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Global Environmental Change and **Food Systems**



Science Plan and Implementation Strategy



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Global Environmental Change and Food Systems

Science Plan and Implementation Strategy

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Executive Summary

GECAFS was launched in 2001 as an international, interdisciplinary research project to better understand the relationships between Global Environmental Change (GEC) and food security. GECAFS is a Joint Project of the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme on Global Environmental Change (IHDP) and the World Climate Research Programme (WCRP). GECAFS also has formal research partnerships with the Consultative Group on International Agricultural Research (CGIAR), the UN Food and Agriculture Organisation (FAO) and the UN World Meteorological Organisation (WMO).

GECAFS' goal is to determine strategies to cope with the impacts of global environmental change on food systems and to assess the environmental and socioeconomic consequences of adaptive responses aimed at improving food security. GECAFS undertakes research that not only studies food security in the context of GEC but also feedbacks from adaptation strategies to the Earth System.

GECAFS has been developed with two essential principles in mind:

- Principle 1: GECAFS research must concentrate on integrative issues of common interest to all three sponsoring Programmes and develop research questions where interdisciplinarity is required.
- Principle 2: GECAFS research must draw together and build on relevant aspects of each Programme's Core Projects and, by linking these with appropriate inputs from other organisations, set them in a broader context of coupled human-environment systems.

GECAFS addresses three major questions of interest to science, development and society:

- (i) How will global environmental change affect the vulnerability of food systems in different regions?
- (ii) How can we adapt food systems to cope with global environmental change and improve food security?

- (iii) How will various adaptation options feedback on environmental and socioeconomic conditions?

To answer these questions, GECAFS is developing a portfolio of conceptual and methodological research closely linked to a set of regional projects.

The conceptual and methodological research employs international research networks. They bring together and synthesise relevant, high-quality research from around the world to improve understanding on four key topics:

- (i) Food systems research: to improve understanding of food systems suitable for GEC research.
- (ii) Vulnerability research: to integrate social science and natural science concepts of what makes a food system vulnerable.
- (iii) Scenario research: to determine how to construct the comprehensive scenarios needed for GECAFS regional research.
- (iv) Decision support research: to determine how best to improve dialogue between scientists and policy-makers on environment and food issues.

Regional research consists of a few regionally-based projects representing a range of major GEC issues and food systems. These projects are designed at the sub-continental scale, which is an important spatial scale for food security, food system research and GEC considerations. The initial regional GECAFS projects are:

- Indo-Gangetic Plain
- Caribbean
- Southern Africa.

The research programme is being implemented in three phases.

Phase I (2003-05) entailed a series of scoping exercises to define researchable issues and prepare initial research proposals.

Phase II (2005-08) will deliver interim methods and tools:

- (i) An analytical framework to help assess food system sensitivities to GEC, based on food availability, access and utilisation.
- (ii) Analytical methods to assess the factors that make food systems vulnerable to GEC, and to assess policy and management options to reduce risk of damage from GEC, and/or options to better deal with environmental stresses caused by GEC;
- (iii) Region-specific scenarios of future socioeconomic, ecological and environmental conditions involving food systems;
- (iv) Decision support systems to communicate GEC issues to policy-makers and to analyse how different adaptation options for food systems may then affect the environment, society and economies; and
- (v) Assessment of several regional food systems, their vulnerability to GEC and their policy contexts for possible adaptation options.

Phase III (2008-11) will deliver the longer-term GECAFS objectives:

- (i) Understand how GEC will additionally affect food security in different regions and among different socioeconomic groups;
- (ii) Determine how different societies might adapt their food systems to cope with both GEC and changing demands for food;
- (iii) Assess how strategies designed to cope with GEC and changing demands for food will affect the environment, societies and economies; and
- (iv) Provide information and research findings in formats that help better policy-making for food systems in the context of GEC.

Global Environmental Change and Food Systems

Global Environmental Change and Food Systems (GECAFS) is a comprehensive programme of interdisciplinary research focused on understanding the links between food security and global environmental change. GECAFS will improve understanding of the relationship between food systems and the Earth System to deliver science-based tools for analysing the socioeconomic and environmental consequences of adaptation strategies. These will be designed to help policy-makers and managers evaluate the best options for reducing vulnerability of food systems to global environmental change while minimising further environmental degradation.

1 Context, goal and research aims

1.1 Vision and research niche

A food-secure future for those most vulnerable to environmental stress.

GECAFS is an interdisciplinary research project spanning natural and social sciences. It is breaking new ground in developing a science agenda with direct inputs to policy-making. The new science explicitly includes both how food systems could be adapted to cope with the impacts of global environmental change (GEC), and how different adaptation strategies could affect socioeconomic and environmental conditions. Of particular interest are possible feedbacks to the Earth System from efforts to improve food security relating to the dynamics of carbon, nitrogen, phosphorus and water. GECAFS brings together the agendas of GEC science and of international development and will form novel partnerships between the GEC research community and a broad range of other organisations, including national and international research bodies, national and international assessment units, national and regional civil society stakeholders and governmental authorities, intergovernmental organisations and UN agencies, and national and international donor agencies. This wide range of scientists and stakeholders working together will build upon and add value to the individual research agendas of the international GEC research programmes.

1.2 Rationale

Global environmental change (GEC) is happening. Human activities, including those related to the production, supply and consumption of food, are partly responsible for changing

the world's climate and giving rise to other, globally- and locally-important environmental changes. These include a changes in freshwater supplies, carbon and nitrogen cycling, biodiversity, and land cover and soils (Vitousek *et al.*, 1997; Steffen *et al.*, 2004).

There is growing concern that GEC will further complicate achieving food security – particularly for more vulnerable sections of society – (Fischer *et al.*, 2002; Rosegrant and Cline, 2003; Parry *et al.*, 2004). There is also concern that meeting society's rising demand for food will further degrade the environment (Tilman *et al.*, 2001; FAO, 2002). This may, in turn, further undermine the food systems upon which food security is based. There is an urgent need to frame and execute research on the components of food systems (ie availability, access and use) within a GEC context, so that the global science community can play its crucial role in improving food security whilst minimising further environmental degradation.

The research community faces several major scientific challenges in dealing with the interactions between GEC and food security. Four issues are of particular interest because they set the context for many researchable questions. First is the need to better understand what constitutes vulnerability to GEC in relation to food. This is key to helping to determine where, when and which sections of society are most at risk, and is especially necessary given problems of predicting global food production (Döös, 2002). Second is the need to construct scenarios of future conditions that encapsulate the socioeconomic and biogeophysical factors that determine food security. Third is the need to assess options for reducing the vulnerability of food systems to GEC. Fourth is the need to understand how best to report

and communicate research results and so help devise improved policies to adapt food systems to GEC.

Socioeconomic and biogeophysical factors both determine food security. It is therefore important to develop an interdisciplinary research approach that builds on and integrates the wealth of disciplinary studies which have characterised most GEC and food-related research to date. These include, for example, studies on: GEC impacts on agro-ecosystem productivity (eg Gregory *et al*, 1999; Fuhrer, 2003); GEC impacts on regional production (eg Fischer *et al*, 2002); societal perceptions of GEC (eg Thompson and Rayner, 1998); vulnerability of agricultural systems (eg O'Brien *et al*, 2004); seasonal forecasting (eg Colman *et al*, 2000); and the spatial scale of climate information in analyses of climate change impacts (eg Mearns *et al*, 2001). New research needs to build on and integrate such studies. It also needs to set new agendas addressing emerging issues for interdisciplinary science related to food security and sustainable development. This in turn requires a novel approach to organising research (Quinlan and Scogings, 2004).

Theoretical and methodological research on vulnerability and scenarios is essentially of scientific interest. However, developing adaptation agendas and communicating research results to policy-makers and resource managers directly addresses the major issue of linking science and policy. The development community and others interested in helping policy formulation are also interested in research on adaptation and the science-policy interface. This component is timely as, to date, the GEC research agenda has not been well linked with the development agenda, despite the fact that development goals and improved environmental management are often closely related.

In 2001 the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme on Global Environmental Change (IHDP) and the World Climate Research Programme (WCRP) jointly launched Global Environmental Change and Food Systems (GECAFS). This ten-year interdisciplinary research programme aims to better address the issues challenging improved food security in the context of GEC. The joint project is in collaboration with the Consultative Group on International Agricultural Research (CGIAR), the Food and Agriculture Organisation of the United Nations (FAO) and the World Meteorological Organisation of the United Nations (WMO).

1.3 Goal and research aims

The GECAFS goal is:

To determine strategies to cope with the impacts of global environmental change on food systems and to assess the environmental and socioeconomic consequences of adaptive responses aimed at improving food security.

This goal will be achieved by improved understanding of the interactions between food systems and the Earth System's key socioeconomic and biogeophysical components. The research agenda will be specifically targeted towards delivering the new science necessary to underpin policy formulation for improving food security in the face of GEC.

GECAFS' long-term aims are to:

- (i) Understand how GEC will additionally affect food security in different regions and among different socioeconomic groups;
- (ii) Determine how different societies might adapt their food systems to cope with both GEC and changing demands for food;
- (iii) Assess how strategies designed to cope with GEC and changing demands for food will affect the environment, societies and economies; and
- (iv) Provide information and research findings in formats that help better policy-making for food systems in the context of GEC.

GECAFS aims to deliver a number of science-based products in the medium-term (3-5 years) to help achieve the long-term aims, for example:

- (i) An analytical framework for food systems research based on food availability, access and utilisation, to help assess food system sensitivities to GEC;
- (ii) Analytical methods to assess the factors that make food systems vulnerable to GEC, and to assess policy, and management options for reducing exposure to risk and/or increasing coping capacity to deal with environmental stresses caused by GEC;
- (iii) Region-specific scenarios of future socioeconomic, ecological and environmental conditions involving food systems;
- (iv) Decision support systems to communicate GEC issues to policy-makers and to analyse how different adaptation options for food systems may then affect the environment, society and economies; and
- (v) Assessment of a number of current regional food systems, their vulnerability to GEC and their policy contexts for possible adaptation options.

2 Conceptual framework and major science issues

2.1 Context

Recent years have seen a greatly increased understanding of how GEC will affect crop and animal productivity and these results pave the way for broader analyses of GEC impacts on food production. However, there is a need to think beyond productivity and production — food security is the ultimate concern, as it is of greater relevance to societal well-being and hence policy-making.

To address this broader concept of food security, research and policy formulation needs to be set within the context of food systems, rather than just food supply. This will allow a more thorough understanding of the links between food security and the environment, and make clearer where technical and policy interventions in food systems might help them adapt to GEC.

2.2 Definitions

Global Environmental Change, Food Systems and Food Security are all key terms for GECAFS.

Global Environmental Change (GEC) includes changes in the physical and biogeochemical environment (Figure 1), either caused naturally or influenced by human activities such as deforestation, fossil fuel consumption, urbanisation, land reclamation, agricultural intensification, freshwater extraction, fisheries over-exploitation and waste production.

Working within this broad definition of GEC, it is clear that GECAFS is concerned with more than just climate change. GECAFS, then, is set within the context of Earth System science and provides a common interest for IGBP, IHDP and WCRP.

Global Environmental Change (GEC) encompasses changes in the biogeophysical environment caused naturally or caused (or strongly influenced) by human activities. These may either manifest at the global scale (e.g. increasing atmospheric CO₂) or be occurring on a local scale but so widespread as to be a global phenomenon (e.g. soil degradation).

