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Mapping a Course for Biofuels: Science-informed Policy Needed

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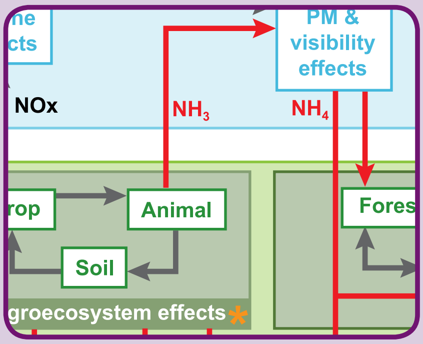

National Committee Science

Guest Editorial

Earth System Governance: Research in Aid of Global Environmental Sustainability

This issue features an emerging initiative of the International Human Dimensions Programme on Global Environmental Change (IHDP) to make Earth System Governance (ESG) an organising focus and a cross-cutting theme in global environmental change research. This editorial highlights the importance of this initiative for IGBP scientists and leaders.

The ESSP's Global Environmental Change and Food Security Project, the Global Water System Project and the Global Carbon Project have already expressed interest to participate in the new project. Many in the IGBP network may find the initiative mysterious or unrelated to their programmes and concerns. Even just understanding the *name* of this initiative requires some social science knowledge! The term "governance" is increasingly preferred by social scientists over the term "management," because the latter tends to connote top-down, governmental control. "Governance" integrates understanding of the fact that environmental sustainability is decided not only by governmental policy makers but by a wide, heterogeneous array of domestic and transnational actors and processes operating both "below" and "above" national governments, including non-governmental environmental organisations, intergovernmental institutions, and industry and citizen groups. The United Nations Intergovernmental Panel on Climate Change illustrates how an intergovernmental, scientist-led institution can influence Earth System science and governance.

ESG will study governance processes and institutions in a broad sense; science and the science-policy interface are important (albeit non-exclusive) parts of this theme. The relevance of the ESG initiative to all IGBP programmes becomes clear once one understands that a great heterogeneity of actors and processes guides not only the uptake of science but also the kind of science that gets produced and the processes by which it is disseminated. This in turn shapes its uptake, since actors tend to be more disposed to accept knowledge from some sources than others. Science and other types of knowledge are only useful if they are perceived as such on the part of users, be they other scientists, decision makers or laypersons; any given piece of knowledge may *objectively speaking* be useful, but its use depends on users' awareness that it exists, their trust in its validity, their judgment that it is relevant to their concerns, and their ability to act upon it. ESG aims to identify the actors, mind-sets, institutions, conditions and complex multi-directional processes that variously limit or facilitate the societal relevance, uptake, and benefits of scientific knowledge. ESG will also need to identify and address important regional differences in the science-policy interface, e.g. differences between the so-called global North and South.

Several common preconceptions among scientists may limit their understanding of the science-policy interface and the conceptual framework of ESG. Along with ineffective organisations, processes and government practices, such preconceptions are part of what ESG needs to identify and help change. Two are worth mentioning:

Preconception 1: Scientists should not concern themselves with policy.

Scientists, especially in developed countries, tend to think that policy concerns should not affect the kind of science they do. Yet analysts mindful of planetary, environmental sustainability challenges suggest that sustainability goals and users' needs should shape science agendas to a greater extent. Contrary to common assumptions on the part of natural scientists, this does not necessarily politicize science, nor mean that they should abandon basic science, engage in policy-driven research or dictate policy agendas. Rather, it means that science agendas need to be shaped such that they best meet societal needs. These needs can and should include basic science to an appropriate extent considering time and resource limitations. Associated deliberations must also balance short- and long-term needs and private gain versus the common good.

Preconception 2: The solution to problems in the science-policy interface lies in improved communication of scientific results to the public.

This preconception is not wrong but overly simplistic. It assumes that scientists speak with one voice and that they are working the right way on the right problems and merely need to communicate more and better to make decision makers and the public understand the importance and policy implications of their work. Yet, as discussed in preconception 1, the sustainability challenges and the reality of limited time and resources require critical analysis of science agendas and careful identification of present scientific knowledge gaps which, if filled, might significantly help move decision making forward and generally improve broad-scale societal benefits from science.

The IGBP is well equipped to facilitate the dialogue for steering science agendas – including those involving basic science – such that they are more likely to help facilitate a transition to global environmental sustainability. The IHDP Earth System Governance initiative can be valuable in this process.

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Mapping a Course for Biofuels: Science-informed Policy Needed

W. A. N. do Amaral and C. Pezzo

Biofuels offer an attractive alternative to fossil fuels, but they are no panacea. Proper deployment requires a consistent scientific framework to inform policies that maximise the positive potential of biofuels and minimise their negative impacts.

Numerous countries are moving towards the partial and gradual replacement of fossil fuels with biofuels, mainly ethanol. The increased move towards biofuels is spurred by global political, economical and environmental events, especially rising oil prices. Between 1974 to 1979 oil prices increased tenfold and threatened the economic stability of oil-dependent countries and of the world at large. This stimulated research into the use of biodiesel (produced from oilseeds and animal fat) and of ethanol (produced out of starch and sugars) as a potential alternative to gasoline. Those promoting voluntary and/or mandatory use of biofuels in diesel and gasoline engines in the transportation sector highlight the fact that it: a) contributes to the reduction of greenhouse gas (GHG) emissions [1] in an effort to mitigate climate change; b) diversifies the energy matrix, which is beneficial considering uncertainties of oil supply and increased prices; c) generates income for farmers and full deployment of agribusiness chains; and d) maintains and/or expands agricultural and industrial subsidies. Thus far, however, the only country to have succeeded in large-scale production and use of biofuels is Brazil.

This article addresses some issues related to biofuels policies, arguing the need for a global research agenda to properly quantify biofuel potentials and comparatively assess current and future biomass conversion technologies that might enhance the environmental, economic and social performance of biofuels.

Newly cut sugar cane.

The Use of Ethanol as a Fuel

Preexisting policies in Brazil were conducive to the production of biofuels. Sugar cane and sugar production and export have been important national economic activities for centuries. Sugar prices are volatile, however, and production of ethanol from sugar surplus became an attractive alternative in times of low sugar prices. In 1931 the Brazilian government wrote the world's first biofuels policy, a decree [2] to develop ethanol as a fuel and blend it with gasoline.

Today the sugar and ethanol production chain in Brazil is completely liberalized and, after a long period of research and investment in the science and technology of sugar cane and ethanol production, production costs are competitive with gasoline. The government established a mandatory blending of anhydrous ethanol into gasoline that varies from 20% to 25%. In 2003 flexi-fueled [3] cars

Country	2004	2005	2006
Brazil	3,989	4,227	4,491
U.S.	3,535	4,264	4,855
China	964	1,004	1,017
India	462	449	502
France	219	240	251
Russia	198	198	171
South Africa	110	103	102
U.K.	106	92	74
Saudi Arabia	79	32	52
Others	1,108	1,541	1,356
Total	**10,770**	**12,150**	**12,871**

Table 1. Annual World Ethanol Production by Country (Millions of Gallons)

Source: F.O. Litch, 2007.

Table 2. Projections for EU Production of Ethanol 2012

	2006				2012			
	Ethanol production		Feedstock production		Ethanol production		Feedstock production	
	(mn liters)	share	(mn tons)		(mn liters)	share	(mn tons)	
Total	**1,560**		**Total**	**For ethanol**	**10,085**		**Total**	**For ethanol**
Wheat	504	32.3%	109.3	1.4	4,034	40%	135.9	11.2
Barley	440	28.2%	53.6	1.1	440	4%	46.1	1.1
Corn	200	12.8%	44.6	0.5	1,291	13%	51.9	3.2
Rye	200	12.8%	7.8	0.5	200	2%	9.1	0.5
Beet	88	5.6%	141.7	0.8	3,864	38%	120.7	35.2
Wine	128	8.2%	–	–	256	3%	–	–

Sources: eBIO, European Commission, calculations by the authors.

started to be commercialized. By 2006, they represented 83.1% of new cars sold [4] creating a very strong internal market for ethanol.

The United States' growing interest in ethanol recently has enhanced the visibility of biofuel issues globally. Initial driving factors were concerns about public health and air quality, which stimulated a search for cleaner alternatives and policies requiring their use, especially in big cities. The US also launched a policy for the rapid substitution of MTBE (a gasoline additive that is toxic and highly pollutant). MTBE was then replaced by ETBE, derived from ethanol.

The promotion of ethanol from corn made the US the world's largest producer of ethanol in 2006 (Table 1), overtaking Brazil. The US has the capacity to produce almost 5 billion gallons annually, and its biodiesel production is one of the fastest growing in the world. However, ethanol production is also heavily subsidized and importations are taxed to protect domestic producers.

Other countries are also investing in ethanol production from sources such as cassava, in the case of Southeast Asia (for sources in the case of EU countries, see Table 2).

Biodiesel Production and its Rationale

The production of commercial biodiesel grew increasingly important in the 1990s, mainly in Europe. Europe currently represents approximately 90% of the global production. Germany, France and Italy are the biggest biodiesel producers in the world. See Figure 1 below.

