme is related to the following proposals: Appendix A, B, F, G and I

3. Socio-economical transformations for sustainable consumption and production of resources, will be at the heart of the UN's Sustainable Development Goals (SDGs) implementation and at providing the necessary resources to ensure the livelihood of a 9,7 billion world-population in 2050. Such a theme requires integrative and interdisciplinary sciences as well as co-production of research within the different communities notably civil society (including indigenous communities) and the private sector. This kind of research need will be of particular importance in order to 1) understand the contribution of natural assets to sustainable development, and 2) better understand the potential trade-offs and conflicts between achieving different SDGs at the same time, e.g. "zero hunger", "life on land", climate action", "no poverty", "health and well-being".

Example of key research needs and questions:

- Identifying the necessary dietary transformations (behaviour, uses, etc) to feed the world's population in 2050 whilst preserving adequate ecosystem services necessary for human well-being (e.g. resources from the oceans). (Appendix B)
- Identify pathways (regulations, culture and behaviour change, communication, etc.) to make these societal transformations possible. (Appendix H)
- Identify changes in food production (from agriculture, ocean-food harvest to industrial processes) and delivery in order to minimize ecosystem services disturbance (Appendix B and C)
    - Examples for ocean-food: ensuring quantity, diversity, alternatives (macro-algae, shellfish, fish aquaculture), use of nutrient/food sources from different trophic levels, etc.
- How did cultural and biological diversity jointly evolve, and how does that impact the sustainable consumption and production of resources? (Appendix II)

This theme is related to the following proposals: Appendix A, B, C, D, G and I

4. Development of scenarios and models to support multilateral agreements

The need to develop scenarios, and supporting models, that would support policy processes such as IPBES and IPCC is among the priorities that were identified during the internal consultation as such scenarios are key tools to help decision makers identify the impacts of various policy options on ecosystem services and natural capital. The need to develop local and downscaling global scenarios was also highlighted, alongside early warning systems for regime shifts and modelling of the impacts of shocks on ecosystems. Thus, there is a particular need to expand existing scenarios and modelling as well as developing stronger ties with stakeholders to improve their use in decision-making processes. This work will also contribute to other stakeholder sectors such as the insurance sectors.

Example of key research needs and questions:

- Developing scenarios of future ecosystems use to inform regional and national policy i.e. “designing the future we want”);
- Developing various models for different ecosystems in order to determine climate change impacts on biodiversity, ecosystem function, ecosystem services and human well being;
- Developing state-of-the-art ecosystem models to test indicators performance and run biodiversity scenarios under different management options;
- Developing models of impacts on biodiversity and ecosystem services, including activities around model intercomparison.

This theme is related to the following proposals: Appendix C, E, G and I

5. Concept of Natural Assets

In the course of the internal consultation, it was recognized that the notion of Natural Asset has different meanings for different people and communities. One example is that some people restrict it to the biological components of ecosystems (biodiversity and ecosystem services) and others include all natural resources (such as air). The natural question is therefore to ask how to account for these differences in defining the objectives and priorities for the Natural Assets KAN and what terminology to adopt to guarantee thematic coherence, inclusive values, efficient communication and collaboration within the network and the broader communities, in view of project prioritization.

This theme could be addressed through a short-term project aiming at bringing together an inter-displinary scientific group, including the field of semantics, to assess the different meanings (based on existing literature on natural capital and natural assets e.g., Mace et al. 2015) and propose a framework to account for the diversity of perceptions while defining the objectives of the KAN, the overlap, synergies, and differences with other KANs, and the tentative portfolio of products expected from the KAN. It could lead to a scientific paper as well as papers/products for different audiences.

This theme is related to discussions from the Core Projects days held in Bern in June 2016

Appendix - Detailed responses received for the Natural Assets KAN call for expression of interests

A. ecoSERVICES

Views on what the core foci of the Natural Assets KAN should be

From the perspective of ecoSERVICES, the thematic foci of the KAN are **the conservation and sustainable use of biodiversity**, **biodiversity's role in human well-being** (notably by using the lens of ecosystem service science though other useful conceptual framework may be of relevance too) and corresponding **effective governance of ecosystems to support transition towards ecological sustainability from local to global scale**. By this we understand that the KAN addresses the **instrumental value** of biodiversity as well as its **intrinsic and relational values**. In this way, this KAN could contribute knowledge to the Intergovernmental Platform of Biodiversity and Ecosystem Services (IPBES) which recognises these three value types. In addition, these themes would be addressed **in the context of globalisation and its impacts** at various scales of governance and on populations' sovereignty.

As operational foci, the KAN could operate as a **platform for debate** among researchers and various social actors that supports broad global participation as well as sub-network interactions on sub-topics or sub-regions. The KAN should provide opportunities to operationalise **transdisciplinary research** through various projects and initiatives. It should explicitly aim to support **collaborative learning** among participants. Besides, the co-production of new knowledge should not be the sole focus of the KAN; rather the KAN should also look at means to mobilise and make available in the timeliest and the most relevant manner knowledge that has fallen in the research-implementation/application gap. To achieve all this, the KAN should rely on excellent **facilitation** in particular because in the course of its implementation, interactions, compromises and conflicts between participants in regards to benefits derived from ecosystem services may become palpable. Thus, and in accordance with ecoSERVICES challenge (2), synergies and compromises will need to be found in order to really foster sustainability and equitability. Finally, the **major types of products** needed from this KAN should be **project- and audience-specific** thus defined on a case-by-case basis among participants. As a result, we do not believe that a one-size-fits-all type of products will be suitable neither that the KAN should focus on delivering novel synthesis products – syntheses will be one type among the diversity of possible products. Other types of products include those designed for general awareness-raising purposes. The KAN would thus actively involve professionals from the communication sector in the broad sense (from Arts to Journalism) so they can help **broadcast the knowledge produced in a diversity of palatable formats** suitable for a diversity of audiences not directly involved in the KAN.

Results from enhanced research and empirical evidence onto the relationship between human well-being and the state of the biological environment meet the needs of many stakeholders at the global and regional level, e.g. through the science-policy interfaces for climate and

biodiversity policy[4], but also through public and private efforts to sustainably improve human well-being by better management and/or conservation of the biological environment. The KAN should help magnify all this.