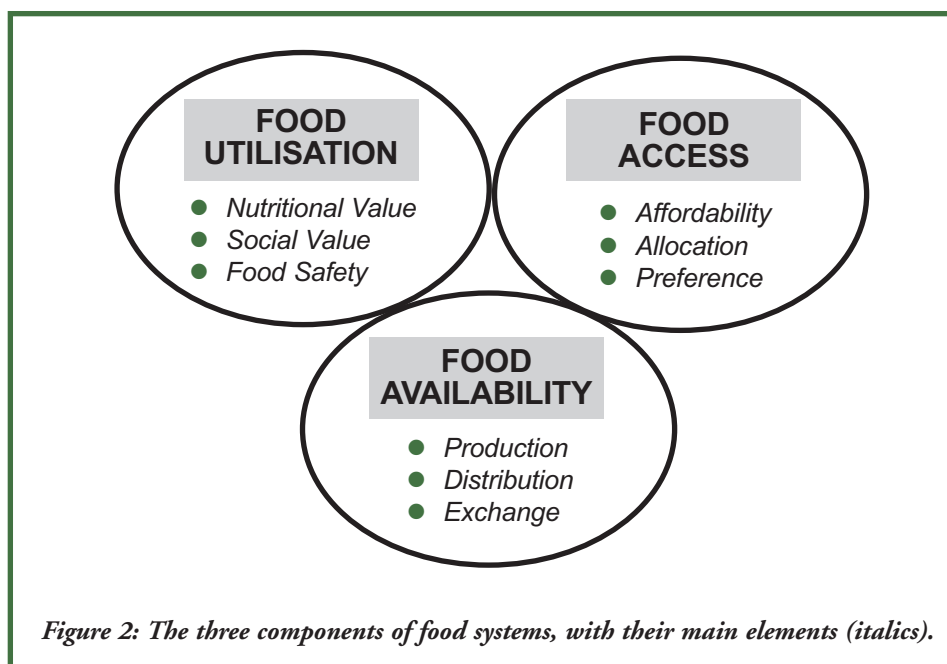
GEC includes, for example, changes in:

- Land cover and soils
- Atmospheric composition
- Climate variability and means
- Water availability and quality
- Nitrogen availability & cycling
- Biodiversity
- Sea currents & salinity
- Sea level

Figure 1: Definition of Global Environmental Change

Food systems are a set of dynamic interactions between and within the biogeophysical and human environments that result in the production, processing, distribution, preparation and consumption of food. They encompass (i) food *availability* (with elements related to production, distribution and exchange); (ii) food *access* (with elements related to affordability, allocation and preference); and (iii) food *utilisation* (with elements related to nutritional value, social value and food safety) (Figure 2).

Food security is underpinned by food systems. Food security is the state achieved when food systems operate such that ‘all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life’ (FAO, 1996). Food security is diminished when food systems are stressed. This can be caused by a range of factors in addition to GEC (eg conflict, changes in international trade agreements and policies, HIV/AIDS) and may be particularly severe when these factors act in combination.



2.3 Background questions and conceptual framework

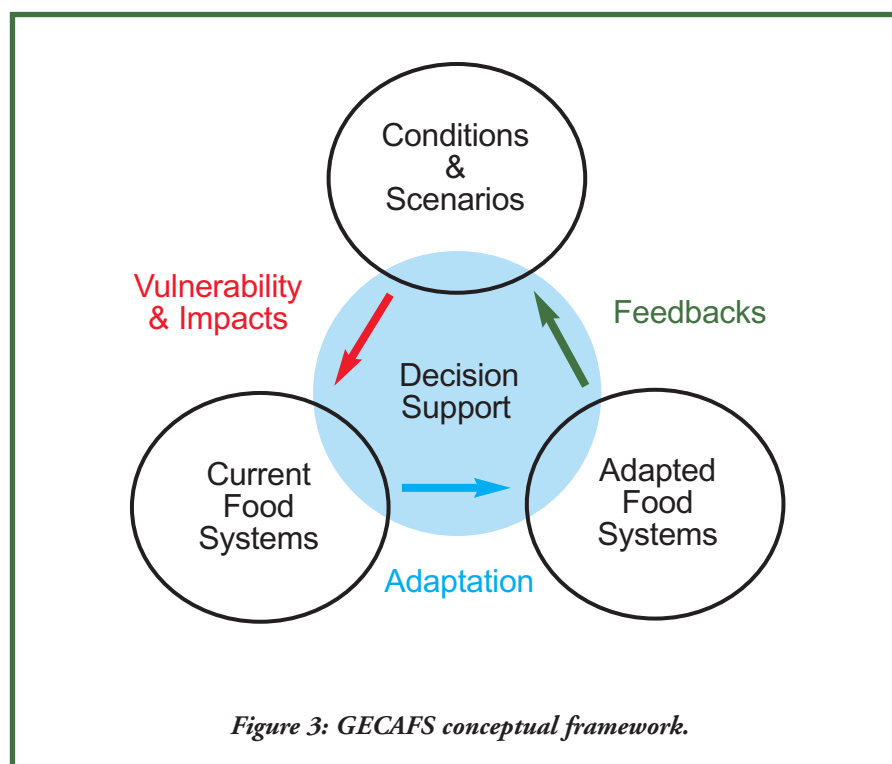
GECAFS has been developed in the context of three major questions of interest to science, development and society:

1. How will GEC affect the vulnerability of food systems in different regions?
2. How might food systems be adapted to cope with GEC so as to enhance food security?
3. How will various adaptation options feedback on environmental and socioeconomic conditions?

Addressing issues raised by these three questions (vulnerability, adaptation and feedbacks) GECAFS will undertake research on how GEC interacts with the three components of food systems that underpin food security (food availability, access and utilisation). This defines a clear niche for GECAFS within the panoply of international research projects on food and agriculture. The conceptual framework for the project is shown in Figure 3. This shows

that a relationship exists between current socioeconomic and environmental *conditions* and *current food systems*, and highlights the importance of their *vulnerability* to future *scenarios* of changed conditions. It also shows how policy and/or technical adaptation options to cope with the added stresses of GEC leads to adapted food systems; and that *adaptation* options will, in turn, feedback to socioeconomic and environmental conditions. Finally it highlights the importance of *decision support* in assisting with credible assessment of adaptation options, and especially in analysing their trade-offs between environmental goals (eg minimising damaging feedbacks to carbon budgets, the hydrological cycle and other components of the Earth System) and developmental goals (eg maximising positive feedbacks to food security, livelihoods and other socioeconomic conditions). Improved decision support systems are needed to help in designing and interpreting more quantitative analyses of trade-offs between environmental goals and developmental goals.

This framework for research will be developed through (i) projects that focus on underlying conceptual and methodological interests, and (ii) a series of regionally-based studies of food systems.



A wide range of sciences needs to be integrated to address the GECAFS agenda. Issues related to food *availability* are addressed by agricultural, ecological and climatological sciences; issues related to food *access* and food *utilisation* are largely addressed by social sciences, nutrition sciences and learning and communication sciences. Economists and policy analysts may work on a specific issue or investigate interactions and trade-offs across the entire food system. These disciplines need to be brought together to conduct research on the three inter-related GECAFS questions. This will lead to the development of interdisciplinary frameworks and methods to address scientific issues underlying the sustainability of food systems worldwide in the context of GEC. In addition to being of direct value to GECAFS, research output will also benefit IGBP, IHDP and WCRP Core Projects with interests in these topics, other ESSP Joint Projects and activities, and other collaborative agencies such as FAO, WMO and the CGIAR.

2.4 Conceptual and methodological issues

Building on the underpinning science of the three sponsoring Programmes, and that within bodies such as FAO, WMO and CGIAR, the GECAFS interdisciplinary approach to research will allow significant advances in four major conceptual and methodological issues:

1. Food systems research
2. Vulnerability of food systems research
3. Scenario construction
4. Decision Support Systems development

2.4.1 Food systems research

The main components of food systems (Figure 2) are each influenced by many factors that determine how the system actually operates in any given location at any given time. These determinants are both biophysical and socioeconomic (Figure 4). Food systems operate through interactions between determinants so as to provide food security (as defined in 2.2 above).

Research on food systems has been undertaken from a wide variety of perspectives and for a number of different purposes. These include, for example, energy analysis in food systems (Giampietro *et al.*, 1994); studies of globalisation of agro-food systems (Goodman 1997); developing a food and nutrition system conceptual model (Sobal *et al.*, 1998); analysing community food systems (Gillespie and Gillespie 2000); establishing an ecological viewpoint (Francis *et al.*, 2003); assessing vulnerability of food systems (Downing 2002); and an approach based on provision/consumption issues (Fine 2004).

Despite the variety of research approaches, none is ideally suited to GEC research as none provides an analytical framework specifically designed to identify those determinants of food systems most sensitive to GEC. Further, there are clear knowledge gaps about which determinants are most flexible for adaptation options, particularly at the regional level. There is also weak co-ordination between research, management and policy bodies to design robust food systems.

Food systems operate through connections between the

related determinants. Food security is compromised when GEC and other stresses disrupt given determinants, and/or the links between them. This undermines strategies aimed at sustainable livelihoods and perpetuates poverty. Food systems can however be adapted to reduce their vulnerability to GEC by (i) identifying which determinants are particularly sensitive to GEC; (ii) enhancing effective determinants and/or the links between them; and (iii) restoring disrupted determinants and/or the links between them. The determinants approach provides a framework for systematic research on the relationship between GEC and food systems for both present and future conditions.

Key GECAFS food systems research issues are:

- (i) Which parameters describe food systems so as to facilitate GECAFS research?
- (ii) Which parameters are most sensitive to GEC within given food systems?
- (iii) Who are the agents within each major food system, what are their roles, and how do they interact?