European farmers were the

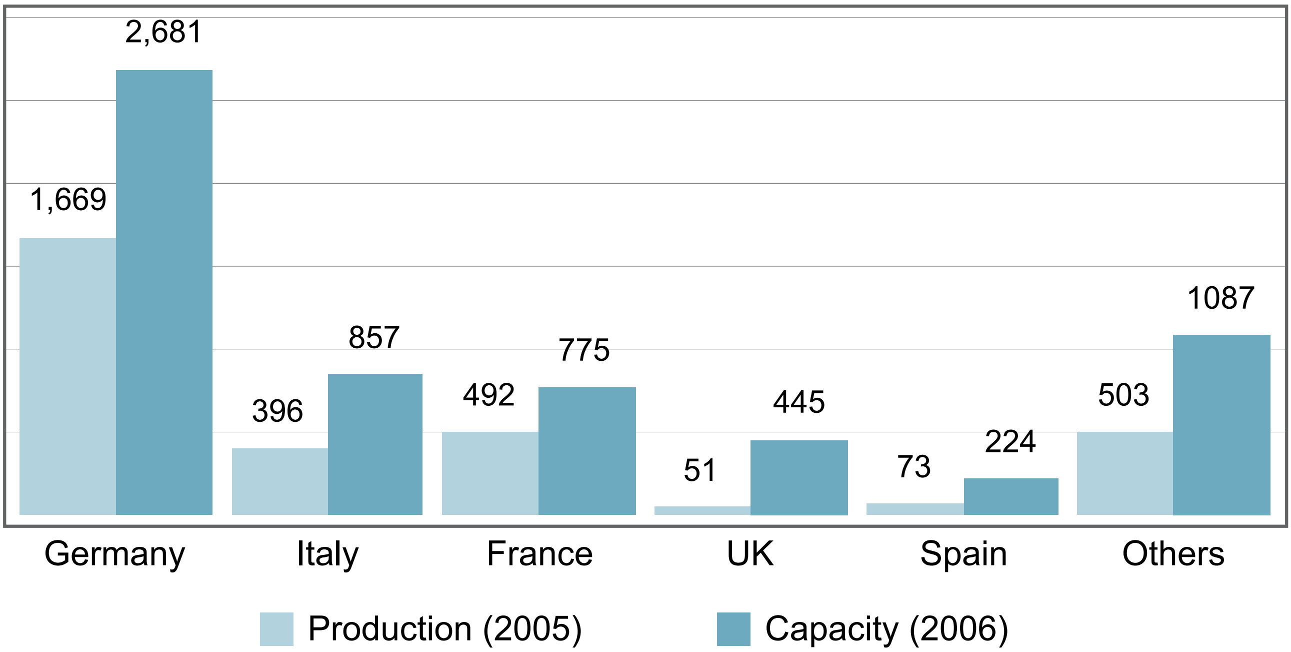

Figure 1. Main producers of biodiesel in the EU – Source: IEA, 2007.

first to support policy incentives towards biodiesel production. Their main concern was to address the persistent problem of vegetable oil surpluses. Much less competitive than American and South American farmers in this area, European farmers were worried about international trade agreements that partially opened European markets for foreign agribusiness commodities, mainly soybean oilseed, oil and oil meal produced in the US.

The Environmental Debate and Biofuels

The 1992 Earth Summit [5] in Brazil resulted in two important Conventions: the Convention on Biological Diversity (the CBD) and the United Nations Framework Convention on Climate Change (UNFCCC). One of the most concrete products of the UNFCCC processes, the Kyoto Protocol, [6] defined responsibilities for the most polluting countries, including quotas for greenhouse gas emission reductions. The Protocol came into force in 2005. Other significant results similarly pressuring policy makers to adopt environmental-oriented policies were the conclusions of the Third Assessment Report [7] of the United Nations Intergovernmental Panel on Climate Change (IPCC) that anthropogenic activities influence current and future climate changes and the Fourth Assessment Report that the evidence for anthropogenic climate change was unequivocal. Current policies to gradually increase renewable energy use in transportation sectors are part of a broader agenda of reducing dependence on fossil fuels and reducing greenhouse gases to mitigate climate change and its impacts through carbon sequestration.

A wide range of technologies are being introduced to increase use of renewable sources of electricity, including wind power, photovoltaic panels, small hydropower plants, biogas and biomass conversion plants. The only products currently available to significantly replace liquid fossil fuels in transportation on a global scale are biodiesel and ethanol fuels, however, despite advances of electric cars and hydrogen powered ones. As a result, several policies have been proposed recently to support biofuels research and production. In May 2003, the European Commission launched its Biofuels Directive 2003/30/EC [8], establishing a legal basis for blending biofuels and fossil fuels. EU member countries were urged to replace 2% of fossil fuels with biofuels by 2005 and 5.75% by 2010. From 2003 to 2005 EU members enhanced biofuels' market share from 0.6% to 1.4% [9]. However, they have not yet achieved the first target. The EU Directive 2003/96/EC [10] has also established tax incentives to encourage renewable energy use. [11]

The Need for a Scientific Agenda and Framework to Fully Deploy Biofuels' Potentials

The most relevant biofuel policies were designed during this decade, significantly stimulating biofuel production worldwide, and raising worries about the sustainability of biofuel production and its environmental, economic and social impacts.

One important concern is the environmental performance of biofuels. Considering that one of the main goals is to reduce greenhouse gas emissions, proper understanding of the relative emissions from biofuels and fossil fuels is needed. Each type of biofuel has to be studied independently, as their greenhouse gas emissions and energy balance differ (See Figure 2).

Other causes for concern are land use changes and associated processes affected by the expansion of bioenergy crops, particularly non-planned expansion in developing countries. The competition between food production and land and water use, as well as between other production factors, is also subject to concern.

Several initiatives and projects are being established to define sustainability criteria to assess the benefits and impacts of biofuels. Some of these work through market instruments, such as the implementation of certification processes and schemes. In addition, several projects are addressing new technologies for biomass conversion towards the second generation of biofuels and the synthetic renewable ones.

While the above concerns are well-justified, some criticism of biofuels and their impacts are motivated by protectionism and interest in agricultural subsidies and agribusiness production chains in several developing countries. Proposed certification schemes may become non-tariff barriers rather than environmentally and socially sound schemes. Scientific and technological assessments about the performance of the different kinds of biofuels are needed to reduce the play of such interests and to establish the strengths and potential of biofuels along with their dangers and limitations.

The OECD's [12] latest report on biofuels [13] illustrates how fears can be perpetuated without proper scientific basis. Suggestively titled "Biofuels: is the cure worse than the disease?", the report stated:

"Even without taking into account carbon emissions through land-use change, among current technologies only sugarcane-to-ethanol in Brazil, ethanol produced as a by-product of cellulose production (as in Sweden and Switzerland), and manufacture of biodiesel from animal fats and used cooking oil, can substan-

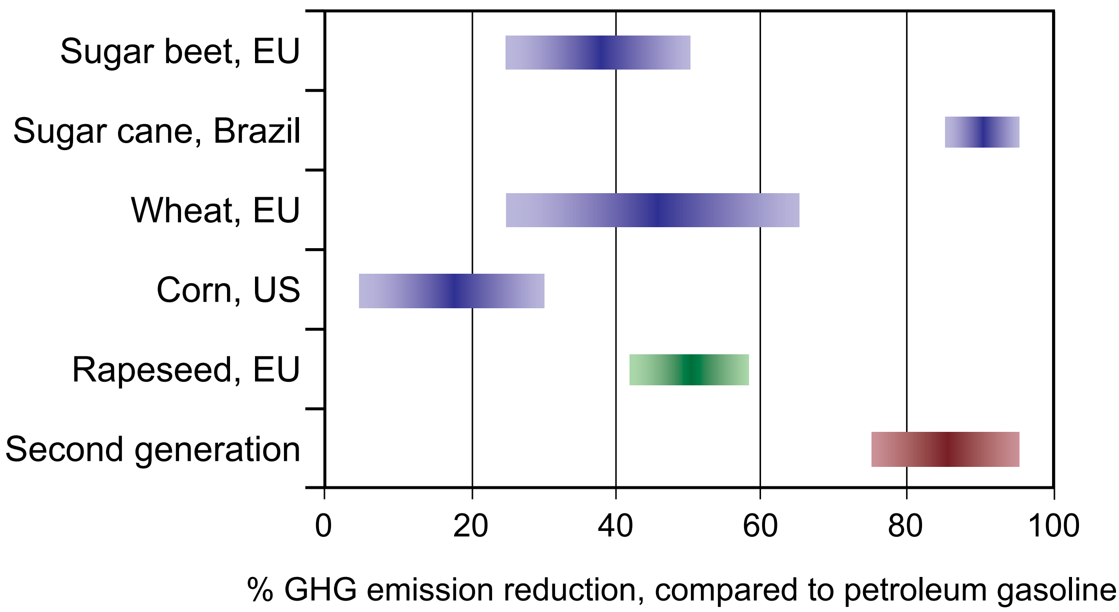

Figure 2. Greenhouse gas emission reductions gained by switching to the various biofuels, with gasoline as the baseline. Source: IEA/OECD 2006

tially reduce [greenhouse gases] compared with gasoline and mineral diesel. The other conventional biofuel technologies typically deliver [greenhouse gas] reductions of less than 40% compared with their fossil-fuel alternatives."