Shortlist of core ideas to develop under such foci

To start off with the KAN will collectively address core ideas from ongoing efforts of participating core projects (this consultation). Specific (new) core ideas will, under principles of inclusion and co-design, be co-defined among KAN participants once the KAN involves significant numbers of participants outside Academia. From our standpoint, however, we suggest that the science strategy of ecoSERVICES [5] provides a full set of core ideas consistent with the KAN and the core foci mentioned above (e.g. addressing issues in ecosystem service supply such as synergies and tradeoffs, scale-dependent emergent properties, non-linear responses, planetary boundaries). Indeed, ecoSERVICES "assesses the links between biodiversity, ecosystem services and human well-being and their role in achieving equity and sustainability", confronting three challenges: (1) "How, when and where are ecosystem services co-produced by social-ecological systems?", (2) "Who benefits from the provision of ecosystem services?" and (3) "What are the best practices for the governance of ecosystem services?"[6]. Likewise, the Natural Assets KAN aims to "achieve a scientifically-based, sustainable and fair stewardship of terrestrial, freshwater and marine natural assets underpinning human well-being by (a) understanding relationships between biodiversity, ecosystems and their benefits to societies, and (b) developing effective management and governance approaches"[7]. **Thus there is a perfect thematic overlap between ecoSERVICES and the KAN**: (1) and (2) contributing towards (a), and (3) towards (b). In addition, **ecoSERVICES could contribute a unique perspective to the KAN** as we untangle (a) in two sub-challenges and are the only Future Earth core project focused on ecosystem service science.

List of concrete actions to make them happen

<u>ecoSERVICES challenge (1) Co-production of ecosystem services:</u> Develop coherent sets of scenarios for sustainability with respect to the human-environment relationship to assess pathways to desirable futres [collaborators: ecoSERVICES, PECS, bioDISCOVERY, GLP, FTI Bright Spots[8], ScenNet[9], others]. Investigate the potential of new modelling approaches to increase

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[4] Intergovernmental Panel on Climate Change, IPCC (http://ipcc.ch) and Intergovernmental Platform on Biodiversity & Ecosystem Services, IPBES (http://ipbes.net)

[5] Bennett EM, Cramer W et al. 2015 Linking biodiversity, ecosystem services and human well-being: Three challenges for designing research for sustainability. *Curr Opinion Environm Sust* 14:76-85

[6] http://futureearth.org/ecoservices/science

[7] Future Earth Natural Assets Knowledge-Action Network (KAN) description document circulated by the Secretariat on 21 Jan 2016 [Word doc name: Natural_Assets_Knowledge_Action_Network_Description (1)]

[8] http://www.futureearth.org/ecoservices/bright-spots-seeds-good-anthropocene

the relevance of natural asset studies in transformations to sustainability [collaborators: ecoSERVICES, bioDISCOVERY, FTI Linking models[10], AIMES[11], others]. Review the specific observation needs for research and monitoring on natural assets [collaborators: ecoSERVICES, CA Global Biodiversity Monitoring[12], GEO-BON, HLPF on Sustainable Development[13], others].

ecoSERVICES challenge (2) Beneficiaries of ecosystem services: Map the most pressing needs of major stakeholders for scientific knowledge about natural assets and sustainability [collaborators: ecoSERVICES, IPBES, IPCC, others at global level; relevant partners at regional and other levels]. Map stakeholders relevant to the topic of the KAN then design an engagement strategy for each.

ecoSERVICES challenge (3) Governance of ecosystem services: Co-design a research agenda around the governance of ecosystem services by bringing together the knowledge of the global ecosystem services community through a survey in multiple languages; and this to foster a network of researchers and practitioners working on governance in the KAN (under development) [collaborator: ecoSERVICES, collaboration will be sought with Earth System Governance (ESG)].

Awareness-raising/capacity-building: Develop broadcasting facilities to share knowledge and experience from the KAN within and outside the KAN community such as podcasts, videos, etc. on lectures/conferences (e.g. in the format of – or in partnership with – TED talks), debates, capacity-building/training activities, art-science workshops, etc. where speakers are practitioners or scientists [collaborators: all KAN participants to provide inputs, a communication/IT facilitator]. Support capacity building for place-based transdisciplinary sustainability research through intensive field courses and for collaborative learning at any scale [collaborators: ecoSERVICES, PECS, Future Earth Europe and European Alliance]. Organise courses or summer schools for postgraduate students and young scientists and possibly a version for the general public too (under development).

[9] http://www.agence-nationale-recherche.fr/?Project=ANR-14-JPF1-0002

[10] http://www.futureearth.org/linking-earth-system-and-socio-economic-models-predict-and-manage-changes-land-use-and-biodiversity

[11] http://www.futureearth.org/projects/aimes-analysis-integration-and-modelling-earth-system

[12] http://www.futureearth.org/global-biodiversity-monitoring-prediction-reporting

[13] https://sustainabledevelopment.un.org/hlpf

B. IMBER

Introduction

Most human food (about 96%) is based on intensive land-based mono-culture farming. The global population is assumed by the end of this century to level out at about 10-11 billion (about 50% more than today). If we at the same time shall reach the UN Sustainable Development Goals such as "no poverty", "zero hunger", "good health and well-being", covering the demand for healthy food will be a major challenge in the years to come. Continuing to rely on land based farming for necessary food production will put additional pressure on already challenged terrestrial biodiversity. A thorough investigation of the potential for other systems, like the oceans to drastically increasing human healthy food supply is therefore necessary in conjunction with terrestrial food supply becoming more efficient and less impacting. With around 50% of global primary production taking place in the ocean there may be sustainable avenues for future food provision from the oceans to bring us closer to meeting UN goals.

1.Views on what the (marine biology part of) **core foci of the Knowledge Action Network should be;**

Is it possible to sustainably increase human food supply from the ocean (from say 100 to 1000 mill. tonnes/year) to fill everyone's dietary needs in a near future world with 10-11 billion people?

2.Shortlist of core ideas to develop under such foci;

a Which trophic levels are most likely to sustain increased harvest (and how much)?

b How much increased marine food production can be achieved within current fisheries management (management, waste treatment, where to fish, what to catch) and where are improvements needed?

c How much increased production can realistically be achieved by aquaculture (macro-algae, shellfish, fish), and what are the spatial requirements (on land, coastal, and marine) for increased aquaculture production ?

d What changes would need to be made in the food production industry and/or human's food cultural practices to take up potential increased marine harvest and aquaculture production?

e What regulations are needed to secure fair distribution of the marine food resources?

f How will climate change and ocean acidification affect the solutions?

3.List of concrete actions to make them happen;

a Synthesis of global production at different trophic levels.

b Synthesis on status vs. potential production and distribution of major fish stocks.

c Improve 4-dimentional bottom-up ecosystem models to investigate potential for sustainable harvesting at lower trophic levels.

d Quantify how multiple drivers and stressors cumulatively affect ecosystem structure, functioning and response to change.

e Quantify how end-to-end ecosystem processes (including humans) can be further identified, quantified and modeled over multiple scales.

f Analyse for potential tipping points/ critical thresholds in fishing versus climate change.

g Synthesis on spatial scales related to massively increased aquaculture.

h Global modelling exercise to find suitable locations for aquaculture from an ecological, social (e.g. food security need) and economic perspective (e.g. distance from market).

i Analyse investment and operational costs and technology needs for large scale open ocean farming.

k Develop human food supply scenarios based on best available marine ecosystem, management and societal models including scenarios/predictions for global change.

l Analyse in an environmental and human perspective the needs for new regulations for securing sustainable and fair marine food supplies.

l Risk assessment. What can go wrong?