2.4.2 Vulnerability research

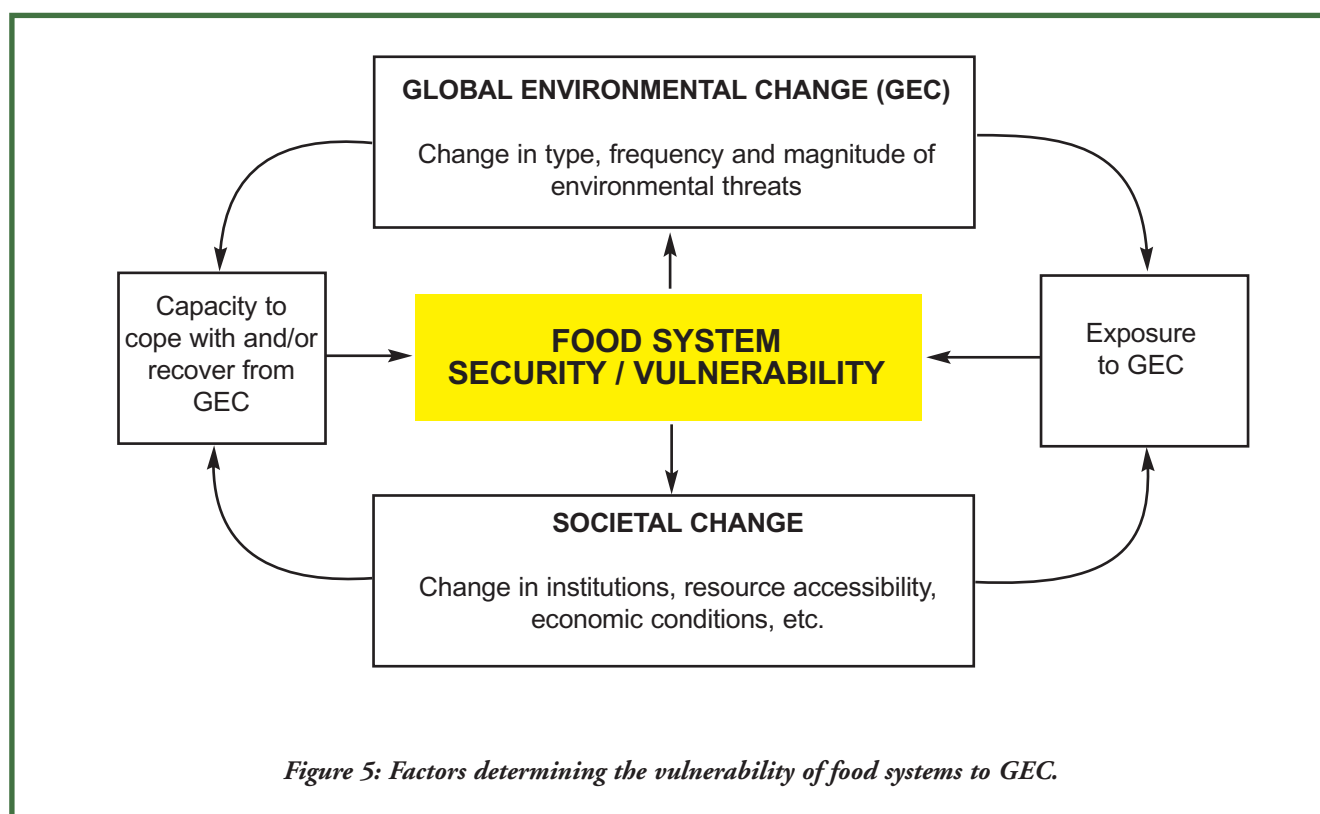
An improved understanding of food system vulnerability to GEC is a central component of GECAFS. It is important because the capacity to cope with existing variability in biophysical and socioeconomic systems, and the ability to

perceive GEC and adapt food systems, underpins food security.

Vulnerability research has, to date, typically been place-based and focused on either environmental or social vulnerability (Mustafa, 1998). A new approach to vulnerability studies specifically relevant to food systems research is needed. Environmental vulnerability refers to stresses originating from drought, storms and landslides and other such phenomena, often exacerbated by human-induced factors such as deforestation, land degradation, soil erosion, land and water pollution, etc. Social vulnerability relates to communities' lack of capacity to cope with and recover from all kinds of stresses, including, but not limited to, environmental stresses. Figure 5 (derived from Bohle, 2001; Brklacich & Bohle, 2004; Wisner *et al.*, 2004) shows how the vulnerability of food systems is not determined by the nature and magnitude of environmental stress *per se*. It is determined by a society's capacity to cope with, and/or recover from GEC, coupled with the degree of exposure to stress. While the coping capacity and degree of exposure are both related to environmental changes, they are both also related to changes in societal aspects such as institutions and resource accessibility (Adger, 1999). Finally, changes in the food system aimed at reducing vulnerability feed back to environmental and societal changes themselves. They may, for example, reinforce agricultural practices that either reduce or exacerbate land degradation and increase or reduce farm profitability. The research aim is to enhance understanding of

Socioeconomic	Biogeophysical
<ul style="list-style-type: none"> ● Advertising and media ● Customs, tastes and trends ● Food prices and household budgets ● Food standard regulations ● Labour availability and productivity ● Land policy and land tenure ● Market policies (input prices, credit and subsidies) ● Supply chain infrastructure ● Storage, processing and food preparation technologies ● Trade policies (border controls, international agreements) 	<ul style="list-style-type: none"> ● Appearance of food produced ● Bioavailability and bioefficacy ● Contamination and toxins ● Germplasm ● Natural resource base and productivity potential ● Nutrient content of food ● Plant and animal pests and diseases ● Primary processing ● Quantity and quality of food produced ● Seasonality of food produced ● Waste disposal and management

Figure 4: Example determinants of food system components.



how integrating concepts of food system social vulnerability to GEC with concepts from natural science can provide a more holistic approach to vulnerability studies in the context of GEC.

Initial work is focused on developing an improved theory to couple concepts of ecological and social vulnerability (eg Franklin, 2004; Shiferaw and Bantilan, 2004), developing integrated research methods (eg Downing *et al.*, 2004) and constructing case studies that can be synthesised across regions and food systems. It will build on previous research, which has focused largely on micro-scale issues, and adapt it for analyses at regional level that will characterise GECAFS food systems projects. Methods will be reviewed for determining present vulnerability of food systems to GEC and extended to allow assessment of future vulnerability based on integrated scenarios of GEC (see below). This work will be followed with research to design an integrated methodology suitable for GECAFS studies and evaluate it in the context of a number of the regionally-based food systems.

The GECAFS theme on vulnerability will draw upon existing research programmes and developments. The following are of particular relevance to the implementation of vulnerability assessment in GECAFS regional projects:

Livelihood-based food security assessments and future vulnerabilities. There has been considerable progress in employing human livelihood approaches to assess local food security over relatively short periods of time (Solesbury, 2003). These provide a foundation for GECAFS

vulnerability assessments but their applicability at regional scales and over longer timelines needs to be tested.

Multiple-stressors and vulnerability hot spots. Assigning weights to the multiple dimensions of vulnerability, particularly in their representation of stakeholders' different views and values, and in identifying consensus or conflicts in vulnerability mapping should be further explored.

Multi-level modelling. Understanding vulnerability and multiple stresses embedded in regional environmental and economic models provides a means to represent the exposure of vulnerable groups within more conventional regional assessments. In addition, global scenarios are poorly connected to the regional scale that interests GECAFS. Similarly, the global scenario driving forces are unlikely to represent the regional conditions and driving forces of food security.

Linking vulnerability to food security. Vulnerability assessments have typically focused on identifying communities and regions that are food insecure. They have not been designed to examine strategies promoting future food security. Merging vulnerability assessments with adaptation and resilience research provides an opportunity to provide explicit links between vulnerability assessments and the formulation of policies supporting future food security (Adger *et al.*, 2003).

Key vulnerability research issues relating to food systems are:

- (i) Which aspects of food systems (availability, accessibility, utilisation) are now most vulnerable to environmental stress and which stresses are most threatening?
- (ii) How might these vulnerabilities change and to what extent might GEC either heighten or mitigate these vulnerabilities?
- (iii) Which strategies, involving both the private and public sectors, will most likely reduce food system vulnerabilities and thereby increase food security?

2.4.3 Scenario construction

GECAFS is concerned with medium- to long-term prospects for food security in the context of GEC. Prediction involves considerable uncertainties and hence GECAFS studies will need to be set within clearly defined, plausible alternative futures – or scenarios – of biogeophysical and socioeconomic conditions. The overall research aim is to develop the conceptual frameworks and methods necessary to formulate a set of scenarios for researching the interactions between regional food systems and GEC. These scenarios will be specifically designed to assist analyses of possible policy and biogeophysical interventions for adaptation to GEC and will frame a set of manageable exploratory futures and contexts in which to undertake GECAFS analyses. They will also assist with developing better links between GECAFS, the GEC science community and regional/national policy-makers.

Global scenarios have already been successfully used to help reveal and address knowledge gaps about the plausible future interactions between GEC and a number of ecosystem goods and services, eg food or water availability or climate regulation (IPCC, 2000; ICIS, 2000; Alcamo, 2001; UNEP/RIVM, 2004). It has been difficult to down-scale global scenarios such as IPCC-SRES because they are relatively coarse in scale for particular regions or specific driving forces important for eg food systems analysis. Furthermore, there are no scenarios specifically designed to investigate the wider issues that underpin food security. Creating regional scenarios is not just a matter of downscaling. Some of the information in global scenarios (eg climate change projections) can be down-scaled for regional use, while other information will be new and will come directly from the region in question. To this end, GECAFS research will bring together regional knowledge and global

scenario exercises and draw on cross-scale linking (or nesting) methodologies developed by other research groups. This will deliver a product of direct relevance to the region in question.

The scenarios will encompass the factors affecting all aspects of food security and therefore represent key GEC (not just climate change) and socioeconomic changes. They will both help ensure full representation of these changes in GECAFS analyses and clarify regional development objectives. They will involve key components of the *food system* (eg availability, access and utilisation); the *socioeconomic conditions* (eg population, economic performance, technology, institutional arrangements and cultural variables); *climate* (eg analysis of current and future climate variability, as well as long-term climate trends, which will build on the improved climate descriptions of the last 45 years now being published); and *other biogeophysical conditions* (eg changes in land and water quality and availability).

Initial research needs to review and build upon relevant aspects of existing global scenarios to develop a small set of global storylines relevant to food systems research. Global scenarios will then be fine tuned and enriched to develop a consistent scenario set suitable for addressing the needs and interests of regional stakeholders. The list of key global drivers in global scenarios needs to be reduced to key drivers relevant to food systems. These are of principal relevance at the regional level, where some drivers are more measurable than at the global level, and where responses to scenarios will be quicker. Management options must be viable within the context of a given scenario, but it will be important to differentiate clearly between the scenario itself and possible management interventions.

Key scenarios research issues relating to food systems are:

- (i) What are the plausible changes in environmental and socioeconomic conditions that will affect food systems?
- (ii) What elements of global scenarios are most important for regional-level food system analyses?
- (iii) How best can global scenarios be linked to the regional scale so as to capture regional-level factors relevant to food systems?

2.4.4 Decision Support Systems development

Assessing the possible strategies for adapting food systems to GEC must be done with policy formulation and decision-making in mind. This needs much better collaboration between scientists, private sector decision-makers and the policy-making community. Decision Support Systems (DSS) help by providing a platform for dialogue between science and policy. The research aim is to develop, evaluate and refine innovative DSS to help analyse policy options by looking how they may feedback to the Earth System (included, for instance, changes in greenhouse gas emissions, soil erosion, water resource degradation and biodiversity loss), and to socioeconomic conditions (such as potential markets, labour migration and livelihoods).

Analyses of these socioeconomic and environmental trade-offs for different policy options will likely require purpose-built DSS based in part on innovative modelling approaches. GECAFS research will build on recent advances in systems approaches and simulation modelling (eg Kropff *et al.*, 2001) and on analyses of using model applications for analysing benefits from changed agricultural practice or policies (eg Meinke *et al.*, 2001). It will combine these with evaluation and assessment tools (eg Water Poverty Index; Sullivan *et al.*, 2002), revised concepts (eg food system vulnerability) and policy projections (regional, national and international). A range of dissemination mechanisms (eg policy briefs, printed maps and animations) will relate biogeophysical and socioeconomic conditions in GECAFS regional food systems projects with the policy goals.

In addition to decision support tools such as simulation models, GECAFS DSS development will also include interpretation and delivery mechanisms for discussion with policy-makers, resource managers and other stakeholders. It is crucial to engage these decision-makers early on in DSS development. DSS development therefore needs to build on research on how best to determine stakeholder information needs, and on communicating and interpreting output (ODI/RAPID, 2004). This will allow DSS to be used to help retrieve information, evaluate scenarios and in policy exercises that depend on multi-stakeholder negotiations, role playing, and a wide range of participatory scenarios.

Key DSS research issues are:

- (i) What is the best way to determine the information needs of policy-makers, resource managers and other stakeholders?
- (ii) How can DSS best be developed to help analyse the socioeconomic and environmental trade-offs of adaptation options?
- (iii) What is the best methodological approach to DSS development to optimise communication with stakeholders?