This report also recognized that while trade barriers would persist to the international market, it will be difficult for the world to take advantage of the environmental qualities of the use of some biofuels, mainly the ethanol form sugar cane and so forth, as international markets are not yet fully created for biofuels.

A huge challenge facing policy makers, businesses, scientists and societies as a whole is how to responsibly establish sustainable production systems and biofuel supplies in sufficient volume that meet current and future demands.

Biofuels are not a panacea. They do not solve all problems related to the over-consumption of fossil fuels, such as the emissions of greenhouse gases and climate change. But if properly deployed, biofuels can be environmentally beneficial and contribute to the diversification of the energy matrix globally, thus reducing the vulnerability that comes with dependence on a single energy source. A concerted and coherent scientific agenda involving scientists from different countries and disciplines is most welcome and needed to meet the challenge of designing technologies, systems and policies that maximize the positive potential of biofuels and reduce their negative impacts.

Without expansion, continuity, commitment and proper concentration of efforts, the multiple, isolated initiatives being carried out in the world will not help us sufficiently understand the critical questions of sustainable production of biofuels.

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Biofuel Notes

1. Greenhouse gases (GHG) occur naturally in the atmosphere and maintain the heat in the earth's surface. Anthropogenic activities, mainly the burning of fossil fuels, have increased greenhouse gas concentration in the atmosphere, which has resulted in progressive global warming.
2. The Decree 20.356 of 1 September had the aim to develop the use of ethanol as a fuel. Available at http://www6.senado.gov.br/sicon/MudaVisualizacaoDocumentos.action.
3. Flex-fuel vehicles are fueled with gasoline, hydrated ethanol or a mixture of both in any proportion.
4. National Association for the Automobile Industry (ANFAVEA/Brazil). Brazil- automobiles- production, internal retail and export. In Annual Report for the Brazilian Automobile Industry, Ed. 2007.
5. The documents from the Earth Summit (also known as the United Nations Conference on Environment and Development – UNCED) held in Rio de Janeiro, Brazil in 1992 are available at http://www.un.org/esa/sustdev/documents/docs_unced.htm
6. To learn more about the Kyoto Protocol and its rules, visit the United Nations Framework Convention on Climate Change (UNFCCC) website at http://unfccc.int/kyoto_protocol/items/2830.php
7. A summary for policy makers is available at the IPCC website http://www.ipcc.ch/pub/un/syreng/spm.pdf
8. Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003. On the promotion of the use of biofuels or other renewable fuels for transport. Official Journal of the European Union. Found at http://ec.europa.eu/energy/res/legislation/doc/biofuels/en_final.pdf
9. Communication from the Commission of the EC, An EU Strategy for Biofuels, 8 February 2006, found at http://ec.europa.eu/agriculture/biomass/biofuel/com2006_34_en.pdf
10. Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity, Official Journal L 283 of 31.10.2003, found at http://eur-lex.europa.eu/LexUriServ/site/en/oj/2003/l_283/l_28320031031en00510070.pdf. To avoid undue distortion of competition and over-compensation, these tax concessions are considered state aids and may not be implemented without prior authorization by the European Commission.
11. United Nations Conference on Trade and Development, The Emerging Biofuels Market: Regulatory, Trade and Development Implications, 2006, found at http://www.unctad.org/en/docs/ditcted20064_en.pdf.
12. The Organisation for Economic Co-operation and Development (OECD) groups 30 member countries that represent the most developed economies of the world. More information can be found at www.oecd.org.
13. OECD. Biofuels: is the cure worse than the disease. Paris: September, 2007. Available in http://www.oecd.org/dataoecd/40/25/39266869.pdf.

IGBP and the Nitrogen Cycle: An Earth Systems Approach

K. Hibbard and K. Noone

Humans have dramatically altered Earth's nitrogen balance, impacting the health and welfare of people and ecosystems worldwide. The key to a better understanding of the nitrogen cycle lies in the type of international collaboration and Earth System science approach fostered by IGBP's research network.

Nitrogen is one of many elements that are key to understanding fundamental nutrient cycling and transformations in the biosphere and, after the carbon cycle, is arguably the most important nutrient to living organisms (Sprent, 1987). The exponential increase in available nitrogen compared to increases in CO_2 creates orders of magnitude imbalances in nitrogen compared to other constituents (Rabalais, 2002). For instance, there is little doubt that reactive nitrogen (Nr) fixed by human activities has increased substantially over the last one and a half centuries and that anthropogenic nitrogen is accumulating in environmental reservoirs and altering many ecological processes (Vitousek et al., 2002, Galloway and Cowling 2002, Galloway et al., 2004).

Increased nutrient levels along with altered nutrient ratios contribute to multiple and complex changes in aquatic and terrestrial ecosystems. It is difficult, if not impossible, to separate the nitrogen effects from other nutrient inputs or other stressors, particularly at the community or ecosystem level. However, this does not diffuse the fact that the nitrogen cycle, its transformations and application is in itself a primary focus of many research activities, programmes and the central theme of many scientific careers. Nitrogen is a multi-scale problem from process understanding to management (Figure 1). The vast majority of nitrogen-focused studies in ecosystem ecology have addressed understanding processes and mechanisms that affect ecosystem function and more recently, biodiversity and sustainability.

This article reviews nitrogen-based activities in the International Geosphere-Biosphere Programme (IGBP) with an emphasis on cross-cutting themes and gaps. Many activities do not focus solely on nitrogen, but rather on nitrogen as one of many elements to consider. The goal of this article is to provide a mechanism that communicates both a window for collaboration and communication as well as the international commitment towards understanding the nitrogen cycle. We describe a taxonomic structure and project-level activities that flow from process understanding of the nitrogen cycle through to applied Earth System science. We summarize with science gaps and suggestions for future research in understanding and quantifying the nitrogen cycle in an Earth Systems approach.

Process Understanding of the Nitrogen Cycle

Freshwater and Coastal Ecosystems

Aquatic ecosystems respond variably to nutrient enrichment and altered nutrient ratios, along a continuum from fresh water through estuarine, coastal and marine systems (Rabalais, 2002). Rivers play a crucial role in the delivery of nutrients to the ocean. These rivers often terminate in the estuaries or in the near-shore coastal ocean, where the effects of nitrogen enrichment are most pervasive.

The Land-Ocean Interactions in the Coastal Zone (LOICZ) core project addresses in two of their five themes the flux of nutrients (including nitrogen) and other constituents from the watershed, the biogeochemical cycling of these constituents in estuarine, coastal and shelf waters, and the impacts and interactions with human welfare. Theme 3 (Human influences on river basin–coastal zone interactions) activities address nutrient flux (including nitrogen) of regional riverine flux trajectories, considering natural and human drivers, and the development of global river data archives for use in models across a full range of river-coastal interfaces, and global modeling of river export to the open ocean. The LOICZ theme 4 (Biogeochemical cycles of coastal and shelf waters) investigates the coastal zone and continental shelf as a continuum, concentrating on the interactions, feedbacks, and changes in the climate system.

Improvements and applications of these approaches will be useful in identifying where nitrogen loads have increased, what factors are correlated with changes in the catchments, and what impacts these changes may have on biogeochemical cycles in coastal marine systems.

Terrestrial and Atmospheric Ecosystems

Recent evidence has emerged, mostly from North America, suggesting that base-poor upland/mountain aquatic ecosystems are demonstrating a response to atmospheric nitrogen deposition even at very low inputs (e.g. Baron et al., 2000; Wolfe et al., 2001; Fenn et al., 2003; Sickman et al., 2003). Whether this is independent from, or an interaction with climate change has not yet been ascertained. Furthermore, the interactions between acidification and eutrophication or oligotrophication are complex; for example, the aluminum released by acidification may inactivate phosphorous (P) through complexation (Kopáček et al., 2001), leading to P limitations. Other studies in the United Kingdom uplands have used phytoplankton bioassays to show that around three quarters of 30 study lakes are either N limited or co-limited by N and P (e.g., Maberly et al., 2002).

Nitrous and nitric oxide (NO_X; $NO+NO_2$) emissions from a large range of ecosystems are an important component of local, regional, and global atmospheric chemistry. Together with reactive hydrocarbons, NO_X compounds take part in ozone formation in the troposphere, and their sources have to be precisely quantified to improve local and regional studies of atmospheric processes, in particular those linked with biosphere-atmosphere exchanges. Recent studies (e.g., the International Global Atmospheric Chemistry (IGAC) 2000 report) have shown the importance of these emissions, but have also underlined the gap in obtaining experimental data from and modelling processes in differentiated zones.