C. ESSENCE

Background and core foci: The KAN on Natural Assets seeks to achieve a scientifically-based, sustainable and fair stewardship of terrestrial, freshwater and marine natural assets underpinning human well-being by (a) understanding relationships between biodiversity, ecosystems and their benefits to societies, and (b) developing effective management and governance approaches.

The appreciation for the sustained state and functioning of ecosystems under manifold global environmental change pressures is increasing. In this context, the concepts of natural capital (NC) and ecosystem services (ESS) as the benefits that human societies obtain from ecosystems have emerged as a tool to support policy development and to assess diverging options for sustainable ecosystem management, including the identification of co-benefits and conflicts. In addition, the recognition of ecosystem state and function as being crucial for the supply of essential resources also facilitates a close connection with aspects of biodiversity research and management, and conservation policies. An example would be the management of ecosystems for climate regulation services (ie carbon dioxide storage and uptake) which could in principle also foster conservation purposes and habitat diversity, but which also requires conflicts with other land-uses such as food provisioning to be identified and resolved.

Still, even though the NC and ESS terminology can be found now in many policy-frameworks such as the Conservation Biological Diversity, CBD, or the EU biodiversity strategy, there is still an open debate and missing knowledge in how to best combine the necessary natural, social

and economic science into a common, quantitative methodological framework that allows to apply NC/ESS principles for practical application. This is especially apparent in the need to apply robust modelling tools to investigate how NC/ESS issues might change in space and time under different projections of climate and socio-economical changes.

Abbreviated here as "ESSENCE" we propose to develop activities specifically on two emerging areas of research within the KAN on Natural Assets:

1) Keeping climate warming below 2^{o}C is essential for the supply of many ESS (ie food & water provisioning), and will also greatly help us in achieving many of the Aichi targets (https://www.cbd.int/sp/targets/), especially those related to land management. However, after the Paris COP21 agreement, we face the need to rely on large scale bioenergy (in combination with CCS) for climate change mitigation, which inevitably cause conflicts with other ecosystem services (i.e., land needed for food production). As land is a scarce resource, especially the proportion that is suitable for growing food or growing bioenergy this puts enormous pressure on other crucial goals such as protection and renaturation of ecosystems. In other word, potential trade-offs between UNSDGS 2 ("zero hunger"), 13 ("climate action") and 15 ("life on land") are pre-programmed and must be understood, tackled and resolved.
2) Following on from (1) arises also the question of how climate and/or socio-economic episodic events (shocks, extreme events) atop of trends affect ecosystem state and function. At the same time, ecosystems can also help to mitigate effects of hazards that arise from these extreme events. Assessments of the future state of ecosystems, functioning and services derived consider only trends in parameters of global environmental change. But extremes will impact ecosystem vulnerability, and "test" their resilience, to a very different degree, since gradual trends (eg in temperature and precipitation) will allow for acclimation while frequent shock (eg recurring heat waves and rain storms) might not. Studies that focus on trends are likely to miss important system tipping points. With extreme events plausibly increasing (in the climate system) and being unpredictable (in the socio-economic system -- and hence only accessible via novel future scenarios that account for these) it is essential to get a much clearer, quantitative picture of what different types of "shocks" would mean for ESS supply, and how we manage ecosystems for maximum resilience. In particular, how could we potentially increase capacity of ecosystems for hazard mitigation and how could that lead to co-benefits with other ESS and biodiversity?

Shortlist of core ideas: ESSENCE aims to combine synthesis efforts to bring together existing modelling and observational information in novel ways and also aims to explore development of new concepts and methods to understand and quantify the above issues and to translate new science into information for policy and business. We envisage contributing to the KAN on Natural Assets by the following activities:

1) Identify hitherto un-tapped knowledge w.r.t. assessment of NC and ESS. For instance, a multitude of experimental, monitoring and model experiments exist on terrestrial ecosystem–atmosphere interactions that have been undertaken with a focus on questions raised by UNFCCC and the IPCC, but which have not yet been analysed from NC/ESS perspective;

2) Explore options of including biodiversity and ecosystem conservation/restauration in scenarios that underlie climate change assessments (e.g., interface with the RCP/SSP/SPA process).
3) Explore ideas and options for cost-effective investments in protecting or renaturing ecosystems in view of episodic events and shocks through methodologies for estimating the 'insurance value of ecosystems' (e.g., capturing both the use of 'insurance' as a metaphor for ecosystem vulnerability and resilience to shocks, as well as capacity of ecosystems to mitigate hazard risks).

Actions: ESSENCE aims to provide knowledge and tools that will help to solve the conundrum between ecosystem conservation and other demands human societies have on ecosystems. A community that tackles the concept of NC/ESS from various perspectives already exists, and under the ESSENCE umbrella of ideas we would aim to bring these together to jointly address the above questions. For instance, in Europe we can build on a network stimulated currently by two large projects in the NC/ESS domain (OPERAS and OPENNESS – need to add URL and perhaps also the EU funding). Yet there is still a large disconnect between research on NC/ESS and "classical" ecosystem function modelling and observations (e.g., research that traditionally addressed questions related to land surface-atmosphere interactions), and also with the large communities dealing with disaster risk mitigation. Actions therefore need to identify ways to integrated better between these disjoint groups of researchers, policy maker and businesses, to reap the expected scientific and societal benefits.

The proposed project also builds on a current activity under the auspices of bioDISCOVERY, funding by UNESCO and the CBD, which aims at bringing together the climate and biodiversity scenarios and modelling communities in order to link modelling approaches, and to develop joint scenarios for IPCC and IPBES.

D. The Hjort Centre

Introduction

Half of the biological production is marine, but most of our food comes from land-based farming. We need to utilize more of our marine living resources in a sustainable manner to feed a growing population.

The world´s population is expected to continue increasing in the years to come. Thus, it is of great concern that the current global production of food does not cope with this predicted increase. Even though approximately half of the biological production takes place in the oceans, most of our food is currently originating from land-based farming. In the future, we need to utilize more of our marine living resources, which must occur in a sustainable manner. This is one of the major issues the Hjort Centre for Marine Ecosystem Dynamics will address. The Hjort Centre, explained simply, will explore how a larger portion of our nutrients can be obtained sustainably from the oceans. To answer this question, we need more knowledge and a comprehensive understanding of the complex marine ecosystems in our surrounding seas, as well as in distant waters.