GECAFS DSS research products will help regional stakeholders both develop markets to satisfy consumer demand and maintain environmental integrity.

3 Implementation Strategy

GECAFS will implement its Science Plan in two principal ways:

- *International networks* for conceptual and methodological research on food systems, vulnerability analysis, scenario construction and decision support; and
- *Regional projects* for research on a range of food systems.

GECAFS research is implemented in phases over the 10-year life of the Joint Project.

Phase I entails scoping exercises to define researchable issues and prepare initial research proposals on each of the conceptual research themes and study regions. Phase I research is planned for completion by the end of 2005. Phase II is planned for completion by the end of 2008 and will deliver a number of interim methods and tools (as listed in section 1.3 above). Phase III research will build on Phase II to deliver the longer-term GECAFS objectives.

3.1 Conceptual and methodological research

GECAFS conceptual and methodological research lies at the project's core. A series of *multidisciplinary* workshops identifies the interdisciplinary GECAFS agendas on food system approaches, vulnerability research, scenario construction and decision support development. International research networks will be launched for each topic to bring together relevant, high-quality research from around the world and to conduct synthesis exercises to develop improved generic understanding. Networks will comprise scientists and institutions from the sponsoring ESSP Programmes' science networks, other partners (ie FAO, WMO, CGIAR) and other groups (eg SEI, MA) as appropriate. These networks will be open to all scientists with expertise to contribute and will allow a wide community of researchers to engage in GECAFS.

Each network will be co-ordinated by a dedicated GECAFS Science Officer working closely with a designated leading scientist on the GECAFS Scientific Advisor Committee (see

below) and with the Executive Officer. The GECAFS IPO will support network development, assist with fund-raising, facilitate liaison and information exchange among scientists collaborating on each topic, monitor progress and report to sponsors and donors, and maintain a web-based publications programme for disseminating intermediate outputs and research results.

3.1.1 Food system concepts and descriptions: implementation

Conceptual research will identify elements particularly sensitive to GEC.

Phase I: The main components of food systems detailed in Figure 2 will be analysed to produce a framework for describing food systems specifically designed for GEC studies.

Phase II: Conceptual research will deliver a clear baseline from which to describe a given region's food systems, within the framework of the standard GECAFS approach. It will form an important component of each regionally-based GECAFS food systems project (see below). Supported by a dedicated budget line in the regional projects, work will be conducted by regional scientists supervised by the regional project scientific steering committee. It will be assisted by designated members of the GECAFS Scientific Advisory Committee (SAC) and will contribute to the international network approach. In addition to laying the foundation for regional GECAFS studies, the product will be relevant to current policy formulation.

3.1.2 Vulnerability research: implementation

GECAFS research is based on integrating socioeconomic and biogeophysical factors contributing to the vulnerabilities of food systems (Figure 5).

Phase I: Initial planning centred on a multidisciplinary workshop hosted by the US National Academy of Sciences, Washington DC in January 2003 and follow-up discussions. This planned a major

literature review of both natural and social science research, with joint funding established from NAS and the ESRC. Initial work delivered a monograph (Franklin *et al.*, 2004) and methodological reviews (Downing *et al.*, 2004) covering concepts underpinning vulnerability in general, and of food systems in particular.

Phase II: Research will include designing new methods for GECAFS vulnerability analyses and their pilot applications. These will be trailed in Southern Africa, and will be closely linked to the Southern African Vulnerability Initiative (SAVI, funded by ICSU) and with other IHDP-GECHS initiatives in other regions. Collaboration will also be sought with the Resilience Alliance.

3.1.3 Scenario construction: implementation

Several groups have been engaged in constructing global scenarios including, for instance, SRES-IPCC, MA, World Water Vision of UNESCO and the World Bank, Global Scenarios Group of SEI and others, GEO-4 of UNEP, CGIAR-IFPRI, IIASA, European Environment Agency, FAO and the industrial/commercial sector (eg Shell). Working with these groups and relevant ESSP activities, the GECAFS strategy is to review and build upon the relevant aspects of these global scenarios to develop a core global scenario set to address the needs and interests of regional food systems research. GECAFS scenarios research started early in the project's timeframe to provide an agreed context for regional studies. Further sets of regional and local scenarios will be developed in the medium-term, fine tuned in respect of regional issues and conditions. These regional scenarios will be developed to be consistent with the global set so as to facilitate inter-regional comparisons.

Phase I: Based on a preliminary discussion meeting in August 2003 in Reading, UK and a short review paper of existing approaches prepared in early 2004 (Zurek *et al.*, 2004), research started with an international scoping workshop hosted by FAO in April 2004. A small team has been established to review different groups of scenarios to determine which are relevant and adaptable to help construct regional-scale GECAFS scenarios.

Phase II: This will start with an international workshop in 2005 to review Phase I output, especially with reference to regionally-based GECAFS food systems projects. Methods to identify and integrate necessary components to construct outline scenarios will be established, drawing on skills and tools from ongoing scenarios exercises (eg MA, GEO-4 and EEA) and within ESSP projects (eg WCRP-GEWEX experiments, and land-use projections from LUCC/GLP). It is anticipated that a prototype GECAFS regional scenarios for the Caribbean will be available by early 2006. Phase II will be developed in collaboration with IAASTD.

3.1.4 Decision Support Systems: implementation

GECAFS DSS research will be implemented in close collaboration with the regionally-based food systems research (see below) as DSS cannot be developed in the abstract. Research will involve several steps. First, stakeholder information requirements for improving policy formulation in a changing environment will be determined in consultation with policy-makers, resource managers and NGOs. This is a crucial initial step. Second, key biogeophysical and socioeconomic variables for DSS inputs and outputs will be defined and available models suitable for quantifying inputs and outputs reviewed. A wide range of crop and fisheries productivity models already exist. Further model development for cropping systems (which integrate crop, soil and possibly also pests) is envisaged (Porter *et al.*, 2005). When represented within GIS, cropping systems models can be used to assess the impacts of GEC on regional production. Next, the DSS conceptual framework will be developed, and processes and mechanisms for linking the regional models with the regional scenarios identified. Finally, regional-scale DSS will be developed and preliminary tests undertaken in a number of case studies.

Phase I: Each GECAFS regional food systems project will include initial workshops with stakeholders to establish the information requirements of stakeholders or end-users involved in formulating regional policy. These workshops will be followed by key informant interviews, focus group discussions, surveys and examination of policy documents at different scales. The dialogue with end-users will be maintained throughout the research implementation and reporting phases. This process allows a DSS research agenda to be designed to target stakeholder needs while also improving the understanding of DSS construction and implementation (see Box 2, below).

Phase II: Research on developing the DSS conceptual framework and linkages with regional scenarios will start with a review of current approaches to DSS design and be followed up with workshops and desk studies. Reviews and joint model comparison workshops with IGBP, IHDP and WCRP Core Projects, FAO, WMO and CGIAR, and other groups will assess models for use in analyses at regional scale; and prioritise aspects appropriate to regional conditions and DSS development. Regional workshops involving international DSS experts, collaborating scientists, and potential users will define specific input and output variables relating to DSS for the food systems in given regions. An analytical framework for developing regional-scale DSS will be developed based on the GECAFS food systems projects and demonstration workshops with stakeholders will be conducted using historical data to evaluate the DSS.



3.2 Regionally-based food systems research

The GECAFS strategy includes developing a small number of regionally-based projects representing a range of major GEC issues and food systems. These projects are designed at the sub-continental (meso) scale, which is an important spatial scale for food security, food system research and GEC considerations for several reasons. First, climate and weather-related perturbations are often experienced at the sub-continental scale and adaptation strategies may be applicable across more than one district or nation. Second, the adaptation strategies themselves may prove most effective if managed at the regional level, eg in terms of improved intra-regional trade, food storage and transport facilities. Third, some environmental management issues only manifest at this spatial scale (eg water resource depletion) and solutions to such problems may often require supra-national considerations. However, while many natural science issues are already being addressed at the meso-scale (Tyson *et al*, 2002a), social science theories, methods and data are often better developed at the micro- and macro-scales (Rayner and Malone, 1998). GECAFS regional research is helping to develop a more integrated approach at this important spatial scale.

Research at a sub-continental scale is therefore important in its own right and it also brings possibilities for collaboration with other GEC programmes working at similar spatial scales, eg ESSP Integrated Regional Studies (IRS) and START. Conducting research at this scale also means that it can address both rural and urban issues, and will fill a research gap between the many sub-national and national analyses of food production and food security (as conducted

by national governments and FAO, for instance) and those at the global scale (as conducted by IIASA, for instance). GECAFS regionally-based food systems projects will directly involve policy-making bodies mandated to work at the sub-continental level (eg CARICOM, for the Caribbean; SADC, for Southern Africa) thereby bringing together national studies and helping them to interact with regional organisations.

Regionally-based research will also provide an opportunity for capacity building by linking researchers addressing regional issues with others world-wide engaged in the GECAFS conceptual research agenda.

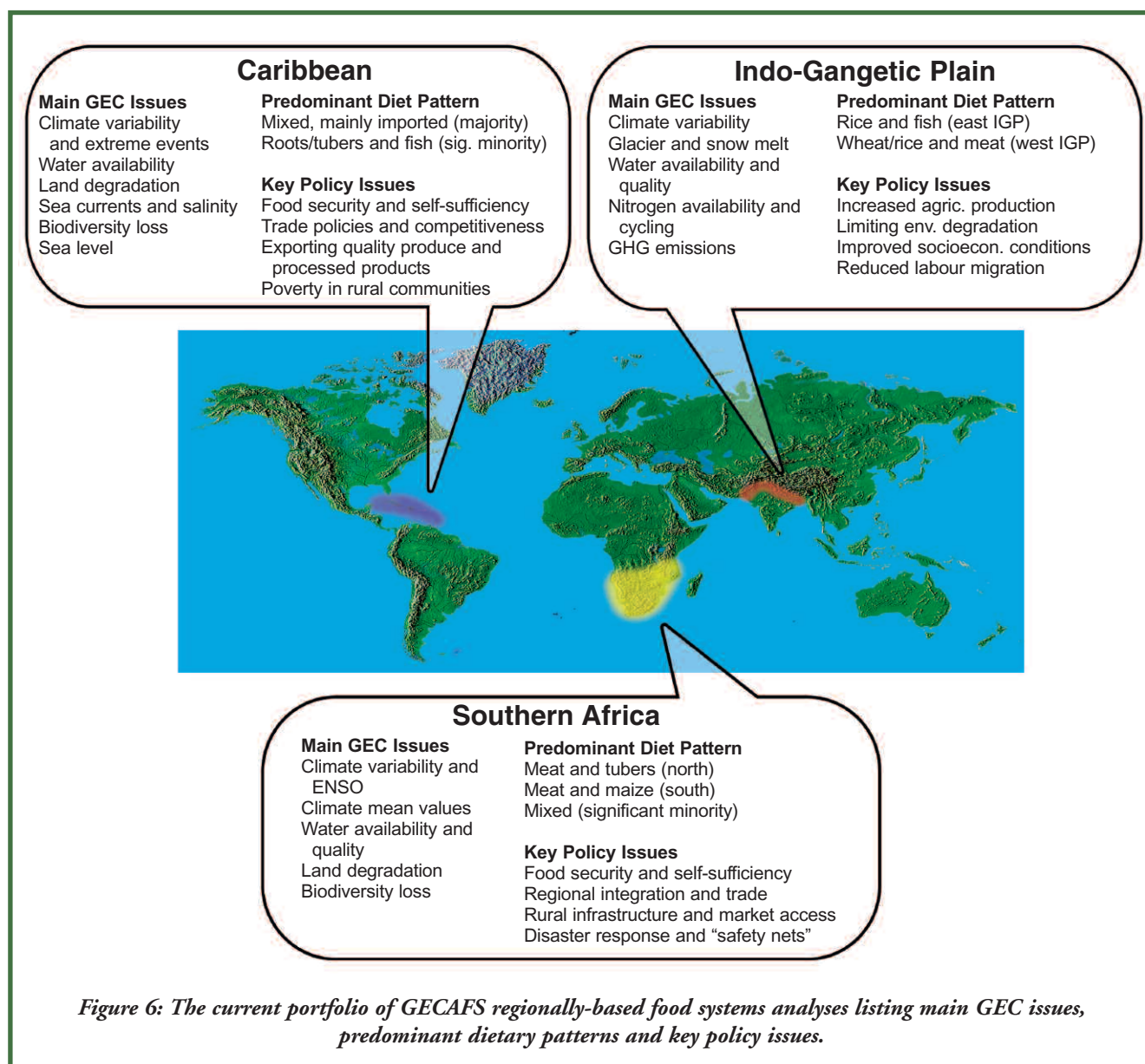
3.2.1 Selection criteria for regionally-based projects

GECAFS food systems projects aim to build a portfolio of research that satisfies two principal criteria:

- (i) coverage of a range of GEC issues; and
- (ii) coverage of a range of food systems.