The African Monsoon Multidisciplinary Analyses (AMMA) is an international project to improve knowledge and understanding of the West African Monsoon and its variability. The AMMA project is co-sponsored within IGBP by both IGAC and the Integrated Land Ecosystem-Atmosphere Process Study (iLEAPS) and by the World Climate Research Programme (WCRP) Global Energy and Water Cycle Experiment (GEWEX) and Climate Variability and Predictability (CLIVAR) projects.

Nitrogen activities within AMMA include the documentation of spatial and temporal variability of nitric oxide (NO) emissions in relation to physical-chemical soil parameters, and microbial processes (soil respiration, link with nitrogen cycle). Soil NO emission parameters are estimated by linking measured NO emissions and the non-linear relationships to soil properties with a neural network technique. The NO emission dataset will be used to develop soil NO emission inventories and implemented into chemistry transport models. To date, modeled fluxes compare well to measured fluxes, providing confidence in the simulated emissions.

The IGAC/DEBITS/Africa (IDAF) programme started in 1995 with the objective to study dry and wet deposition of important trace species and more generally the biogeochemical cycles of key nutrients. Specifically, the IDAF component of DEBITS and AMMA is: (a) to study and measure surface gaseous (NH_3, HNO_3, NO_2) and bulk aerosol (particulate ammonium and nitrate) concentrations; (b) better understand nitrogen wet deposition; and (c) to estimate an atmospheric nitrogen deposition budget for Africa. IDAF and AMMA share similar objectives with respect to nitrogen. IDAF is also part of the international IGAC/DEBITS II deposition program in tropical regions. DEBITS II and AMMA Atmospheric Chemistry (AC) are the two new tasks of the second phase of the IGAC programme.The Land Ecosystem-Atmosphere Reactive Nitrogen (LEARN) activity, endorsed by iLEAPS, is interested in quantifying and understanding the processes associated with nitrogenous atmosphere-biosphere interactions (emissions, deposition and foliar uptake), atmospheric chemistry and atmosphere-biosphere feedbacks, and ecosystem-community effects. LEARN plans to take a two-tiered approach to advancing the understanding of atmosphere-terrestrial ecosystem exchange of reactive nitrogen. The first tier would leverage and expand existing FLUXNET sites currently focusing on carbon to include low-cost samplers for additional trace gas measurements. LEARN will also investigate the possibility of deploying passive samplers at other network sites (e.g., terrestrial sites in the Global Climate Observing System (GCOS) surface network). The goals will be to gain an improved understanding of the spatial and temporal variability in surface levels mixing ratios of NO_X and NH_3 (and possibly O_3) and, where deposition velocities can be quantitatively determined, reactive nitrogen fluxes. This component of LEARN's activities will focus on sites outside of Europe and the UK in order to complement the network of reactive nitrogen measurements implemented by NitroEurope. In the second tier, LEARN will identify a small number of sites for addition of high-resolution, speciated reactive nitrogen measurements. In addition, LEARN plans to work in collaboration with other projects within and outside IGBP (e.g., the Global Land Project (GLP), IGAC, NitroEurope and the International Nitrogen Initiative (INI)) to establish an archive for measurements pertaining to the atmosphere-terrestrial biosphere exchange of reactive nitrogen.

Activities that do not necessarily have a nitrogen focus, or specific task to examine nitrogen issues in terrestrial or atmospheric ecosystems, include: the Volatile Organic Compounds in the Biosphere-Atmosphere System (VOCBAS), the POLar study using Aircraft, Remote sensing, surface measurements and modelling of Climate, chemistry, Aerosols and Transport (POLARCAT), a new Fire-Land-Atmosphere Regional Ecosystem Studies (FLARES), FLUXNET, the Inter-American Network for Atmospheric/Biospheric Studies (IANABIS) and the Global Emissions Inventory Activity (GEIA) initiatives.

Marine Ecosystems

Seawater macronutrients generally occur in fairly constant ratios that can be altered by anthropogenic inputs. Currently, inputs of nitrogen to the ocean are several times their natural values and another two-fold increase is projected to occur by the middle of this century. These human alterations are likely to affect the nitrogen cycle particularly through changes in the biogeochemical processes and fluxes from coastal zones to open oceans. Changes in the structure and dynamics of marine food webs will also impact, and be impacted by, altered chemical forcing such as changes in quality and quantity of nitrogen inputs. The Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project addresses specific nitrogen issues through two main avenues: (1) by promoting a quantitative understanding of the coupled responses of marine biogeochemical cycles and food webs to anthropogenic addition of nitro-

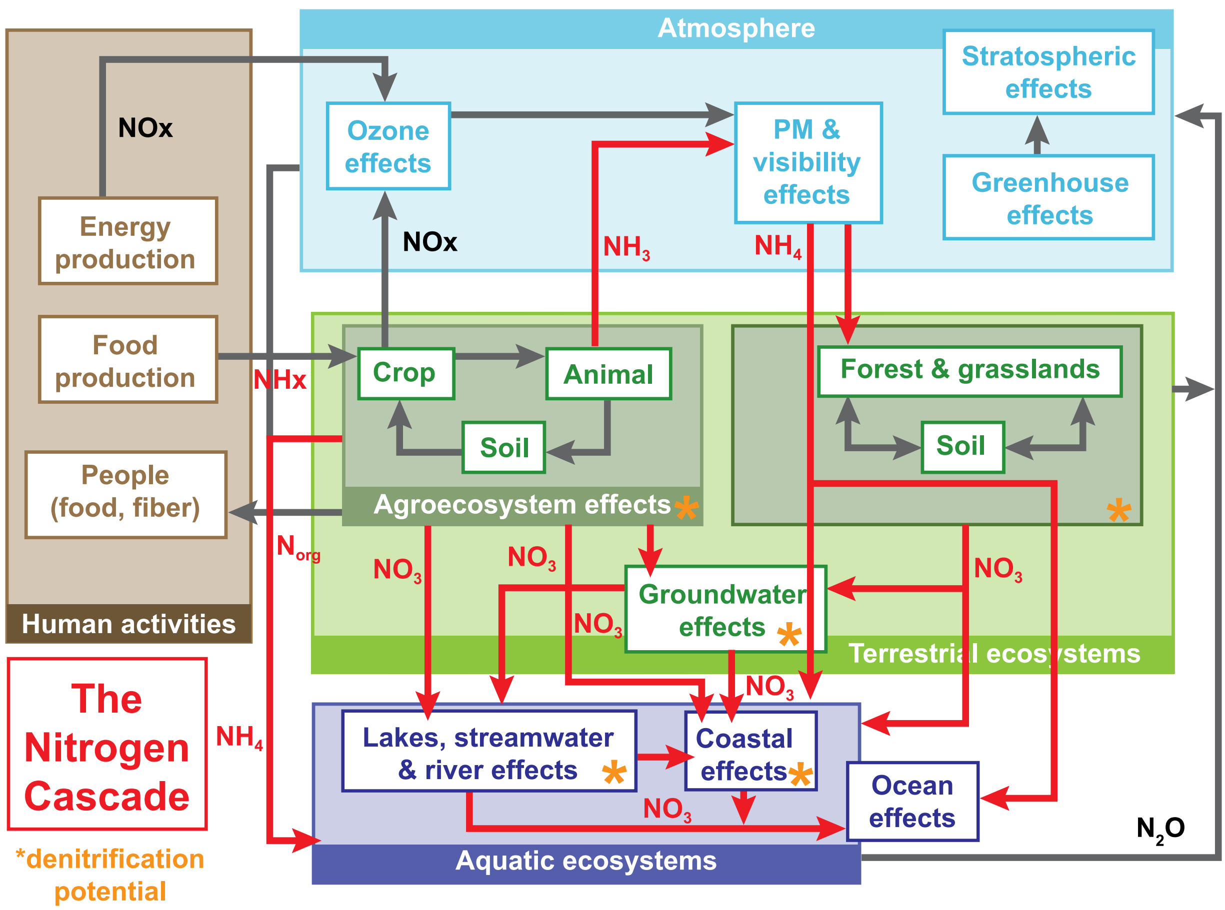

Figure 1. The nitrogen cascade illustrating the movement of nitrogen from one effect to another as it cycles through environmental reservoirs with emphasis (in red) on flows in aquatic ecosystems or flows that lead to aquatic ecosystems (modified from Vitousek et al. 1997, from Rabalais, 2002).

gen, and (2) by determining the feedback to the earth system by assessing the impact of changes in oxygen minimum zones on sources, transport and out-gassing of nitrous oxide (N_2O).

In coordination with the Western Indian Ocean Marine Science Association (WIOMSA), the CLIVAR/Global Ocean Observing System and International Ocean Carbon Coordination Project (IOCCP), IMBER co-sponsored a workshop on the Sustained Indian Ocean Biogeochemical and Ecological Research (SIBER). While the SIBER workshop did not focus explicitly on nitrogen, it reviewed the state of knowledge and identified gaps in our understanding, with particular emphasis on the role of physical and ecological processes in regulating biogeochemical cycles. Examples of gaps include the relative importance of denitrification and anaerobic ammonium oxidation in the oxygen minimum zone, and the relatively poor characterisation of the rates of nitrogen fixation in the open ocean (Hood and Naqvi, 2006).