Global challenges, global solutions

The social mission is well defined, but there exist no simple solution to these challenges. The changes in the oceans are independent of maritime borders. Fish and other marine organisms follow the currents, and migrate between different economic zones. Biological, physical and chemical parameters interact in a varied and complex interplay, while anthropogenic activities, such as fisheries, aquaculture, climate change, industries and environmental impacts, continuously influence the marine environment. No single discipline, research community, or a nation by itself, can fully explain the changes that currently occur in the oceans, nor predict future changes and consequences. The Hjort Centre has established an extensive international network of collaborators to compare different marine ecosystems, and will seek to find global solutions.

Where to fish, and what to catch?

We have two alternatives when increasing the exploitation of marine living resources: We can start to utilize organisms from lower trophic levels, or we can better manage stocks that we are currently harvesting. At lower trophic levels, we find mesopelagic fish (small deepwater species as pearlsides and spotted lanternfish) and zooplankton. The biomass of such species are very large and the nutrition value high. However, even though marine resources from lower trophic levels could provide us with feed, oil, and be a prospective human food source, it is necessary to obtain thorough knowledge of how marine ecosystems will respond to a commercial exploitation of such species.

Protect existing marine resources

The present commercial fishery includes often top-predator species, and by catching more than 100 billion tons of fish yearly we are challenging a sustainable management of these resources. The Hjort Centre will implement new technology for monitoring, evaluating, and predicting the conditions of marine ecosystems. This will aid in understanding and predicting the observed variation in the occurrence of species like cod, herring, and other commercially important species. More knowledge of the ecosystem dynamics will thus aid the communication and advising of the fisheries. This will help ensuring an efficient management of existing fish stocks, and at the same time secure marine resources for future generations.

Consequences of climate changes

It has become evident that the oceans are significantly affected by anthropogenic activities. Naturally, this includes the harvesting of marine resources, but also indirect influence through global warming, ocean acidification, and eutrophication. The Hjort Centre will explore how the climate changes affect the marine biota, and will address three essential questions: Do species adapt by genetic adaptation or by changing habitat location, how fast do the changes occur, and how will this affect how humans administrate marine resources.

New technologies provide new opportunities

The ocean comprises the Earth's largest biotope, covering 71 % of its surface area and with an average depth of 3500 m. The ocean, with its complex physics and wealth of organisms, is highly dynamic with critical spatial scales from micrometers to basin scale and time scales from seconds to centuries. The North Atlantic Ocean and Arctic Ocean are well-observed ocean

areas, but still under-sampled with respect to key ecosystem processes. Through the past hundred years technological development in the laboratory, mesocosms and field has strongly improved our ability to picture and understand central biological and oceanographic processes. This includes e.g. recent major progresses in genetic tools and in acoustics (e.g. submerged echo-sounders). Satellite remote sensing technology has also given us a new and global view of the surface oceans since the 1970s. Over the last decades numerical ocean modelling has provided novel tools to understand and interpret key processes across spatial and temporal scales and across trophic levels. However, there is still a vast need for technological improvements to properly address key questions in ecosystem processes and dynamics studies. The Hjort Centre will advance marine research by continuously exploring and adopting new technologies for monitoring, analysing, and predicting current and future state of marine ecosystems and the resources and services they provide, across multiple sectors. Capacity building will here play an integrated role.

Research approach

The Hjort Centre will be organized to encourage creative and productive discussions among researchers and students with different scientific backgrounds as the above-mentioned challenges require a true, focused interdisciplinary and cross-sector approach. Each of the six defined established research themes start off with challenging research questions followed by how the Hjort Centre will specifically address these, although recognizing that the Science Plan will be dynamics in nature as new progresses are continuously made and new challenges might emerge. These themes are: 1) 'Dynamics of ocean primary productivity'; 2) 'Dynamics of trophic pathways'¸ 3) 'Dynamics of harvestable resources'; 4) 'Dynamics of marine ecosystems under past, present and future climate'; 5) 'Observation methodology'; and, 6) 'Integrative modeling'. The last two themes will perform research and develop tools to be applied across all other themes.

Key approaches for improved marine ecosystem research capacity are:

- Use of fundamental principles within general life history theory and theoretical ecology as platforms for further hypothesis testing and validation in laboratory and field, as well as for further redefining or development of existing theoretical models
- Actively use of a range of dedicated experimental studies to parameterize key variables in relevant numerical ocean models
- Design of observations and experiments across sampling platforms and ocean regions for comparative studies
- Establishment of innovative ways to address the large dynamics seen in the productivity of harvestable stocks across various time scales and biogeographically defined marine regions, and the anticipated conflict between long-term sustainable harvest and increased landings
- Strengthen observation capabilities and strategies tailored to quantifying ecosystem state and processes with modern statistical models reflecting levels of uncertainty
- Development of global and integrated physical, biogeochemical and ecological ocean models for studies of ecosystem dynamics, and of the predictive capacity for ocean productivity to accelerating global change in the Anthropocene

- Engage and actively support talented students and emerging early career research leaders to be involved in all activities of the Hjort Centre
- Give room from innovative ideas and challenging research questions in any facets of this field of marine science

E. ISPRS (Mario Hernandez)

Clearly the Natural Assets KAN will have some common themes with other Future Earth KANs. Its main particularity or proper niche will be to focus on emphasizing the important contribution that natural assets have for sustainable development.

In Latin America, the state of the natural environment is rapidly declining: biodiversity getting diminished, forest coverage severely affected, current degradation of soil due to inefficient agriculture and/or heavy rains and flooding are having an impact in the national economies. Environmental damage feeds directly into costs for government, business (e.g. tourism), supply chains and households.

There is an urgent need to undertake an overall research that can demonstrate the high value that natural assets do have for the overall economic welfare of each country. By undertaking such an interdisciplinary research, decision-makers will then have concrete scientific evidence to take associated action on the use of natural resources protecting all the associated natural assets.

In particular in Latin America the following topics need to be researched:

- Uncontrolled tourism infrastructure development, tourists that do come because of the national natural assets, is significantly affecting the state of the natural assets and mainly affecting the tourism industry (corals being destroyed, surrounding water being contaminated, the whole landscape being modified, etc.)
- In particular in Central America and the Caribbean increased number of hurricanes significantly affects the natural resources and as a consequence the associated natural assets: excess in deforestation is causing severe soil erosion; destruction of mangroves is causing coast erosion; severe flooding affects drinkable water and health; etc.
- The severe changes in land use cover (deforestation, excessive urban development, etc.) are severely affecting biodiversity. Illegal trade of protected species increases the biodiversity loss. Such an extremely rich biodiversity, when exploited properly by the local populations, provides the means for such local populations to live and to have a proper economical income. External factors are over exploiting these resources and the local populations, losing these natural assets are suffering.