Other factors influencing the priorities given to selecting a particular food system include (alphabetically listed) the potential for:

- links with other ESSP elements (eg Core Projects, other Joint Projects, IRS)
- links with strategic research partners (eg FAO, CGIAR)
- regional co-ordination/leadership
- results that contribute directly to regional development policy.



GECAFS regional research started by developing a limited set of projects (Figure 6). Based on these criteria above, the portfolio may expand once these initial projects are successfully established. Further regional activities will not necessarily be confined to the developing parts of the world.

3.2.2 Development of food systems projects

Each GECAFS regional food systems project will also be developed in a number of phases:

Phase I Project planning involves workshops, informal conversations and discussions with a wide range of potential stakeholders in the region. Key groups include scientists, policy-makers, NGOs and GEC scientists in ESSP Core Projects, and the process determines major regional science and policy interests. The results of these discussions are fed

back to the GECAFS Scientific Advisory Committee who then recommend scientific priorities and help identify possible collaborative links. Phase I output is prepared as a scientific paper for publication in the international literature. A proposal for Phase II GECAFS food systems research is drafted and a regional Scientific Steering Committee will be established.

GECAFS has completed Phase I for food systems research in the Indo-Gangetic Plain (Aggarwal *et al*, 2004) and is nearing completion for the Caribbean.

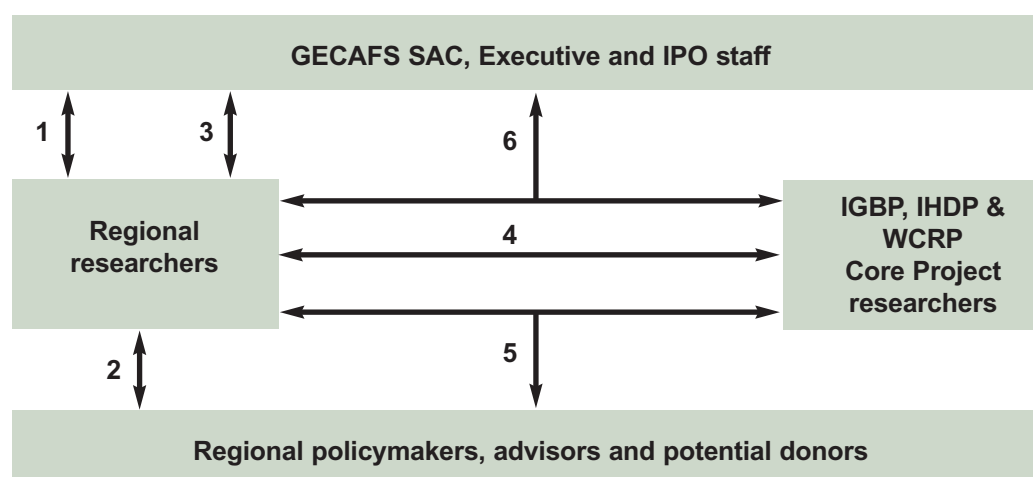
Phase II: Phase II research will start by describing the region's current food system(s) (based on the elements given in Figure 2) and current

environmental and socioeconomic conditions. This will provide the baseline upon which to develop both analyses of adapted food systems and scenario research. It is also a useful output for current policy formulation in its own right. Regional information from both local and international sources on current and projected socioeconomic and environmental conditions will be reviewed and form the basis for a prototype regional DSS.

Figure 7 maps the key steps in the phased process. Overall, the process promotes regional scientific involvement, increases science investment by regional policy-makers and raises awareness of GEC issues within the regional policy-making community, and helps build links with the Core

Projects of IGBP, IHDP and WCRP. The joint design of regional science agendas by regional scientists and Core Projects representatives fosters strong links between the two groups and helps develop both regional and Core Project agendas. It also helps with two-way capacity building.

Food systems projects will be managed by regional Scientific Steering Committees in close collaboration with the GECAFS IPO and a designated member(s) of the GECAFS Scientific Advisory Committee. GECAFS aims to continue raising funds for food systems projects from development and regional GEC-funding agencies. Annex 1 gives summaries of the rationale and research questions for GECAFS food systems research in the Caribbean and the Indo-Gangetic Plain.



- Step 1 Identify regional scientists interested in GECAFS interdisciplinary approach and establish GECAFS regional research group.
- Step 2 Working with regional scientists, identify regional policy interests and potential donors, and determine stakeholder information needs.
- Step 3 Working with regional scientists, develop GECAFS regional research questions.
- Step 4 Working with regional scientists and Core Project representatives, establish regional research/Core Project collaboration and jointly design and implement GECAFS analyses.
- Step 5 Working with regional scientists and Core Project representatives, deliver and interpret GECAFS results in policy context.
- Step 6 Integrate results with other regional studies to improve understanding of food systems and their vulnerability to GEC, scenarios and decision support.

Figure 7: Key steps in design and implementation of GECAFS regional food systems research.

3.3 Integrating conceptual and regionally-based research

Integrating conceptual and regionally-based research is central to GECAFS design. The GECAFS conceptual framework (Figure 3) provides the basis for this integration, and it is addressed during all phases of implementation.

The diverse environments found in the regional projects provide a framework for integrating conceptual and methodological research to help deliver improved generic understanding of each topic (Figure 8a). Emerging science and policy priorities as identified by national scientists and stakeholders in regional projects help define the conceptual research agenda (Figure 8b). This integration will develop over the research phases, mutually reinforcing each component. Box 1 details how this integration is envisaged, working ultimately toward the overall GECAFS goal.

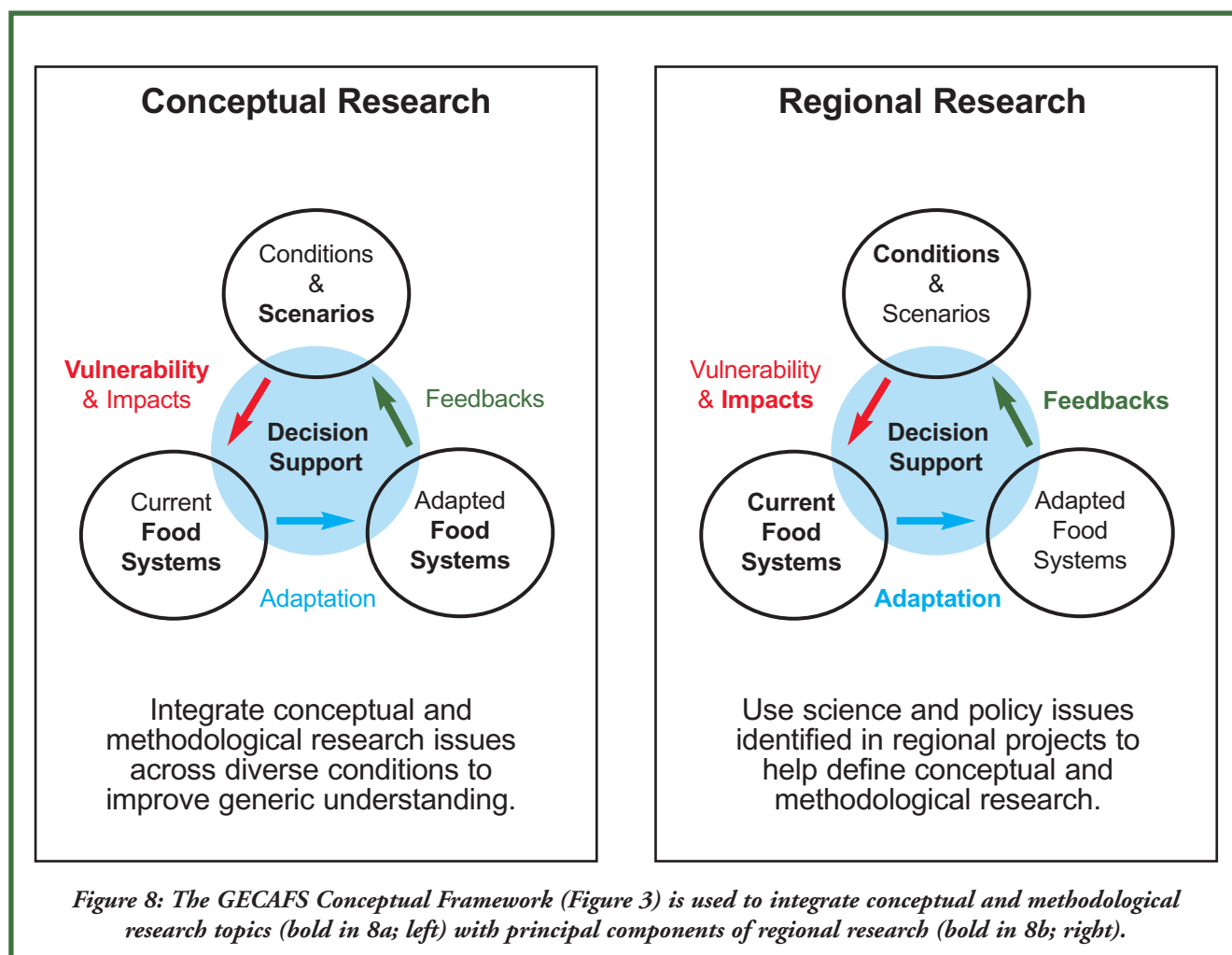
This integration approach is powerful as it uses the GECAFS conceptual framework to draw together, and add value to, what could otherwise be independent research efforts. The approach also provides an opportunity for capacity building by linking researchers addressing regional issues with others

world-wide engaged in the GECAFS conceptual research agenda.

The efficacy of this approach is already becoming apparent: initial planning and scoping for the GECAFS vulnerability studies has been conducted in the context of the emerging research issues for the Indo-Gangetic Plain, Caribbean and southern Africa, rather than in the abstract. This helped identify key issues for vulnerability research, and also highlighted aspects requiring more consideration in designing regional research.

Developing conceptual research in the context of regional issues is also enriching the overall conceptual research agenda by showing how different aspects interact. For example, conceptual developments in vulnerability are helping to identify key attributes of food systems regarding GEC, and the improved understanding of regional-scale scenario construction is helping shape DSS research and methodological development.