An additional initiative, Integrating Climate and Ecosystem Dynamics (ICED), co-sponsored by IMBER, the Global Ocean Ecosystem Dynamics (GLOBEC) project, the Scientific Committee on Oceanic Research (SCOR), and the Scientific Committee on Antarctic Research (SCAR), will develop a coordinated circumpolar approach to understand climate interactions in the Southern Ocean, the implications for ecosystem dynamics, the impacts on biogeochemical cycles and the development of management procedures. A first ICED Science Planning Workshop was held in 2005 at the British Antarctic Survey, involving 33 participants from 14 countries. A summary of the workshop was published in the April 2006 issue of the International GLOBEC Newsletter. A Science and Implementation Plan for ICED is currently being developed and will be submitted to both IMBER and GLOBEC.

The International Marine Past Global Changes Study (IMAGES) is a marine project co-sponsored by the Past Global Changes (PAGES) and SCOR projects. IMAGES research has a strong engagement in the investigation of palaeoceanographic nitrogen-cycling and related biogeochemical processes. Particularly, past changes in the nitrogen supply as a major nutrient to high-productivity regions, e.g. coastal and equatorial upwelling areas as well as the subantarctic frontal zones is a major target in many IMAGES-related marine palaeoclimatic and palaeoceanographic studies.

Palaeo Process Studies

Through the analysis of the Dome C ice core of the European Project for Ice Coring in Antarctica (EPICA), a record of atmospheric nitrous oxide (N_2O) concentrations is now available back to 650,000 years before the present. Detailed comparisons of the N_2O and CH_4 records reveal interesting differences that raise a number of questions, for instance, on the functioning of its oceanic and terrestrial sinks and sources, and on feedbacks of the natural nitrogen cycle with climate change. Furthermore, it extends the challenge of unraveling past changes in CO_2 concentrations, like those associated with glacial-interglacial transitions, to understanding the amplitude and relative timing of atmospheric greenhouse gas chemistry as a whole.

Applied Earth System Science and the Nitrogen Cycle

The Analysis, Integration and Modeling of the Earth System (AIMES) core project, on behalf of IGBP, is developing a strategy that transitions fundamental science into applications for the policy, assessment and resource management communities. There are many examples of successful transitions from scientific understanding to application, including the Montreal Protocol, seasonal to interannual forecasting of El Nino Southern Oscillation (ENSO) events, satellite-based famine early warning systems and the IPCC. A very clear direction from AIMES is in applied Earth System science. The International Nitrogen Initiative (INI),affiliated with AIMES, is a pathfinding activity that transfers process understanding of the nitrogen cycle and provides solutions to problems.

The overall goal of the INI is to optimize nitrogen's beneficial role in sustainable food production and minimize nitrogen's negative effects on human health and the environment resulting from food and energy production. The INI operates in three phases, that do not necessarily occur in sequence: (1) assessment and knowledge, (2) identification of solutions; and (3) implementation of solutions. There are five INI Regional Centers: North America (USA), Europe (The Netherlands), Asia (China), Latin America (Brazil) and Africa (Uganda). INI sponsors several workshops, and published a book with the Scientific Committee on Problems of the Environment (SCOPE) on agriculture and the nitrogen cycle (Mosier et al., 2004). The Fourth International Nitrogen conference was held in October 2007 in Salvador, Brazil.

Additional activities and workshops that contribute to complex problem-solving capacity in natural resource and disaster risk management include the LOICZ sponsored, Indonesian-German research initiative on Science for the Protection of Indonesian Coastal Marine Ecosystems (SPICE). From 2006-2010, the jointly sponsored GLOBEC and IMBER China programme entitled "Key Processes and Sustainable Mechanisms of Ecosystem Food Production in the Coastal Ocean of China" will carry out integrated studies on multidisciplinary subjects by focusing on core subjects such as coupling mechanisms of the marine biogeochemical cycles and the end-to-end food web in the China seas.

Summary

While the carbon cycle has traditionally been the biogeochemical focus for IGBP research, nitrogen, as a constituent of greenhouse gas emissions and a co-limiting factor for terrestrial and marine productivity, is not so different from carbon. In fact, nitrogen adds a level of human complexity beyond carbon with regard to problems of excess nitrogen in agricultural systems (e.g., eutrophication, infant methemoglobinemia, groundwater quality). Excess nitrogen is often counterproductive to the needs of developing countries where there is insufficient nitrogen for agricultural production.

From process-level perspectives, the IGAC (2000) report identified a number of priorities, including mechanistic, interactive studies, modelling and scaling flux estimates from plot to landscape and regional scales through explicit linking with the 3-D modelling community.

In addition, the IMAGES project in PAGES will quantify the interactions between nitrogen dynamics and biological production from the past to the present. This information is urgently needed to improve process-level understanding on the interaction between climate change and ocean biogeochemical processes, as well as to the importance of global scale denitrification and nitrogen fixation processes for the nutrient and oxygen inventory of the past ocean.

Processes that operate on multiple scales such as the nitrogen cycle are difficult for development and research-application organisations and institutions to handle. The mission and philosophical goals of many research institutions and organisations do not necessarily cross the same temporal and spatial problem-solving scales. These are difficult questions, and the research communities are still learning how to organize information and activities that follow end-to-end (process to management) implementation. In this regard, work being done within the Earth System Science Partnership (ESSP) projects on Global Environmental Change and Food Systems (GECAFS) and the Global Water Systems Project (GWSP) look at nitrogen flows in an end-to-end perspective. With this article, we have presented a map of the current landscape within the IGBP network with respect to nitrogen research, a map that will enable a more connected and cohesive structure to be developed.

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Earth System Governance as a Crosscutting Theme of Global Change Research

F. Biermann

A new International Human Dimensions Programme on Global Environmental Change (IHDP) project will look at how processes of governance can support a sustainable co-evolution of nature and human societies. Its main line of activities—from researching crucial political questions to integrating governance mechanisms in modelling exercises—has direct relevance to the IGBP community.

In 2001, the four global change research programmes, including IGBP, declared in their joint Amsterdam Declaration an "urgent need" to develop "strategies for Earth System management". Yet what such strategies might be, how they could be developed, and how effective, efficient and equitable they would be, remained unspecified. The IGBP sister programme IHDP (International Human Dimensions Programme on Global Environmental Change) took up the challenge of developing these strategies in March 2007 by mandating an international group of governance experts (mostly political scientists and lawyers) to develop a science plan for a new international long-term research project within IHDP – the Earth System Governance Project.

IHDP has opted for the concept of 'governance' instead of 'management'. In many social sciences, 'management' can have connotations of hierarchical, centralised and top-down approaches, which are inappropriate if not impossible for the governance of coupled human-nature evolution on a planetary scale. In the social sciences, the term 'governance' refers to modern forms of steering that are non-hierarchical or at least decentralised and generally open for the self-organization of societies. The notion of governance includes not only public, but also non-state and private actors, ranging from industry and non-governmental lobbying groups to scientists, indigenous communities, city governments or international organisations. How processes of governance can support a co-evolution of nature and human societies that leads towards sustainable development is the core research interest of the IHDP Earth System Governance Project. The project will integrate a variety of disciplines in the social sciences – including political science, sociology, policy studies, geography, and law – and address all levels of governance, from local governance to global conventions and agreements.

The science plan for the project is still in its drafting phase. Key research questions will focus on: (a) the performance of the overall *architectures* of earth system governance, or the hardware of the governance process; (b) the role of *agency* in earth system governance, including private agency and state agency; (c) the *adaptiveness* of governance mechanisms at both global and local levels; (d) the *accountability* and legitimacy of current and future mechanisms of earth system governance, and thus the quest for democratic earth system governance, and finally (e) the modes of *access* and *allocation* in

IGBP's earth system illustration shows the connection between nature and human society. Governing a sustainable co-evolution of the two is the theme of a new IHDP project.

earth system governance, including considerations of equity, fairness and justice. These five A's – architecture, agency, adaptiveness, accountability / legitimacy, and access / allocation – will stand at the centre of the IHDP Earth System Governance Project. In planning for this new research activity, governance researchers can rely on the results from a related earlier research programme, the IHDP core project on Institutional Dimensions of Global Environmental Change (IDGEC). This project – headed for most of its duration by the political scientist (and current IHDP Chair) Oran Young – ended in 2006 in a major Synthesis Conference in Bali, Indonesia, and its core findings – four book volumes and a series of journal articles – are currently under review for publication. The Earth System Governance Project will build upon, and further develop, the legacy of this successful predecessor programme.

While the Earth System Governance Project will be an activity of IHDP, as the social science branch of the global change research community, it will be relevant to the IGBP community in a number of ways.

First, the Earth System Governance Project will be the central activity to initiate, compile and disseminate research on the crucial *political* questions accompanying broader earth system analysis and IGBP's work: what systems of governance can best realise a co-evolution of natural and human systems in a way that leads towards more sustainable development paths?