There is urgent need to undertake an overall research that can estimate the economic consequences of losing such natural assets; there is a need to identify different alternatives that can be provided to the local populations more oriented to benefit from the natural assets as compared to destroying the natural resources; there is a need to improve legislation and

national policies. If all this is done, the results will automatically contribute to selected Sustainable Development Goals.

F. The Inter-American Institute for global change research - Sandra Diaz (DiverSus), Alberto Piola (Servicio Hidrografico), Holm Tiessen (IAI), Carolina Vera (CIMA)

Latin America has several mega-diverse regions with important reservoirs of biodiversity and genetic pools of agriculturally important plants. At the same time, Latin America still has large areas of agricultural frontiers, and of degraded pasture lands that could be improved, restored and used under natural, agricultural or a mixed land cover. Climate change already has major impacts on ecosystems and agricultural production in the Andes. A combination of land cover change and global climate change is changing temperature and rainfall patterns over large areas of the South American lowlands. Changes in run-off from the continent, ocean productivity, and fisheries exploitation are impacting marine ecosystems and biodiversity off the South American coasts. Both ocean and land environments present challenges of natural resource management and sustainable development and of to balancing conservation and use under climate change.

The IAI's collaborative research networks are spread across the continent and link scientists and institutions from many disciplines in studies of global change and resource use. We here propose to **consolidate network interactions on the management of natural assets. Land cover and land use, coastal development and ocean productivity, biodiversity, agriculture and fisheries, land reclamation and development**, all our themes researched in existing networks and many institutions beyond. Increasingly, the research aims at helping **decision-making and policy development.** The needed dialogue between science and society is still incipient, and linking knowledge to decision-making and action requires innovation in science administration, institutional dialogue, and research planning. In particular, the interdisciplinary collaboration between natural and human sciences, and its transdisciplinary orientation towards the knowledge users are critical areas for development. At the same time, much knowledge is available already to be synthesised into usable products. The network has an initial interest in developing guidelines for product and production certification that take impacts on ecosystem services and sustainability into account.

Initial partners in this endeavour will be the IAI as a coordinator and link to its continental research networks, the Núcleo DiverSus as a contributor to knowledge, methodologies and research capacity on functional biodiversity and sustainability, the Argentine hydrographic service with its research on marine function and joint resource management projects with the fisheries service (INIDEP), and CIMA, the Centre for marine and atmospheric studies that will provide expertise on climate and climate services. The initial group has a strong focus on the Southern Cone but from this initial pilot program it is planned to open the network to the continent.

A key asset that the IAI will bring to the KAN are 17 ongoing research projects, representing an investment of approximately US$9 million, or dealing with various aspects of natural asset studies and management under global change. This will be expanded further with a targeted call for proposals on the role of ecosystem services in adaptation to global change in 2016. The IAI has also initiated a network of funding agencies in the Americas with the goal to fund international projects on the continent with a mechanism similar to the Belmont Forum. This remains to be ratified, but we are hoping that leadership by Argentina's CONICET, São Paulo's FAPESP, and the US NSF will make the first pilot projects possible within the next year. Two initial activities are planned. First, there will be meetings of methodology development and research synthesis involving stakeholders from resource management and governance of the existing research projects. Most of the funding required for this activity is in place.

Second, a proposal is being prepared on the role of ecosystem services in adaptation to global change, a theme framed to reinforce close collaborations on the human and biophysical dimensions of global change. Adaptation is interpreted as societies' adaptation to change. Together with the service concept of ecosystem services this will require framing of research questions in an integral human-natural interdisciplinary approach. The required team-building will be aided by IAI-provided capacity building at the early stages of the project development, an innovative program design that capitalizes on lessons learned thorough its collaborative research networks, and IAI successes in its long-standing capacity building program. IAI experience shows that interdisciplinarity is developed through team building and through providing enough cross-disciplinary understanding to facilitate the dialogue needed to jointly frame research questions and review research progress. Interdisciplinarity, team-building and networking will be aided by including IAI-provided capacity building in the first stages of project development.

G. bioDISCOVERY

a. Forest management for the Future (Paul Leadley)

Core foci of the Knowledge Action Network

Forests across the world are impacted upon by climate change – distributions of species change with changing temperature and moisture regimes, trees are weakened by changing climatic conditions, in particular extended drought, fires regimes are also changing with changing climatic conditions, and pests and pathogens are becoming more prevalent in many regions. The combination of these factors leads to changes in forest dynamics, and makes them less resilient to climate change. At the same time, forests play an important role in mitigating climate change by storing carbon, and are of considerable economic importance. A large body of literature exists on the changes forests undergo under climatic changes, and a range of models exist that predict the distribution of tree species under future conditions. Knowledge on changing species distribution and species interactions need to be applied to management decisions to maintain healthy forests that continue to provide climate mitigation as well as economic returns.

Shortlist of core ideas to develop under such foci

- Development of multi-species forest models to determine

    - climate change impacts on productivity
    - optimisation of harvesting strategies for economic returns and climate mitigation
- Development of scenarios of future forest use, informing regional and national policy

List of concrete actions to make them happen

- Workshop, bringing together the various groups working on forest models
    - understanding processes behind forest dynamics
- feedbacks with climate system, biogeochemical cycles and biophysical system
- Participatory approaches to develop scenarios, for e.g. optimal harvesting
- Model intercomparison approaches

b. Marine ecosystem indicators (Lynne Shannon & Yunne Shin)

Implement marine ecosystem indicator frameworks for assessing fishing and climate change impacts and providing scientific support to management decisions

Marine biodiversity and ecosystem services are threatened by an array of anthropogenic drivers and stressors. In many marine ecosystems, fisheries exploitation has been, and still is, the main cause of reductions in species, functional and genetic biodiversity. Protection of marine biodiversity is key to support productive and healthy oceans and the provision of marine ecosystem services. This has evoked responses from regulatory bodies and policy drivers such as the Convention on Biological Diversity (CBD) Aichi Targets, calling for effective Ecosystem-Based Fisheries Management (EBFM) to be in place by 2020 (target 6), the minimization of impacts on coral reefs and vulnerable marine ecosystems (target 10) and the implementation of an effective network of Marine Protected Areas (target 11). To progress towards effective EBFM by and beyond 2020 will require the interdisciplinary integration of information on the broader biodiversity, climate and human dimensions of marine ecosystems. The scientific community has emphasized the development of indicator-based approaches, e.g., integrated ecosystem assessments, to track and evaluate changes in marine ecosystems, especially as a result of fishing, and to assess the effectiveness of management measures aimed at sustainable resource usage.