As well as helping to integrate the project's scientific aspects, the GECAFS design offers a new way to bring together GEC and food systems science with international development agendas at the regional scale. This has the overall twin goals



of reducing food system vulnerability to environmental stress – thereby improving food security prospects and improving environmental management. This type of integration has guided much of Phase I in GECAFS regional projects (Figure 7, Steps 2 and 3) and will be further built up as regional research proceeds, underpinned by GECAFS conceptual research. Integrating the science and development aspects also helps set a new agenda for improving the science-policy dialogue (see Box 2, below).

Workshops involving regional scientists and policymakers, and the broader GEC research community, supplemented by

follow-up interviews, are used to identify stakeholder information needs and to raise awareness of GEC issues: regional planning in the Indo-Gangetic Plain and Caribbean, and southern Africa has involved GEC scientists, and regional policy advisors and resource managers. This has helped highlight key GEC issues which have direct bearing on regional policy objectives related to food security, regional development and improved environmental management (see Annex 1). It has also helped the science community become more aware of regional policy priorities, the degree of perception policy-makers and their advisors have about GEC, and nature of the policy formulation process.

Box 1: Envisaged integration of GECAFS conceptual and regional research

Phase I: Preparation and scoping: clear research goals (years 1-3)

- | | |
|-------------|---|
| Conceptual: | Identify key aspects of conceptual research and establish main research goals based on current science agendas, regional GEC and socioeconomic issues, and policy objectives. |
| Regional: | Identify main information needs of regional and national planners and resource managers. Define researchable questions related to GEC and regional food systems (see Annex 1). Raise awareness of GEC issues in the policy community to help build stakeholder group. |

Phase II: Project start-up: assessment and synthesis of existing information (years 3-6)

- | | |
|-------------|--|
| Conceptual: | Review current understanding and develop improved concepts specifically related to GEC and food systems. Develop improved regional-scale scenario and DSS concepts and methods related to issues identified in regional contexts. Tailor research methods to underpin research related to regional food systems. |
| Regional: | Synthesise and assess current environmental and socioeconomic stresses on regional food systems. Develop prototype models, databases, and applications relating to GEC impacts, adaptation and feedbacks, and assess further information needs. Use regional priorities to guide scenario and DSS development. |

Phase III: Main analysis: science and policy contributions (Years 6-10)

- | | |
|-------------|--|
| Conceptual: | Improve understanding of food systems' vulnerability to GEC and refine methods to construct scenarios and DSS based on regional studies. Analyse concepts in a number of case study regions in order to improve generic and regionally-explicit understanding of the interactions between food systems and the Earth System, and improve insight into how GEC will additionally affect food security among different socioeconomic groups. |
| Regional: | Construct regional-scale decision support systems based on improved understanding of regional-scale scenario construction and the vulnerability of food systems to GEC. Analyse trade-offs of possible adaptation options. Use policy briefs, seminars and other policy-relevant science outputs explaining key issues and concepts to provide basis for improved policy formulation and environmental management. |

3.4 GECAFS in ESSP research and innovative partnerships

GECAFS is a Joint Project of IGBP, IHDP and WCRP (three major international GEC Programmes in the Earth System Science Partnership, ESSP). GECAFS has been developed to satisfy two essential principles:

- Principle 1: GECAFS research must concentrate on integrative issues of common interest to all three Programmes and develop research questions where interdisciplinarity is required.
- Principle 2: GECAFS research must draw together and build on relevant aspects of each Programme's Core Projects and, by linking these with appropriate inputs from other organisations, set them in a broader context of coupled human-environment systems.

GECAFS builds on ongoing ESSP research, helps set new ESSP agendas, and helps set IGBP, IHDP and WCRP Core Project research in the broader context of socioeconomic development. Because this requires innovative research partnerships, GECAFS has established formal research partnerships with the CGIAR, FAO and WMO. This helps set the precedent for formal collaboration between science and development agendas in GEC research and shows donors that such collaboration is underway. It also raises the priority of GEC issues in development agencies. Research collaboration is underway with the SEI and MA, and is anticipated with several other international research projects outside the ESSP. Figure 9 shows how GECAFS relates to the sponsoring Programmes' Core Projects; and examples of collaborations with other partners, organisations and initiatives. Examples of ongoing and potential collaborative GECAFS-ESSP issues are listed in Table 1.

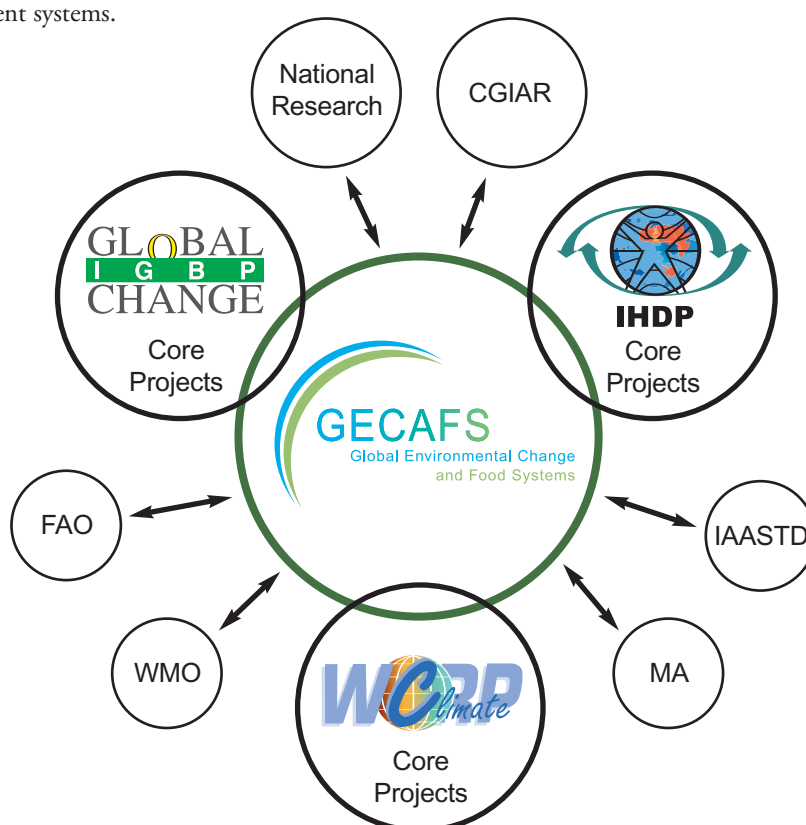


Figure 9: Relationship with ESSP Core Projects and examples of other collaborations.

3.5 Endorsing research

Many of the GEC Programmes' Core Projects have traditionally built up a portfolio of endorsed research. Studies to be endorsed in this way are submitted (often using some sort of *proforma*) and the Core Projects' SSCs then decide if the work is (i) relevant to the aims of the Core Project (or sub-component thereof) and (ii) of sufficient quality and standing. In this way a collection of otherwise disparate pieces of research can be networked (with varying degrees of

formality) so as to help deliver the Core Project's overall aims and to enlarge the community. The *quid pro quo* is that the researchers can collaborate more widely (GECAFS will link together researchers in endorsed projects), and may often be able to use the endorsement to help raise more funds.

GECAFS proposes to endorse contributions to its research programme as follows:

3.5.1 Endorsing conceptual and methodological research

GECAFS will endorse relevant, high quality research from around the world which addresses issues related to the conceptual and methodological research agenda; ie on food systems; vulnerability; scenarios and DSS, as outlined in the GECAFS Science Plan. Endorsing such research will help bring together wide-ranging approaches and joint synthesis exercises etc. Principal Investigators would comprise a GECAFS network which would enlarge the GECAFS science community. The relevant GECAFS Science Officer will be closely involved in identifying such research.

3.5.2 Endorsing regional research on GECAFS themes

GECAFS will endorse relevant, high quality disciplinary and interdisciplinary research aspects directly related to one of the GECAFS regional projects. Contributions must contribute directly to one or more of the three themes (Vulnerability/ Impacts, Adaptations, Feedback), and – when integrated – must benefit the GECAFS regional effort. The relevant GECAFS Regional Steering Committee will be closely involved in identifying such research.

Table 1: Example potential collaborations between GECAFS and selected ESSP elements

ESSP element	GECAFS Conceptual Research				GECAFS Regional Research		
	Food systems	Food system vulnerability	Scenario construction	Decision support	Indo-Gangetic Plain	Caribbean	Southern Africa
IGBP-GLOBEC		Vulnerability of coastal fisheries communities		Resource managers' information needs		Fisheries dynamics	
IGBP-LOICZ II				Coastal system sustainability	Changes in river discharge	Basin scenarios	
IGBP/IHDP LUCC/GLP	Crop production patterns		Land use change models	Feedbacks to Earth System and Thresholds	Cropping system		Rangeland resource tenure systems
IHDP-GECHS		Cumulative change and human vulnerability		Assessment of cumulative vulnerability and human security		Vulnerability relating to preferential trade change	SAVI
IHDP-IDGEC	Institutional adaptability (opportunities and risks)		Future world and regional trade conditions			Preferential world trade agreements; Fisheries EEZ	
WCRP-CLIVAR			Seasonal to inter-annual prediction and coupled modelling		Asian-Australia Monsoon panel	Describing current climate patterns	Extending and improving ENSO predictions
WCRP-GEWEX			Regional monsoon regimes	Inputs for irrigation planning and feedback to the water cycle	Asian-Australia Monsoon panel		
GCP		Differential vulnerability to changes in the carbon cycle		Feedbacks to the carbon cycle	Intensification and methane emissions		Range management, fire and carbon dynamics
GWSP	Regional water use	Impact of water diversions on food security	Water use futures		Water quality and agricultural intensification		Ground water assessments
GECHH	Nutrition						

4 GECAFS Products

4.1 Science products and outputs

GECAFS has already delivered a number of science products including a major paper requested by ICSU for the WSSD in 2002 (ICSU, 2002); a multi-authored paper on information needs for the Indo-Gangetic Plain (Aggawal *et al.*, 2004); a monograph describing vulnerability concepts in relation to GEC (Franklin, 2004); and an information brief for CARICOM's Ministerial Conference (COTED). The delivery of a range of products designed for both science and development end-users shows clear added-value of the project's philosophy and the mutual benefit of interaction with Core Projects and non-ESSP collaborators.

In the 3-5 year time frame the integrated GECAFS approach will deliver a wide range of science outputs, eg:

- Enhanced concepts of food systems and frameworks for analysing vulnerability specifically designed for GEC studies.
- Regional assessments and characterisation of food systems including biogeophysical and societal issues.
- Improved understanding of food system vulnerability to GEC, based on case studies.
- Comprehensive, regional scenarios of future socioeconomic, environmental and ecological conditions involving the food system;
- Decision Support Systems and other tools to aid policy-makers' decisions in response to GEC.
- Analyses of changing human wealth, food preferences and interactions with biogeophysical GEC models to produce new insights of regions where food systems may be sensitive to GEC.
- Use of past records of social adaptations to biogeophysical changes to provide inputs to scenario-based models of the future.

- New insights in research design for "science to aid policy development".

These will be delivered in:

- Scientific output in peer-reviewed literature, complemented by adopting new methods in regional case studies;
- Reports containing standardised descriptions and analyses of regional food systems and factors affecting them;
- Guidelines on stakeholder involvement in GEC research on food security;
- Policy briefs and better consideration of environmental and socioeconomic feedbacks in policy formulation; and
- Two-way capacity building both between Core Projects and regional research communities, and between social and natural sciences.