In addition, the Earth System Governance Project will seek to advance methodological progress in integrated assessments by investigating methods for the integration of governance mechanisms – i.e., the role of institutions, partnerships or legal agreements – in modelling exercises. A pilot study on this subject is currently being developed under a joint programme by the Netherlands Environmental Assessment Agency and the Institute for Environmental Studies of the Free University of Amsterdam.

Related to these two points, researchers from the Earth System Governance Project will directly collaborate with interested IGBP colleagues and programmes under the Earth System Science Partnership. Among the interested thus far are the Global Environmental Change and Food Security Project, the Global Water System Project, and the Global Carbon Project. Such issue-specific research networks provide opportunities for practical, productive interactions between natural scientists and governance experts , and could lead to general methodological progress in interdisciplinary research.

Last but not least, the Earth System Governance Project will continue and strengthen the critical role of the social sciences in the larger global change research community. An inherent part of the Earth System Governance research agenda will be the study of global change research itself as an inherently social activity. Core questions will focus on how scientists frame their problems and how particular worldviews shape scientific research progress, for example in the construction of models or scenarios; how scientists deal with problems of uncertainty and lack of quantifiable knowledge of human behaviour; and how the governance of science influences and structures the production of knowledge.

Through these four lines of activities, analysts of earth system governance will help further the goals of IGBP. To do so, they will need collaboration with, and the cooperation of, their colleagues from IGBP. Research on earth system governance is an activity inherently linked to the social sciences, but it is an integral part of the larger effort of global change research and thus also of interest, we hope, for the IGBP community as a whole.

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Frank Biermann is chair of the Earth System Governance Scientific Planning Committee, head of the Department of Environmental Policy Analysis at the Institute for Environmental Studies, Free University Amsterdam, The Netherlands, and director-general of the Netherlands Research School for the Socio-Economic and Natural Sciences of the Environment. He has developed the concept of earth system governance more extensively in "Earth System Governance as a Crosscutting Theme of Global Change Research", Global Environmental Change, vol. 17, no. 3-4, 2007 pp. 326-337. A project website, www.earthsystemgovernance.org, is currently being developed.

Any comments, suggestions and ideas for this emerging initiative are more than welcome, and can be directed to Frank Biermann at: frank.biermann@ivm.vu.nl

Environmental Consequences of Global Change in Egypt

M. Saber

Egypt stands to suffer greatly from human-induced climate change. Projected increases in temperatures and sea level rise, along with decreases in precipitation, could have severe consequences for Egypt, including water scarcity, food inefficiency and loss of biodiversity.

Egypt emits relatively few greenhouse gases compared to many other nations: it emits 0.34% of total worldwide fossil-fuel emissions (0.36 tons / per capita). By contrast, the average person in the United States emits 5.44 tons and, in Japan, 2.13 tons. Yet Egypt stands to suffer greatly from human-induced climate change. Average temperature increases are expected to reach +4 °C in Cairo and from + 3.1 to 4.7°C in the rest of Egypt by the year 2060, and drops in annual precipitation are projected on the order of 10 to 40% over much of Egypt by 2100. Expected consequences are increased numbers and intensity of flash floods, summer heat waves and winter cold waves, as well as water scarcity, food inefficiency, loss of biodiversity, and sea level rise, all of which will severely impact human health and the national economy.

The first impacts of global change will likely be felt in water resources scarcity and, as a result, in declines in agricultural production on the order of 10 to 60%. A doubling of CO_2 might increase photosynthetic rates significantly, but crop harvests will decline due to water scarcity and heat-associated damage to plant pollination, flowering and the formation of grains. A substantial number of the currently endangered species might be lost as native communities are invaded by competitors and coastal communities are lost. Projected sea-level rise is expected to annihilate about one quarter of the agricultural land of the delta, which also will displace large numbers of people. A 0.5 meter sea level rise in the Nile Delta is projected to cause migration of more than two million people, a loss of more than 214,000 jobs and a value loss of more than $40 billion, while a rise of one meter could displace tens of millions of people and endanger the food supplies of many more.

The most direct health effects in Egypt will be increases in the number and severity of asthma and of infectious diseases, thousands of extra deaths from cardiovascular and respiratory illness, diarrhea and dysenteric infections and malnutrition.

Water from the Nile is an important asset in Egypt.

Global Change Challenges in Egypt

Egypt is the fifteenth most populated country in the world and enormously vulnerable to negative environmental consequences of global change that would exacerbate existing problems and threaten to overwhelm the country, which already is stressed by population pressures and resource scarcities. Important effects include water scarcity, food insufficiency, loss of biodiversity, sea level rise, and new pressures on human health and the national economy.

A mean surface temperature rise has been recorded over some Egyptian regions in the last decade and future rises ranging between 0.01 to 0.04 °C per year have been projected (El-Shahawi, 2004). The temperature rise is expected to reach around +4 °C by the year 2060. If current trends in greenhouse gas emissions continue, global temperatures will rise faster over the 21st century than during the last 10,000 years and annual precipitation will decline by 10 to 40% over much of Egypt by 2100. This, in conjunction with increased evaporation, will increase the frequency and severity of droughts.

Water Scarcity

It is likely that the first impacts of global change in Egypt will be felt at the level of water resources. Water is already a limited resource in Egypt, with per capita share just below 1000 m^3 per year and is thus at the edge of the so-called poverty line (El Quosy, 1999). By 2050, global change is expected to increase water demand by an average of 5% (Eid, 1999). Population growth only adds pressure on this limited resource, threatening to cause serious hardship. Water management is thus becoming an ever urgent priority.

Agricultural and Food Insufficiency

Hotter and drier conditions would widen the area prone to desertification northwards into new areas. Desertification would also be aggravated by increases in erosion and reductions in soil fertility. The economic and human costs of an increase in desertification would be tremendous.

Significant sea level rises along the Mediterranean shoreline could sweep away about one-quarter of the agricultural land of the delta and displace millions of people. Productive land in coastal areas may also be lost through flooding, saline intrusion and water-logging (Tealeb, 1999). Agricultural production might cease altogether over an area extending 20 km inland.

Egypt's annual population growth presently surpasses that of agricultural production, requiring importation of a substantial slice of national food supplies. Though it is difficult to assess exactly how global change will impact food insufficiency, agricultural self-sufficiency is expected to decline by 10-60% due to increases in temperature, precipitation, evapotranspiration, ultraviolet radiation, CO_2 levels, and the prevalence of pests and diseases (Pam, 1990). Major crops in Egypt (wheat, maize, clover, rice, cotton, sugar-cane, horsebean, sorghum and soybean) are expected to decrease as a result of climate change and drought. By 2050 decline in yields due to global change is expected to reach 28% for soybean, 18% for wheat and barley, 19% for maize and sorghum and 11% for rice, while yield of cotton would be increased (Eid, 1999). Livestock production would also suffer due to reduced land quality and land availability.

Biodiversity

Global changes in the form of temperature, precipitation, drought and solar radiation, will reshape the main habitats in Egypt (El-Bagori, 2004). Although Egypt is either arid or semi-arid, its exceptionally varied eco-zones subsume great diversity of habitats, fauna and flora, despite overall low species numbers (Zaghloul, 2006). These ecosystems and habitats must be maintained to safeguard biodiversity and, inversely, species must be protected in order to conserve the ecosystems and habitats.

As in agriculture, different wild species of plants and animals will react differently to global change. Some are more flexible than others and may manage to migrate northwards. Northern coastal and low-lying areas – rich in species and subsuming mangroves and natural reefs that are among the richest in the world in terms of biodiversity – will be damaged by rises in sea level and population. The associated immigration of species to new areas will cause severe socio-economic problems. Climate change will also impact marine habitats in a complex and interactive way.

In the old valley and delta habitats, where more than 95% of Egyptians live, flooding will increase soluble salt content up to 1500 ppm in ground water, adversely impacting the inhabitants and biodiversity. As a result of sea level rise in the delta, it is expected that some damage will affect the surrounding areas adjacent to the Egyptian northern lakes, e.g., El-Manzala Lake. In Sinai and eastern desert habitats, marginal pasture areas will be affected by expected reduced precipitation, and many cultivated areas will be prone to desertification due to water deficiency. At high altitudes, an anticipated increase in rainfall might have some minor positive effects on natural vegetation. In the Red Sea, a northward shift of the rain belt would stimulate primary productivity in some habitats, but the reefs would be negatively affected. Mangrove growth, however, would be favored by temperature rise and increased precipitation.

In the western desert and the southern valley habitats, the expected increase in temperature will increase the water requirements of field crops and fruit trees, and a substantial number of the currently endangered species might be lost as coastal communities are lost and native communities invaded by competitors.

Sea Level Rise

Coastlines and the northern delta are particularly vulnerable to global change (Halim, 2004). Climate change will most certainly accelerate coastal erosion. Large areas of farmland behind Alexandria and in the mid-delta are already below sea level and hence vulnerable to flooding and underground salt water intrusion that would cause catastrophic socioeconomic losses and large-scale population displacement.