There is now a wealth of ecosystem and biodiversity indicators proposed by the scientific community and frameworks have been developed for the selection of indicators. These indicator sets are mostly based on ecological theory and data availability, and favour sets of indicators that are widely available if not global in their coverage. Indicators have been developed to accurately reflect the effects of fisheries on marine ecosystems, but further work is needed in order to differentiate between fishing effects and other ecosystem drivers such as environmental impacts and human drivers, and to facilitate effective communication of these effects to managers, policymakers and the public. However, this is only a part of what is required for meeting the objectives of EBFM, and other sustainability targets.

Building on the work of SCOR/IOC Working Group 119 on “Quantitative Ecosystem Indicators” (2001-2004), and the IndiSeas Eur-oceans/IOC/EuroMarine WG (2007-2015), this KAN proposal will aim to **implement marine ecosystem indicator frameworks for assessing fishing and**

climate change impacts and providing scientific support to management decisions. We will address several gaps identified as being major impediments to effective implementation of EBFM: too few assessments of global change impacts on world marine ecosystems integrating the ecological and human dimensions, too few global assessments using fisheries-independent data, absence of reference points for ecosystem indicators to trigger management actions, difficulty in quantifying and communicating uncertainty in the ecosystem assessments, and lack of bridges between EBFM and current existing management procedures. In this proposal, we aim to make substantial progress by:

- developing a range of integrative assessment methods bringing the ecological, climate and human dimensions together. The network will strengthen and forge new links with other research fields (climate change, conservation biology, sociology and economics) to promote an integrative ecosystem approach to marine resources under a changing environment;
- developing decision-making frameworks based on ecosystem indicators, ecosystem models, and management strategy evaluations. This will bring stakeholders including field scientists, statisticians and modellers together;
- building a global database of marine indicators based on scientific survey data. To facilitate comparative analyses across ecosystems, a clear Memorandum of Understanding will need to be established between many institutes around the world. The aim is to make these indicators accessible for global ecosystem assessments;
- using state-of-the-art ecosystem models to test indicators performance and run biodiversity scenarios under different management options. The network will establish links with the Fish-Mip intercomparison project, the marine branch of the cross-sectoral ISI-MIP project;
- transferring scientific expertise within the KAN network across developed and developing nations. The network would involve local regional experts from different marine ecosystems, data analysts and modellers;
- transferring scientific knowledge to diverse policy drivers frameworks.

c. "Tailored IPBES scenarios": Scenarios and Models supporting Multilateral Environmental Agreements, in particular IPBES, IPCC and CBD

Rationale:

Future Earth is a key strategic partner of IPBES, and by making use of its broad scientific community, can catalyse the generation of new knowledge, and address gaps in knowledge that have been identified by the Platform. Building on its already existing expertise in scenario and model development, and by bringing in new disciplines, Working with the MEP, the TSU and Expert Group on scenarios, Future Earth can catalyse the development of scenarios and associated models tailored to IPBES assessments, in particular the Global Assessment. Using new approaches and methodology, this provides also an opportunity - by using participatory approaches and methodologies - to develop new scenarios and supporting models in a co-designed approach with decision makers and other society users including Indigenous

Peoples and Local Communities that adequately capture and reflect a range of world views, knowledge systems, and policy options.

The new work on scenarios and modelling can also make a considerable contribution to other assessment processes, such as IPCC, GBO and GEO, as new scenarios and models will be an important contribution to setting the post-Aichi biodiversity targets for 2021 – 2031, and to providing information on the trajectories needed to achieve SDGs.

Core Foci / Objectives

Gap filling activities

- Development of integrative "earth system" models
  - linking models across different spatial and temporal scales
  - integrate across climate, bio-geochemical cycles, land use and biodiversity
  - models linking ecosystem services to biodiversity and ecosystem function and ecosystem processes
  - development of integrated assessment models that incorporate modelling of drivers and impacts on biodiversity and ecosystem services
- Scenario development
  - furthering the development of participatory methods, especially at regional and global scales
  - linking scenarios across different spatial and temporal scales

Scenarios development

- Development of short-term and long-term scenarios that support the work of IPCC and IPBES, UNFCCC, CBD and other conventions where applicable
  - contributing to IPBES global assessment and further scenarios work
  - contributing to IPCC AR6 and implementation of the UNFCCC Paris climate agreement
  - contribution to the SDG process
  - long-term socio-economic scenarios
    - exploration scenarios of specific drivers relevant for biodiversity and ecosystem services
    - policy intervention scenarios focusing on indirect impacts of policies on biodiversity and ecosystem services
  - short-term scenarios comparing policy options
    - assessment of alternative futures

Core ideas / Activities

1. Development of "Tailored IPBES scenarios"

Develop a flexible framework of multiple exploratory and intervention scenarios that address drivers and policy options operating at different spatial and temporal scales, including the development of tailored participatory scenarios that are co-designed with a broad range of stakeholders, including decision-makers, different sectors to capture a range of world views, knowledge systems, and policy options

This is includes:

I. Analysis of scenarios assessed in regional assessments
II. the development of participatory scenarios on an above-local to global scale, which requires
    A. the development of new methodologies
    B. the inclusion of wide range of (scientific) disciplines, most notably social sciences and humanities
    C. inclusion of local stakeholders, including indigenous peoples and local communities
III. the development of intervention scenarios for a range of sectors
IV. scenarios of direct and indirect drivers
    A. across scales (national, regional, global)
    B. varying time frames (10 yrs, 25 yrs, 50 yrs)

2. Development of models of impacts on biodiversity and ecosystem services, including activities around model intercomparison.

d. Sustainable use of coastal and marine resources

Views on what the core foci of the Knowledge Action Network should be

An activity focused on sustainable use of natural resources provides an opportunity for multidisciplinary work within Future Earth across many core projects and disciplines, and linking to a range of stakeholders, from local communities, local, national and international NGOs, governments to multilateral environmental agreements. Work on sustainable use of natural assets provides a contribution to larger sustainability questions and a broader sustainability context, and ensures that biodiversity remains a focus in the SDGs. The activity's focus could be on small-scale marine, coastal and freshwater fisheries, and sustainable use of forests and forest products, but emphasis could also be placed on hunting and bushmeat. The work will contribute to linking ecosystem services and sustainable use, and would provide scientific support and information for the IPBES thematic assessment on sustainable use. Information generated will also inform the SDG process.

Shortlist of core ideas to develop under such foci

- Development of sustainable use framework for small-scale, subsistence fisheries, focussing on freshwater and coastal zones
- Development of sustainable use standards for forests
- Development of sustainable use standards for hunting and bushmeat
- Improvement of FAO data
- Development of Indicators for monitoring and assessment

<u>List of concrete actions to make them happen</u>

- Workshop on sustainable use systems
    - definition of sustainable use systems
    - identification of suitable indicators for monitoring and assessment

- develop framework for small-scale, subsistence fisheries:
  - freshwater version of marine work:
- improvement of FAO data
- systematic mapping of use of natural assets
- identification of case studies

e. Traits, functions, services: understanding the relationships between biodiversity, ecosystem function and services

Views on what the core foci of the Knowledge Action Network should be

Understanding relationships between biodiversity, ecosystem functioning and ecosystem services contributes to understanding how biodiversity and ecosystem function underpin human well-being.