GECAFS plans to deliver a number of fast-track products. These will include:

- A food systems research approach designed for GEC research;
- Policy briefing papers detailing critical GEC issues relating to regional food systems;
- Conceptual frameworks for Phase II regional research; and
- Assessment and review reports of ongoing regional research, for developing GECAFS research.

In the longer-term GECAFS aims to deliver the necessary tools and analyses to achieve its goal.

4.2 Assessing overall success

The project's overall success will best be assessed by determining how GECAFS research improves understanding of the complex relationships between GEC and food systems, and in turn how this improved understanding leads to reduced vulnerability of food systems and enhanced environmental governance. However, it will take some years for the full impact of the project to be fully apparent. In the meantime, an indicator will be the adoption of new concepts, methods and tools by the science and policy-making communities, and the heightened awareness of GEC issues. The GECAFS research process and the effectiveness of delivering policy-relevant research will be assessed to

determine the efficacy of its interdisciplinary research design. This can be done with a combination of internal reviewers (ie Scientific Advisory Committee members) and external reviewers (eg leading scientists familiar with the policy debate, technical advisors for policy formulation and development experts). Best practice will then be communicated to all participants and other interested parties. The GECAFS Communication Strategy (see section 5.2) will be designed to help deliver this potentially key output from the project, and to publicise and capitalise upon the benefits that the GECAFS approach brings to GEC science.



E. Marni/UPAO

5 Linking GEC science with the policy-making process and resource managers

The aim of delivering science to inform agencies' policy decisions raises an initial question which has guided GECAFS conceptual development:

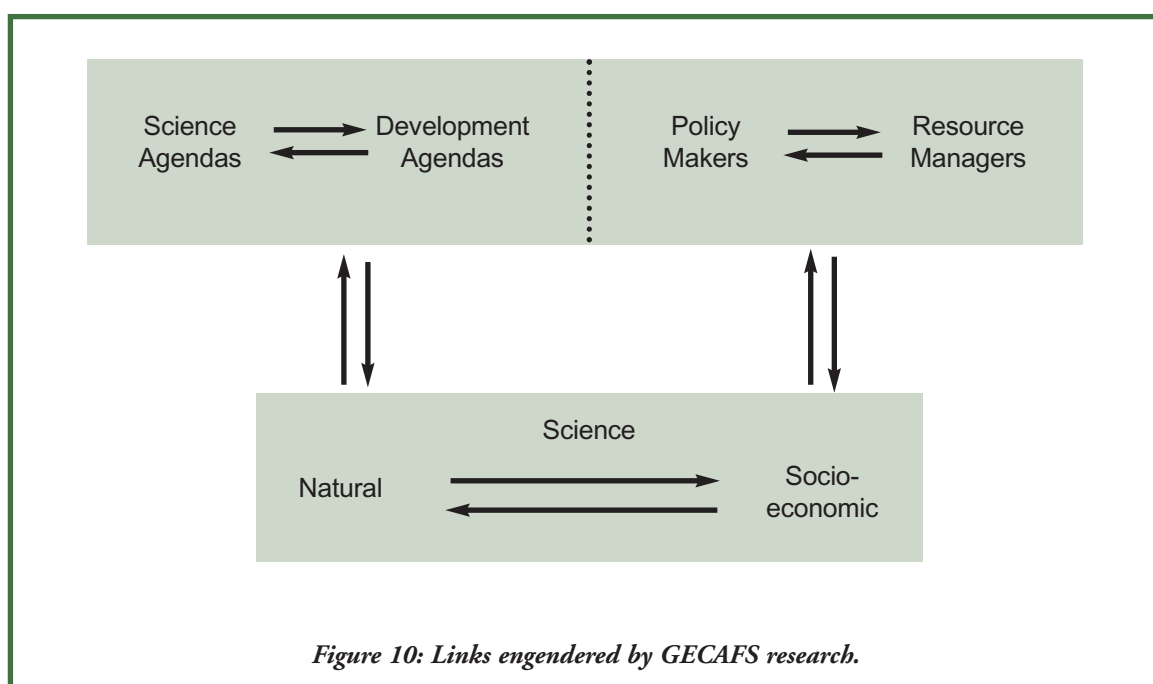
Within the context of global environmental change, what are the regional policy issues and what interdisciplinary science can GECAFS undertake and deliver to strengthen policy formulation?

5.1 Defining science questions relevant to policy formulation

The agendas of natural and social sciences within the GEC community have been relatively isolated from one another and this has limited the policy relevance of GEC science output. In addition, the GEC community has traditionally viewed interacting with the policy community as something to do during a project's later phases when synthesising major products. This has limited the full adoption of major

scientific projects and programmes' results. Establishing information needs of policy-makers and resource managers, translating these requirements into relevant science questions and delivering results in a useful way to policy formulation are challenging tasks. GECAFS aims to address this by developing the science-policy interface as an integral part of its science agenda. This is part of the project initiation process and is ongoing. Figure 7 sets out the initial stages in developing a policy-relevant regional project. Figure 10 outlines the broad linkages that will allow GECAFS to work with the science and development policy communities, and communicate its findings to influence public environmental and food security programmes.

Within a given region GECAFS aims to find constructive ways of engaging with ongoing food security activities. Box 2 summarises the complex set of stressors affecting food systems in southern Africa and gives examples of key initiatives addressing food security in the region.



Box 2: Engaging with regional food security initiatives: an example based on southern Africa

The need to increase food availability in southern Africa could be satisfied by increasing within-region supply (Scholes and Biggs, 2004), and/or by imports. Food security is however also underpinned by food access and utilisation. Availability will not necessarily be improved due to a poorly-functioning agricultural sector, inappropriate government policies and actions, widespread poverty and the HIV/AIDS epidemic. Stressors, including erratic weather, contributed significantly to the 2001-2002 food crisis in the region (USAID, 2003), but while agroecological approaches offer some promise for improving yields, improving food security necessitates broader considerations including major socioeconomic issues (Rosegrant and Cline, 2003).

In addition to socioeconomic stressors, GEC is further complicating an already food-insecure future for many, and will further compromise the ability to achieve regional food self-sufficiency. Key issues are changes in climate variability, in water resources and in rangeland condition (Hulme et al, 1996; Tyson et al, 2002b). Enhancing food security while limiting further environmental degradation is a priority for the region's national and regional policy-makers and planners (SADC-RISDP, 2003), but the complex interactions between the stressors on the region's food systems challenge effective policy formulation and resource management.

The GECAFS approach of analysing the interaction between GEC and the region's food systems can help deliver greater understanding of the factors underlying several critical food security problems. To be effective in delivering quality science to help improve policy formulation, research must address an agenda set not only by the region's GEC scientists, but also by policy-makers, resource managers and NGOs. To this end it is important to note that other processes related to food security are underway in the region, and that they are intended to consolidate lessons learned from the recent crisis and to ensure continued dialogue between policy and research. These include:

- Regional and national Vulnerability Assessment Committees (VACs), which are finalising a five-year plan.
- The South African government interest as a donor on regional food security issues, as seen in its recent (2004/05) support to FAO and the World Food Programme.
- Development of the eight agency UN RIACSO in Johannesburg, coupled with the development of the UN document on The Triple Threat (food insecurity, weakened capacity for governance and HIV/AIDS) (UN/CEBC, 2003).
- SADC's role and interests in food assessments and options for adaptation to GEC, expressed through its Directorate for Food, Agriculture and Natural Resources (FANR).
- The Forum for Food Security in southern Africa, with its focus on policy issues.

In addition to interacting with the region's science community, GECAFS research is designed to recognise regional processes and initiatives by inviting the people involved to contribute to research planning and DSS development. This helps to ensure that local and regional institutions are engaged in developing the science strategy and play an active role in the research process. This will, in turn, help establish a science agenda which is more effectively tuned to the region's needs.

5.2 Communications

GECAFS uses communication techniques including formal workshops, policy paper reviews and technical guidelines, and one-to-one interviews conducted by regional scientists. Research planning workshops and web-based communication bring the research and policy communities together around the research questions (Figure 7, Step 4).

Research outputs will be communicated to the policy, environmental and resource management communities in a variety of ways. Reports on key GECAFS topics, such as

vulnerability and characterisation of regional food systems, will be prepared and disseminated through policy briefs and seminars (Figure 7, Step 5). Decision Support Regional scientists, with input from other partners, will lead in developing systems with regional and state policy-makers as a key communications aspect. Further communication techniques will include regional, policy-relevant discussions with end-users and media coverage in targeted outlets (eg policy fora).

6 Funding Strategies and Governance

6.1 Funding Strategy

The science approach is underpinned by an innovative funding strategy aimed at science agencies (the traditional investors in GEC research) and development agencies. This means that a wider range of funding sources can be engaged, a fact which the donor community welcomes in that it helps them support research.

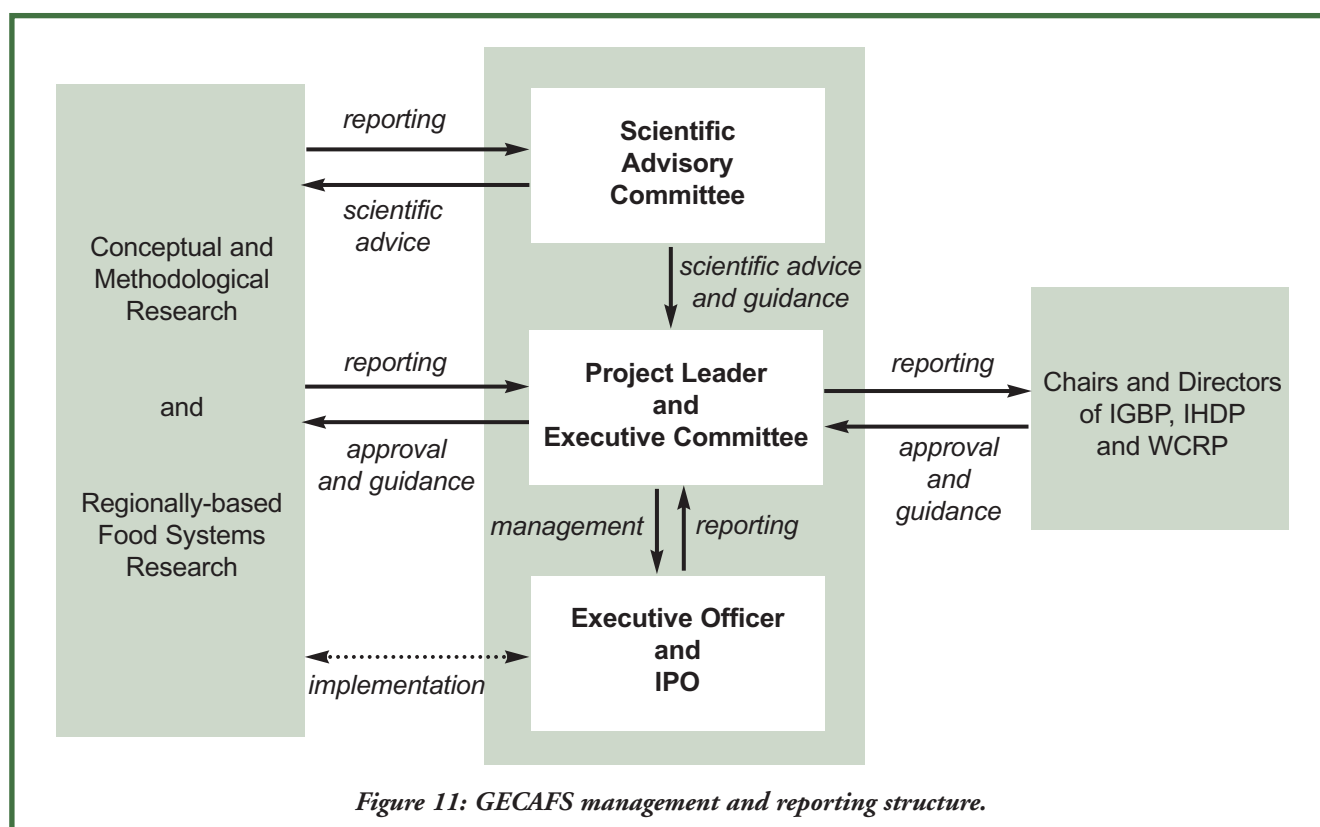
Core funds are currently provided from the sponsoring Programmes, the IPO host institution (UK-NERC) and other IGFA-related agencies. These are needed to support the scientific management of the project. Research funds are sought from a wide range of agencies interested in both science and development agendas.