Wetland sites will face the dual threats of drying out and being inundated by seawater. Up to 85% of wetland sites in Egypt could disappear with a 3 to 4 °C rise in temperatures, which also would damage food plants and reduce waterfowl and fish populations. Fisheries and tourism are thus two additional economic activities that stand to be negatively impacted by global change. A 0.5 meter sea level rise in the delta would cause migration of more than two million people, loss of more than 214,000 jobs and a value loss of more than $40 billion. A 1 meter rise in sea level could lead Egypt to loose one percent of its land, displacing tens of millions of people and endangering the food supplies of many more (Halim 2004).

Health Impacts

The most direct health impacts in Egypt will be an increase in the occurrence of asthma as higher temperatures will result in even more severe urban air pollution. Higher temperatures would also increase the transmission and severity of many infectious diseases. More frequent heat waves are expected to result in thousands of extra deaths from cardiovascular and respiratory illness. There could also be deaths and injuries from extreme weather events (storms, heat waves). Food- and water-borne infective agents causing diarrhea and dysenteric infections are likely to spread more readily in warmer and wetter conditions. Deterioration of freshwater quality would reduce health standards and worsen epidemics. Reductions in food security would increase the risks of malnutrition and hunger for millions in Egypt.

Conclusions

Global change is more than climate change and its full extent and complexity is still being discovered. Egypt has planned and established a range of global change-related policies, including new measures to reduce CO_2 and other greenhouse gas emissions as well as ozone depleting substances targeted by the Montreal Protocol. It has instated new measures to ensure rational water and agricultural management, and to preserve ecosystems and species through the creation of national parks and gene banks. The country has also set new goals for health care and for absorbing atmospheric carbon sinks through urban planning and tree planting.

However, addressing global change is a global problem, and it is likely to increase political conflict in Egypt and beyond. Regional conflicts could result from declining natural resources and movements of environmental refugees. Abrupt climate changes would especially threaten to de-stabilize affairs at the geo-political level.

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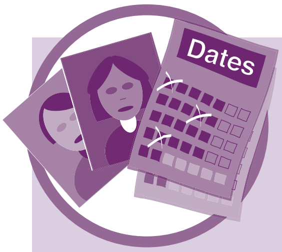

New Roles and Faces

IGBP Secretariat

The IGBP Secretariat welcomes **Emily Brevière** who is temporarily seconded from the SOLAS IPO from 19 September to replace Wendy Broadgate, Deputy Director, Natural Sciences, during her maternity leave. Emily, who is originally from France, has been working as project officer for SOLAS in the UK since 2005. Her PhD work was on the temporal variability of carbon dioxide air-sea fluxes in the Southern Ocean.

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New co-Chair at IGAC

Kathy Law has taken over from Sandro Fuzzi as the European co-Chair of IGAC. Kathy obtained her PhD in atmospheric chemistry at the University of Cambridge, UK, where she worked as a research scientist up to 2002 before taking up a position at CNRS as director of research at the Service d'Aéronomie/IPSL (Institut Pierre Simon Laplace), UPMC (Université Pierre et Marie Curie), Paris, France. Her current research interests include long-range transport of pollutants (co-lead of the IGAC POLARCAT task) and the West African monsoon (as part of the IGAC AMMA task).

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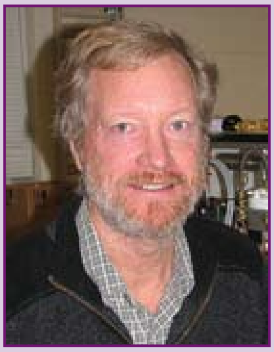
New SSC members at IGAC



David Griffith's areas of interest and expertise are in atmospheric trace gas measurements. David obtained his PhD (1975) in chemistry and molecular spectroscopy at Monash University in Australia. He moved into the development of optical techniques for atmospheric trace gas measurements as a visiting scientist at NCAR in Boulder, Colorado, and then at the Max Planck Institute for Chemistry in Mainz, Germany. Since 1986 he has been at the Dept. of Chemistry, University of Wollongong and leads the university's Centre for Atmospheric Chemistry. His work has focused on Fourier Transform Infrared (FTIR) spectroscopy for both solar remote sensing and *in situ* measurements of trace gases.

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Yutaka Kondo obtained his PhD (1977) at the University of Tokyo and became a professor there in 1992. He has worked mainly in the fields of stratospheric and tropospheric ozone, and studying distributions and causes of variations of aerosols on local and regional scales by using advanced measurement techniques. His current research interests include understanding key physical and chemical processes of aerosols relevant to air quality and climate.

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Celine Mari's expertise includes mesoscale modelling and atmospheric chemistry and dynamics. She graduated with an MS degree in atmospheric chemistry (1995) and a PhD in chemistry and meteorology in 1998. After postdoctoral work at Harvard University, she joined the Laboratoire d'Aerologie (CNRS) in Toulouse as a research scientist. Her research interests include atmospheric convection, ozone's tropospheric budget, improvement of numerical cloud models to interpret observations, and dynamical-chemical interactions and chemistry in the tropics.

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New SSC member at LOICZ

Ramesh Ramachandran's expertise includes coastal ecosystem biogeochemistry and coastal zone management. He received his PhD in environmental sciences from Jawaharlal Nehru University, New Delhi and a second PhD in marine sciences from McGill University, Canada. His current research interests include global climate change and biogeochemical cycles in coastal and riverine ecosystems. He is currently director of the Institute for Ocean Management, Anna University, Chennai, India where he is involved in projects relating to trace gas emissions, coastal pollution, biodiversity research, and coastal ecosystem restoration.

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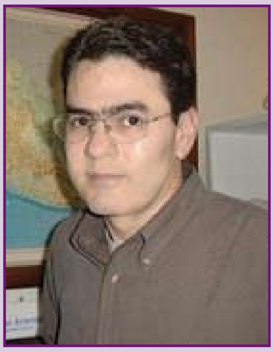
New SSC members at PAGES



Jose D. Carriquiry's expertise includes coral geochemical paleoceanography and marine sedimentary geochemistry. He obtained a PhD (1991) in Geology at McMaster University, Canada. Following his Fullbright fellowship at Scripps Institution of Oceanography (UCSD), he continued his coral palaeoceanography research in coral reefs from the Mexican Pacific and Caribbean. His research interests include marine geochemistry (isotopes and metals), palaeoceanography (corals and forams), sedimentation, and the effects of El Niño and global change on coral reefs.

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Takeshi Nakatsuka's expertise includes marine biogeochemistry, palaeoceanography and palaeoclimatology. He obtained his PhD (1995) in atmospheric and hydrospheric sciences at Nagoya University and has, since 1996, been studying the oceanography and palaeoceanography in the Sea of Okhotsk and biogeochemistry and palaeoclimatology in the Northeast Asian region. His research interests include large-scale linkages between inland and open ocean ecosystems by material transports through river and ocean currents, glacial to interglacial ecological succession in the northern North Pacific region, and novel applications of treering isotopic records to study past changes in the water cycle in East Asian region.

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Pierre Fracus's expertise includes sedimentology and physical geography. Pierre graduated with a PhD in geology and mineralogy at Université Catholique de Louvain, Belgium. After a postdoctoral experience at the Climate System Research Center of the University of Massachusetts, Amherst, Pierre joined the Institut National de la Recherche Scientifique in Québec City. His research interests include new proxies and advanced techniques to study sediment cores in high resolution, arctic environments, and annually laminated (varved) sediments.

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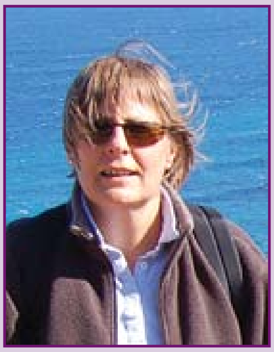
New SSC members at SOLAS



Véronique Garcon's expertise includes coupled physical/biogeochemical modelling, and marine biogeochemistry. She obtained her PhD (1981) in environmental sciences from the University Paris VII. She has been a senior scientist since 1998 at LEGOS (Laboratory of Space Geophysics and Oceanography) and is leading the Physical Dynamics/Marine Biogeochemistry Group. Her research interests include marine biogeochemistry and ecosystem dynamics, large-scale ocean circulation and tracers, global carbon and nitrogen cycles, physical-biological interactions, eastern boundary upwelling systems and biogeochemical climatic monitoring.

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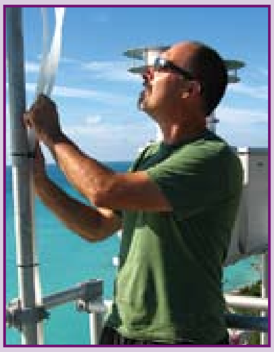

Dave Kieber is a chemistry professor at the State University of New York, Syracuse, New York. He obtained his PhD (1988) from the University of Miami Rosenstiel School of Marine and Atmospheric Science, followed by a postdoctoral position at the Woods Hole Oceanographic Institution. His research is focused on the study of biological, geochemical and photochemical transformations of naturally occurring organic matter in atmospheric and aquatic environments, and the effect of these transformations on global biogeochemical cycles, especially as they are impacted by global change. Some current areas of interest include marine aerosol generation, global carbon and sulphur cycles, and photochemistry.