Such a focus within the Natural Assets Knowledge Action Network provides an opportunity to investigate the impacts of environmental change and governance decisions on biodiversity, the cascading effects on ecosystem function and ecosystem services, and, ultimately, benefits for human societies. The focus also provides an opportunity to investigate alternative pathways that safeguard terrestrial, freshwater and marine natural assets, and thus contribute to human well-being.

In particular, this aspect of the KAN would focus on

1. investigating the links between biodiversity, ecosystem function and ecosystem services provision in a given region / ecosystem / environment,
2. determining how biodiversity and ecosystem function that underpin ecosystem services are impacted upon by environmental change and human activities,
3. investigating what the trajectories and projected changes in biodiversity and ecosystem function are over the next decades, and
4. what intervention / changes are necessary to maintain biodiversity and ecosystem function.

Work should also be geared towards providing scientific support and relevant information for upcoming assessments, in particular IPBES global assessment and Global Biodiversity Outlook 5 of CBD, as well as IPCC AR6, and other relevant assessments.

Shortlist of core ideas to develop under such foci

1. Linking biodiversity (through traits) to ecosystem functioning and ecosystem processes, and ultimately, to ecosystem services
   - linking work on traits to work on ecosystem function and ecosystem processes (building on already existing efforts, e.g. arising from TRY)

2. Linking models of biodiversity to models of ecosystem function to models of ecosystem services
   - biodiversity model intercomparison work (contributing to ISI-MIP)
   - development of models linking biodiversity, ecosystem function/processes and

ecosystem services
- development of models addressing ecosystem processes at a range of spatial and temporal scales, including species interactions and community dynamics
- models to anticipate ecological break points / tipping points and regime shifts
    - coupling of and feedbacks between social and ecological components of systems

List of concrete actions to make them happen

- Workshops bringing together the various communities
    - id key questions & key regions to be looked at
    - id data already collated in data bases that could be brought together to address the key questions identified
- Linking and expanding various databasing efforts capturing trait data and ecosystem function data
- Furthering efforts to develop / improve models of biodiversity and ecosystem function
- Development of research proposals to address gaps

H. PECS

Core foci, core ideas and concrete actions

PECS (together with other core-projects, and in particular ecoSERVICES) believes that a Natural Assets KAN can become a key attractor for work on innovative, transdisciplinary and solutions-oriented research into the broad relationships between Human Well-Being (HWB) and natural capital and the corresponding governance of that can support transition towards social-ecological sustainability from local to global scale. Together with ecoSERVICES, PECS supports that this KAN should create inter- and transdisciplinary networks of researchers, managers, policy-makers, decision-makers and other practitioners of relevance to the KAN's topic in view to support collaborative learning among participants and co-create or mobilize knowledge that enables the transitioning towards sustainability. As such, the production of new knowledge should not be the sole focus of this KAN but it should also look at means to mobilize and communicate knowledge that has fallen in the research-implementation gap. Other participants in this KAN should be people from the communication sector in the broad sense (from Arts to Journalism) so they can help broadcast the knowledge produced in a diversity formats for awareness raising among a diversity of audiences not directly involved in the KAN. Also, we believe that knowledge for this KAN and the associated core projects such as ecoSERVICES and PECS will be co-generated in close collaboration with the key stakeholders where the place-based research is occurring. Below we highlight a short, but not exclusive, list of core foci of this KAN:

1. Social-ecological dynamics of ecosystem services.

Several recent papers have highlighted the importance of understanding the social-ecological dynamics of ecosystem services (Carpenter et al. 2012; Reyers et al. 2013; Bennett et al. 2015).

This approach highlights the importance of 1) measuring and understanding the relative importance of the biophysical, geographical, social and ecological factors that co-produce ecosystem services, 2) the bundles of services produced and their
benefit flows, 3 3) the changes in HWB and their influence on SES management, and 4) the changes in SES management and governance and their effect on (1). The Natural Assets KAN can facilitate a series of workshop and synthesis activities (bringing together a network of case-studies and projects linked to PECS, ecoSERVICES and other core projects) to: i) answer what are the key ecological, social, and geographic drivers to explain patterns of ecosystem services and ecosystem service bundles across multiple case-studies, ii) review existing, and develop new, methods/models to identify/measure bundles of ecosystem services and their drivers, iii) identify general principles about the role played by key drivers on ecosystem services and benefits across contexts, iv) identify governance configurations that can contribute to social-ecological sustainability across contexts.

2. Cross-scale dynamics of social-ecological ecosystem services

Stewardship of ecosystem services at any one location is shaped by connections to other places across temporal and spatial scales. The Natural Assets KAN can mobilize research to begin address the complex, multi-scale dynamics of social–ecological systems that determine ecosystem service dynamics. For example, a series of workshops and synthesis activities can review existing conceptual frameworks that study cross-scale interactions in social-ecological systems, with the purpose to develop and define simpler, robust and manageable frameworks for analyzing ecosystem services at multiple scales.

3. Scenarios and biodiversity

Key policy processes, such as IPBES, have identified scenarios as a key tool to help decision makers and resource users identify potential impacts of different policy options on ecosystem services and natural capital (Kok et al. 2016). The Natural Assets KAN can help develop and invest in developing new scenarios at local scales, as well as in downscaling existing global scenarios. This activity would build on a merging of many local scenario activities, stakeholder networks and local research capacities that are already in place (utilizing the broad networks of PECS, ecoSERVICES and other projects) and existing analyses of large-scale global drivers. This KAN could also facilitate a Future Earth-IPBES science-policy dialogue about scenarios to enable engagement and reflection with key stakeholders through current IPBES assessments. The Natural Assets KAN can also help IPBES assess and identify effective participatory tools and processes that can bridge diverse knowledge systems in scenario processes. Such an assessment could build on existing, but also the launching of new, reviews of local participatory scenario methods and ongoing working groups in different Future Earth core projects and FTIs dealing with scenarios

Other activities

Together with ecoSERVICES we also suggest the following:

- Organize a large “market place of ideas” type of conference, involving projects and initiatives such as the Future Earth core projects ecoSERVICES, PECS, bioDISCOVERY, but also the Ecosystem Service Partnership (ESP), the Natural Capital Project, and others
- Co-design a research agenda aimed at deepening our understanding of the governance of ecosystem services by bringing together the variety of voices present in the global ecosystem services knowledge community in order to shape governance research in this area through a survey in multiple languages. The global survey will also help create a large community of practice on governance thinking in the Natural Assets KAN [survey currently under development by the ecoSERVICES SSC]
- Highlight the risk of using the “ensuring ecosystem services agenda” through the interplay of global and national policies, to dispossess resource users especially indigenous communities, and the potential checks and balances to address these challenges.
- Capacity building for place-based transdisciplinary sustainability research through intensive field courses and writing/communication-skills workshops.