6.2 Governance

GECAFS has a three-level management structure to support its innovative approach: Scientific Advisory Committee, Executive Committee and Executive Officer/IPO. Each has a clear and distinct role (Figure 11).

6.2.1 Scientific Advisory Committee

The Scientific Advisory Committee (SAC) provides overall guidance. In particular it oversees the development of an active science programme; receives reports from GECAFS conceptual and regionally-based food systems projects; and prioritises the science programme's activities. The SAC considers the big picture and needs a wide combination of skills and affiliations in order to offer robust advice on strategic direction.



The SAC comprises 12 scientists from a range of science communities (Table 2). It includes the GECAFS Chair, Vice-Chair and Executive Officer, and a representative from each region where GECAFS regional food system projects are located. These 12 members are invited in their personal capacities, with approval of the IGBP, IHDP and WCRP Chairs and Directors. The SAC also includes a nominee from each of GECAFS' strategic research partners (CGIAR, FAO and WMO). Finally, the SAC includes invitees from different types of funding agencies interested in GECAFS research. These individuals are invited in their personal capacities to contribute to the general scientific discussion, and to liaise with the different types of agencies.

6.2.2 Executive Committee and links to sponsoring Programmes

The Executive Committee oversees implementation and administration issues. It is supported by an Executive Officer and an International Project Office (IPO) to co-ordinate tactical aspects of the whole project, including funding. The IPO is hosted by the Centre for Ecology & Hydrology (part of NERC) in Wallingford, UK.

The Executive Committee includes the GECAFS Chair, Vice-Chair and Executive Officer plus one representative from the IGBP Scientific Committee, the IHDP Scientific Committee and the WCRP Joint Scientific Committee. The Programme representatives' role is to help maintain the links to each Programme's core science (GECAFS Principle 1) and to assist communication between the Executive and the respective programmes' SCs/JSC. The Executive Committee also includes a representative from each of the IGBP and IHDP Secretariats to help with implementation issues.

The Executive Committee meets formally about every six months and all members are invited to attend the annual Scientific Advisory Committee meeting.

Table 2: GECAFS SAC membership (as of April 2005)

General members (12)

Dagoberto Arcos	Fishery Research Institute	Chile
Mike Brklacich <i>Vice-Chair</i>	Carleton University	Canada
Angela Cropper	Cropper Foundation	Trinidad & Tobago
Peter Gregory <i>Chair</i>	Scottish Crop Research Institute	UK
Barbara Huddleston	UN-FAO	USA / Italy
John Ingram <i>Secretary</i>	GECAFS IPO, Centre for Ecology & Hydrology	UK
Saleemul Huq	International Institute of Environment and Development	Bangladesh / UK
Jim Jones	University of Florida	USA
Linda Mearns	National Center for Atmospheric Research	USA
Richard Mkandawire	New Partnership for Africa's Development	Malawi / South Africa
Mahendra Shah	International Institute for Applied Systems Analysis	UK / Austria
Luis Vieira	EMBRAPA	Brazil

Partner organisation nominees and donor community representatives

David Hess	US-Agency for International Development	Bi-lateral agencies
Oran Hesterman	WK Kellogg Foundation	Foundations
Ray Motha	US-Department of Agriculture	WMO nominee
Prabhu Pingali	UN-FAO	FAO nominee
Mark Rosegrant	International Food Policy Research Institute	CGIAR nominee

1 Annex

Examples of regionally-based food systems research

GECAFS Caribbean research

Changes in climate and other important environmental factors are a major concern to food security throughout the Caribbean. Such changes not only directly threaten the production of food from land and sea for local consumption, but also threaten revenue from export crops and other industries, which is needed to import food. Together, both factors will bring added complications for food security in the region.

Regional features

The Caribbean region is characterised by many small island states with diverse cultures, environments and food systems. They import about three quarters of their food from outside the region and largely rely on tourism and export crops to

provide revenue. The region is therefore susceptible to weather extremes and changes in preferential export markets. Regional institutions are only weakly connected.

Regional policy priorities

Regional policy priorities to limit the economic damage of changing international markets, balanced in part by tourism, include:

- Better food security and self-sufficiency by increasing and diversifying agricultural and fisheries production.
- Improved trade policies and competitiveness through exporting more high quality produce and processed products.
- Enhancing sustainability of the food and agricultural sector and alleviating rural poverty by creating more rural employment.

Research questions - Caribbean

National-level

How would changes in climate variability (and especially extreme events), water availability and sea level affect local communities' food systems?

How would national and regional policies best be adjusted to enhance adaptation options?

To what extent would these strategies affect food security by altering the reliance on local or imported commodities? How would changed land management and associated changes in runoff affect coastal fisheries and other aspects of coastal zone ecology, including the income from tourism?

Regional-level

How might GEC alter agricultural revenues and destabilise the region's food system?

To what extent would improving trade between islands improve the resilience of the food system?

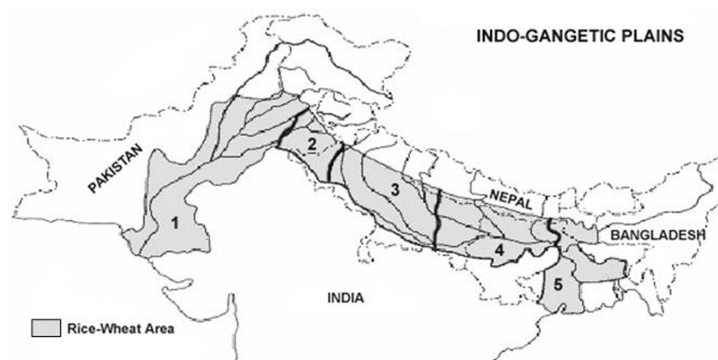
How would enhanced regional trade affect national economic development and natural resource conservation?

GECAFS Indo-Gangetic Plain research

The food systems in the Indo-Gangetic Plain (IGP) are largely dependent on rice and wheat grown in rotation. As seasonal weather greatly affects yield (by directly affecting crop growth and indirectly affecting management), there is concern that changes in climate, especially changes in climate variability, will exacerbate the observed trend. Moreover, the highly-intensive production in large parts of the region is a major source of greenhouse gases and is seriously degrading regional water supplies.

Regional features

The western region (sub-regions 1, 2 and 3) is a food surplus region characterised by higher investment, high productivity, heavy use of fertilisers and ground-water for irrigation, and an influx of labour. In contrast, the eastern region (sub-regions 4 and 5) is a food deficit region characterised by low productivity, low inputs of fertilizer and water, risk of flooding, poor infrastructure and labour emigration.



Regional policy priorities

Policy priorities for both regions are:

- Enhance agricultural competitiveness while limiting further environmental degradation;
- Develop food systems which enhance the social security of the more vulnerable; and
- Create more rural employment opportunities to reduce labour migration and urbanisation.

Research questions - Indo-Gangetic Plain

Western region

How do climate change and increasing non-farm demands for water affect water supply and demand and the resulting vulnerability of the food system?

How can changes in water management (eg through better policies, landuse strategies and community participation) and energy-efficient technologies reduce food system vulnerability to climate variability and other environmental change?

How will alternative approaches to resource-conservation affect rural livelihoods, intra-regional trade, carbon sequestration, greenhouse gas emissions, and water tables?

Eastern region

How will resource-poor farmers' vulnerability to flooding and drought be affected by environmental change, and how will this exacerbate socioeconomic inequities?

What early warning systems would help stakeholders identify regions of potential insecurity? What infrastructure options need to be developed to diversify crops and so better use flood and groundwater? What are the social constraints to their adoption?

How would diversification and increased government interventions affect food systems, rural income, equity, labour migration, employment, water use and quality, biodiversity, and greenhouse gas emissions?

2 Annex

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3 Annex

Acronyms and abbreviations

CARICOM	Caribbean Community and Common Market	IGBP	International Geosphere-Biosphere Programme
CGIAR	Consultative Group on International Agriculture Research	IGFA	International Group of Funding Agencies
CLIMAG	Climate Prediction and Agriculture (of START)	IHDP	International Human Dimensions Programme of Global Environmental Change
CLIVAR	International Research Programme on Climate Variability and Predictability	IIASA	International Institute for Applied Systems Analysis
COTED	CARICOM Council for Trade and Economic Development	IIED	International Institute for Environment and Development
DSS	Decision Support System	IPCC	Intergovernmental Panel of Climate Change
EEA	European Environment Agency	IPO	International Project Office
EEZ	Exclusive Economic Zone	IRS	Integrated Regional Studies (of ESSP)
EMBRAPA	The Brazilian Agricultural Research Corporation	JSC	Joint Scientific Committee (of WCRP)
ENSO	El Niño Southern Oscillation	LOICZ II	Land-Ocean Interactions in the Coastal Zone
ESRC	Economic and Social Research Council	LUCC	Land Use/Cover Change
ESSP	Earth System Science Partnership (of IGBP, IHDP, WCRP & Diversitas)	MA	Millennium Ecosystem Assessment
FAO	Food and Agriculture Organisation of the UN	NCAR	National Center for Atmospheric Research of the USA
GCP	Global Carbon Project	NEPAD	New Partnership for Africa's Development
GEC	Global Environmental Change	NERC	Natural Environment Research Council
GECAFS	Global Environmental Change and Food Systems	NGO	Non-Governmental Organisation
GECHH	Global Environmental Change and Human Health	OECD	Organisation for Economic Co-operation and Development
GECHS	Global Environmental Change and Human Security	SAC	Scientific Advisory Committee
GEO	Global Environment Outlook	SADC	Southern African Development Community
GEWEX	Global Energy and Water Cycle Experiment	SAVI	Southern African Vulnerability Initiative
GIS	Geographic Information Systems	SC	Scientific Committee (of IGBP or IHDP)
GLOBEC	Global Ocean Ecosystem Dynamics	SEI	Stockholm Environment Institute
GLP	Global Land Project	SRES	Special Report on Emissions Scenarios
GWSP	Global Water Systems Project	START	SysTem for Analysis, Research and Training
IAASTD	International Assessment of Agricultural Science and Technology for Development	UNEP	United Nations Environment Programme
ICSU	International Council for Science	UNESCO	United Nations Educational, Scientific and Cultural Organization
IDGEC	Institutional Dimensions of Global Environmental Change	USAID	United States Agency for International Development
IFPRI	International Food Policy Research Institute	NAS	National Academy of Sciences
IGP	Indo-Gangetic Plain	WCRP	World Climate Research Programme
		WMO	World Meteorological Organisation of the UN

4 Annex

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Scientists are invited to participate
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