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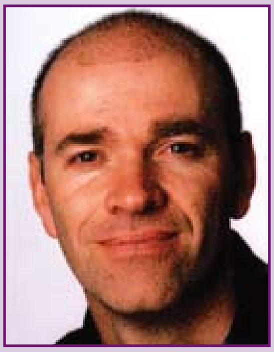

Cliff Law is a principal scientist in the Ocean-Atmosphere and Ocean Ecosystems Programmes at the National Institute for Water and Atmospheric Research (NIWA) in Wellington, New Zealand. He obtained his PhD in microbial biogeochemistry at Plymouth Marine Laboratory (PML), Plymouth, UK in 1990. His research has focussed on biological and physical controls on marine trace gas and nitrogen cycling, and iron limitation in high-nutrient, low chlorophyll regions. Since moving to New Zealand in 2002 this research has expanded to include regional issues of nutrients and productivity in oligotrophic systems, and methane seeps.

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Pin Board

The Pin Board is a place for short announcements and letters to the editor. Announcements may range from major field campaigns, new websites, research centres, collaborative programmes, policy initiatives or political decisions of relevance to global change. Letters to the editor should not exceed 200 words and should be accompanied by name and contact details.

IGBP Celebrates 20th Anniversary

Some 75 representatives from the science, political and private sectors attended an IGBP symposium to mark an important milestone in the study of the Earth as a system: the Programme's 20th anniversary. Plenary and panel discussions offered an interdisciplinary and multi-sector look at potential major scientific and societal issues in the coming decades to determine what sort of science-society interplay will be needed to deal with them. The symposium provided IGBP with an opportunity to not only reflect on what has been learned but also what it can strive to achieve over the coming decades. More highlights from the symposium are available on the IGBP website and will be featured in the next IGBP newsletter.

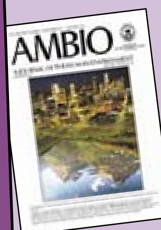
Agriculture, Development, and Nitrogen: A problem of too little or too much?

Nitrogen is an essential component of any plan for reducing world hunger, poverty, and disease. When used in excess, however, N becomes an important pollutant. This duality is one of the major challenges that humanity has to face now and in the future if we want to ensure environmental sustainability. To highlight these issues, the International Nitrogen Initiative hosted the 4th International Nitrogen Conference in October. Some 350 participants from 45 different countries gathered in Brazil for plenary, poster and working group sessions on issues from food and bio-energy production, pollution, policy and human health. Plenary talks can be downloaded at www.nitrogen2007.com. A survey of N-related activities in IGBP can be found in this issue of the NewsLetter.

Global Change Meetings List Now Online

Whether it's the 2008 AAAS Annual Meeting in Boston or the April 2008 EGU General Assembly in Vienna, there's a meeting for every month of the year in IGBP's global change meetings list. Faithful NewsLetter readers will notice that the list is not included in this issue. Instead, IGBP has opted to refer readers to the fully searchable list on its website (www.igbp.net) under the Resource Room. The online list is updated regularly and has links to meeting websites for more information.

Study of Past Offers Hope for the Future



Understanding the history of how humans have interacted with nature can help clarify the options for managing our increasingly interconnected global system, say a group of IGBP scientists in an article published in the November 2007 issue of Ambio magazine. Titled "Sustainability or Collapse: What Can We Learn from Integrating the History of Humans and the Rest of Nature?", the article argues that integrated records of the co-evolving human-environment system over millennia are needed as a basis for deeper understanding of the present and for forecasting the future.

The article offers a glimpse of the research direction of a new research initiative called the Integrated History and future Of People on Earth (IHOPE), co-sponsored by IGBP's core projects on Analysis, Integration and Modeling of the Earth System (AIMES) and Past Global Changes (PAGES).

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Future Climate Change Research and Observations: Learning from the IPCC Fourth Assessment Report

Some 66 key IPCC authors and other climate experts met in Sydney, Australia, 4-6 October, at the joint GCOS/WCRP/IGBP workshop 'Learning from the IPCC Fourth Assessment Report' to look at the most critical gaps in basic climate science, and deficiencies in the way in which information about climate change can be used for the prediction of impacts, design of adaptation measures, and assessment of vulnerability, particularly on a regional scale. The workshop also made suggestions on the research necessary to better quantify climate change impacts. A comprehensive workshop report is forthcoming.

Address Change for START Pan-Africa

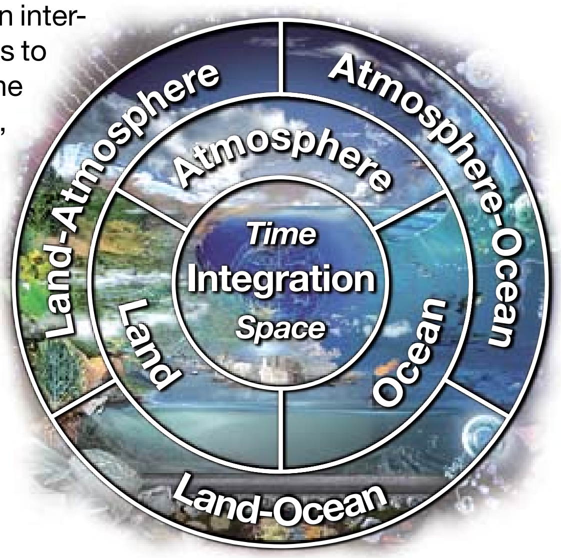
START's Pan-Africa Secretariat (PASS) has been relocated to the Institute of Resource Assessment (IRA) at the University of Dar es Salaam in Tanzania. The new director of PASS is Pius Yanda (email: yanda@ira.udsm.ac.tz). Professor Yanda, a well-known African scientist who has been a member of the Pan-Africa Regional Committee for START (PACOM), is also the Director of IRA. His group at IRA is engaged in START activities in Africa (recent projects include: ecosystem management, climate change and biodiversity conservation). A new website for PASS is being established at the University of Dar es Salaam.

SOLAS Summer School

IGBP's core project on Surface Ocean-Lower Atmosphere (SOLAS) held its biennial Summer School in Corsica, France from 22 October to 3 November 2007. The Summer School brought together some 70 students and 20 lecturers for a mix of lectures and practical workshops. The aims were to teach the skills and knowledge of the many disciplines needed to understand the nature of ocean-atmosphere interactions. It allows doctoral students and early-career researchers to see how their work fits into the broad canvas of SOLAS, and global change research more generally. More information is available on the SOLAS website: www.solas-int.org.

The International Geosphere-Biosphere Programme

IGBP is an international scientific research programme built on interdisciplinarity, networking and integration. The vision of IGBP is to provide scientific knowledge to improve the sustainability of the living Earth. IGBP studies the interactions between biological, chemical and physical processes and human systems, and collaborates with other programmes to develop and impart the understanding necessary to respond to global change. IGBP research is organised around the compartments of the Earth System, the interfaces between these compartments, and integration across these compartments and through time.



IGBP helps to

- develop common international frameworks for collaborative research based on agreed agendas
- form research networks to tackle focused scientific questions and promote standard methods
- guide and facilitate construction of global databases
- undertake model inter-comparisons
- facilitate efficient resource allocation
- undertake analysis, synthesis and integration of broad Earth System themes

IGBP produces

- data, models, research tools
- refereed scientific literature, often as special journal editions, books, or overview and synthesis papers
- syntheses of new understanding on Earth System Science and global sustainability
- policy-relevant information in easily accessible formats

Earth System Science

IGBP works in close collaboration with the International Human Dimensions Programme on Global Environmental Change (IHDP), the World Climate Research Programme (WCRP), and DIVERSITAS, an international programme of biodiversity science. These four international programmes have formed the Earth System Science Partnership (ESSP). The International Council for Science (ICSU) is the common scientific sponsor of the four international global change programmes.

Participate

IGBP welcomes participation in its activities – especially programme or project open meetings (see meetings list on website). To find out more about IGBP and its research networks and integration activities, or to become involved, visit our website (www.igbp.net) or those of our projects, or contact an International Project Office or one of our 74 National Committees.

Contributions

The Global Change NewsLetter primarily publishes articles reporting science undertaken within the extensive IGBP network. However, articles reporting interesting and relevant science undertaken outside the network may also be published. **Science Features** should balance solid scientific content with appeal to a broad global change research and policy readership. **Discussion Forum** articles should stimulate debate and so may be more provocative. Articles should be between 800 and 1500 words in length, and be accompanied by two or three figures or photographs. Articles submitted for publication are reviewed before acceptance for publication. Items for the **Pin Board** may include letters to the editor, short announcements such as new relevant web sites or collaborative ventures, and meeting or field campaign reports. Pin Board items should not exceed 250 words.

Photographs should be provided as TIFF or high resolution JPG files; minimum of 300 dpi. Other images (graphs, diagrams, maps and logos) should be provided as vector-based EPS files to allow editorial improvements at the IGBP Secretariat. All figures should be original and unpublished, or be accompanied by written permission for re-use from the original publishers.

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