I. Workshop from 2 FTIs, IPBES support and biodiversity monitoring (March 2016, Monte Verità)

a. Working group 1: Towards a 1,5°C World (Berta Martin-Lopez, Cornelia Krug)

Project Focus:
Conducting a risk assessment of the implications of global climate change, contrasting different levels of climate change (4°C vs 2°C vs 1,5°C), on biodiversity, ecosystem function, ecosystem services and human well being across realms (terrestrial and marine)

Key questions:
- Implications on biodiversity pattern and trends
- Identification of tipping points / regime shifts / alternate stable states
- Connecting local, regional and global scales, and integrating ILK
- Pathways for transformations, investigating benefits, trade-offs and synergies

b. Working Group 2: Social costs of biodiversity change (Eva Spehn, Adam Wilson)

Hypotheses
1. economic growth is good for biodiversity
2. biodiversity loss leads to decreased human well being
3. globalization spatially decouples the costs<7benefits of anthropogenic environmental change

Use local biodiversity intactness index and techniques of environmental economics to assess Human Well Being

Challenges: biodiversity data availability. Use space for time substitution of biodiversity-wellbeing relationships. Start with assessment of methods to assess social dimensions of changes in environmental services.

Some more ideas for projects:

- **Islands/Coastal as model system** for a global case study (Patrick Weigelt)
  sea level rise and social implications- 1 billion of people living on islands, areas shrinks, people have to move. Predictions from better DEM, expand to coastal areas
- **Genomic observatories** (Nikolai Friberg)
  Linking genetic biodiversity (using new genetic methods) to resilience of ecosystems and ecosystem services (freshwater)
- **Better models of how pressures on ecosystems change** (Andy Purvis)
  Current land use change models are rubbish, can't use them to predict the current state from the past
- **Mountain idea** Adam Wilson
  NASA comes up with a 30 m DEM next year --> reevaluation of mountain spatial- high resolution of mountain environments.

c. Working Group 3 (Brad Cardinale, Derek Tittensor)

Questions from the SRA 2014 to build a Natural Assets KAN on (10 year time frames)

1. Question A1.4 - What are the critical levels of biodiversity that impact ecosystem goods and service?
2. Question B2.1 - How can governance mechanisms for managing commons be strengthened?
3. Question C1.5 - How can new forms of valuing ecosystem services influence economic policy?

Specific, tractable goals for 'mini-KANs' (3-5 year time frames)

1. mini-KAN 1: Generate ecological production functions that mechanistically predict synergies/trade-offs among a select subset of well-developed ecosystem services (e.g., energy, food, water).
   a. GEC programs: ecoSERVICES, ecoHealth, PECS
   b. FTI's: IPBES (Leadley)
   c. Stakeholder: IPBES

2. mini-KAN 2: Produce indicators that tell us whether or not ecosystem services are being 'optimized' or 'under-utilized'.
   a. GEC programs: ecoSERVICES, ecoHealth, PECS
   b. FTI's: IPBES (Leadley)
   c. Stakeholder: IPBES

3. mini-KAN 3: Produce recommendations for a global monitoring program to track biodiversity and ecosystem services.
    a. GEC programs: ecoSERVICES
    b. FTI's: GBM (Jetz)
    c. Stakeholder: NASA,

4. mini-KAN 4: Translate ecosystem services into both economic, and non-economic values that affect multiple aspects of human well-being.
    a. GEC programs:
    b. FTI's:
    c. Stakeholder: TEEB

Additional undeveloped phrases and ideas
5. [LAND-SHARING / LAND-SPARING TRADE-OFF]
6. [SCALING AND OPERATIONALIZING ECOSYSTEM SERVICES FROM LOCAL TO NATIONAL TO GLOBAL]
7. [ACTION MANAGEMENT PLANS FOR DECISION-MAKERS]

d. Working group 4 (Einar Svendsen, Katrin Boehning-Gaese, Klement Tockner)

Joint evolution of cultural and biological diversity over the past up to 50 .000 years,
Natural system creates high biological and cultural diversity. Hypothesis: Systems with high diversity are generally resilient? Research question: What drives the coupling and decoupling between natural and cultural systems in space and time scales and in different terrestrial and marine systems (e.g. oases and mountains)

e. Working group 5 (Paul Leadley, Anita Narwani)

1) Natural Assets KAN / or crosscutting project:
Multi-scale scenarios and modeling of socio-ecological systems

The objective is to improve the pertinence of scenarios and modeling for decision-making by improving their coupling with decision support tools and dialogs with stakeholders.

Scenarios and modeling research needs to be better coordinated across Future Earth projects in order to make it more pertinent for fundamental research and for applications. The Future Earth cluster on "Linking Earth system and socio-economic models" has already initiated interdisciplinary, multi-scale efforts for scenarios and models of land systems, but there is a need to expand this to freshwater and marine systems. In addition, stronger ties are required with stakeholders to improve the use of scenarios and models in decision-making.

2) Natural Assets KAN: Early warning of regime shifts

Early detection of regime shifts in socio-ecological systems could help institutions at many

levels prioritize interventions to avoid undesirable impacts on biodiversity, ecosystem services and human well-being (see www.regimeshifts.org for examples).

This KAN would bring together researchers, practitioners and decision makers to develop observation systems and models for early detection of regime shifts such as rapid declines in species populations or degradation of ecosystem services in terrestrial, freshwater and marine systems. Observations would require combining and rapidly analyzing ground-based observations, including from citizen science, and remotely sensed data. Data analysis techniques such as optimisation theory would be mobilized to analyse large and noisy data sets. Early detection systems would also require the refinement of models that are being developed to detect imminent regime shifts and evaluate risk with a need to focus more on short-term projections.

f. Working group 6 (Anne-Hélène Prieur-Richard, Marten Winter)

How is biodiversity configuration in a landscape linked to ESF & ESS in marine, terr and fw ecosystems?
Which configuration of biodiversity in a landscape maximizes a wide range of ESF & ESS? (ESF & ESS measured at a landscape level)

1. Health
2. Animal movements
3. Monospecies patches vs multispecies patches (alpha, beta etc)
4. Soil Erosion

What is the role of animal movement in an ecosystem for disease spread, food security and maintenance of BD?
Which configuration of BD levels (composition, functions etc) is important for mental & immune health?
What is the ESS provisioning of Monospecies systems vs multispecies systems?
Which configuration of BD levels (composition, functions etc) maximises prevention of soil erosion (in mountain systems)