

GECAFS Report No. 5



Global Environmental Change and **Food Systems**



Indo-Gangetic Plain Science Plan and Implementation Strategy



GECAFS Report Series

1. Science Plan and Implementation Strategy (also ESSP Report No. 2)
2. Caribbean Prototype GEC/Food System Scenarios
3. Southern Africa Science Plan and Implementation Strategy
4. Caribbean Science Plan and Implementation Strategy
5. Indo-Gangetic Plain Science Plan and Implementation Strategy



Global Environmental Change and Food Systems

Indo-Gangetic Plain Science Plan and Implementation Strategy

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Executive Summary

Social, economic and political factors are increasing food insecurity in the Indo-Gangetic Plain (IGP). Global environmental changes (GEC) are further complicating what is already a food insecure situation for many, and the technical and policy interventions required to enhance the region's food security must take account of GEC.

A three-year consultation and planning exercise identified the need for, and necessary components of, an integrated research endeavour on the links between IGP food security and GEC. The exercise, organised by the international research project Global Environmental Change and Food Systems (GECAFS), involved a diverse group of regional researchers, and regional and international organisations and donors, and culminated in the preparation of this Plan for a GECAFS IGP project (GECAFS-IGP).

Recognising and building upon ongoing national and regional GEC and food security research, the Plan provides a strategy to deliver policy-relevant information about the interactions between GEC and the food systems that underpin food security. Research will contribute to a number of major food security initiatives in the region and support both local interests and those of major regional activities (e.g. CARICOM, FAO). It will constitute an integral component of the internationally-endorsed GECAFS agenda.

GECAFS-IGP research is identifying the social and geographical distributions of vulnerability of the region's food systems to GEC in the context of other stresses. Based on these new insights it will determine how, when and where adaptations to food systems to reduce their vulnerability to GEC can be instituted in line with long-term national and regional developmental goals. It will also assess the long-term social and environmental consequences of different adaptation measures adopted to enhance regional food security. In addition to addressing regional priorities, proposed research is also fully consistent with the international GECAFS conceptual and methodological research agenda and will be networked with other GECAFS research worldwide.

GECAFS-IGP will be implemented over five years via:

- (i) selected Case Studies across the region, each addressing the food systems questions relating to GEC vulnerability and impacts, adaptation options and feedbacks at district level
- (ii) Regional Scientific Networking, linking Case Studies with other relevant research in the region and internationally
- (iii) Regional Synthesis and Integration to add value to individual research endeavours
- (iv) Science-Stakeholder Interface, linking national researchers with policymakers, the private sector, civil society and representatives of regional food security programmes.

Research is organised in defined phases with clear outputs at each stage. When integrated, outputs will provide policy-relevant information at both local and regional levels with the communications strategy underpinned by stakeholder engagement at all research stages. Research will thereby support both local and national interests. Research capacity will be developed by collaborative research within the international GECAFS project.

GECAFS-IGP research projects will apply for funding from regional and international funds, making reference to this Plan. Coordination funds will be raised to cover general regional networking activities, the science-policy interface and research management. A GECAFS-IGP Regional Steering Committee (RSC) will be established and a Regional Coordinator appointed. The RSC will provide scientific oversight of GECAFS-IGP, supported by the Regional Coordinator.

The GECAFS-IGP Science Plan and Implementation Strategy provides an innovative and timely research framework on improving regional food security in the context of environmental stress. This is an issue of growing importance for the region.

1 Food Security in the Indo-Gangetic Plain and Global Environmental Change

Social, economic and political factors are increasing food insecurity in the Indo-Gangetic Plain (IGP). Changes in the environment (Global Environmental Change, GEC) are further complicating what is already a food insecure situation for many. The technical and policy interventions required to enhance the region's food security need to take account of GEC. Interventions must consider three issues: (i) how GEC will further complicate food security across the region; (ii) the feasibility of policy and technical adaptation options at both regional and local levels; and (iii) the socioeconomic and environmental consequences of different adaptation options designed to improve food security.

1.1 IGP food security, GEC and the policy context

The Indo-Gangetic Plain (IGP) comprises the flood plains formed by the Indus and Ganga rivers covering an area of about 2.25 million km². The IGP is now home to about 900 million people and includes the most densely populated areas of Pakistan, India, Nepal and Bangladesh. The region is largely recognised as the “bread basket” for these south Asian countries producing about 30% of the rice and 42% of the wheat requirements on ca. 12 million hectares. While overall cereal production in the region exceeds demand, acute poverty and malnourishment persist, principally due to the low purchasing power of many (FAO, 2002).

Historically, food insecurity in the IGP has resulted from a combination of factors, including, inter alia, changing demographics, poor agricultural infrastructure and widespread poverty. All the countries of the IGP region are still classified as “medium” on the Human Development Index (UNDP, 2007a) despite an improvement in HDI from 0.36 in 1975 to 0.56 in 2005. Child malnutrition is an important indicator of future food insecurity. In South Asia, home to half of the world's malnourished children, the number of malnourished children is projected to decline by 18 million between 1995 and 2020, but the incidence of malnutrition is so high that, even with this reduction, two out of five children could remain malnourished in 2020 (Wiebe et al, 2001). So, although the last decade has seen the overall percentage of under-nourished people in South Asia fall from 25% in 1990-92 to 21% in 2002-04 (UNDP, 2007b),

the increasing population pressure will likely undermine these advances: assuming a medium growth scenario, the population of South Asia is predicated to increase by a further 700 million people (about equal to the current population of Europe) in the next 30 years. This will result in a greater demand for food and it is estimated that the food grain requirement by 2020 in the region will be almost 50% more than at the turn of the century (Paroda and Kumar, 2000). It is anticipated that the IGP will have to meet much of this increased demand.

The IGP is highly varied and exhibits a number of contrasts as one moves from the west in Pakistan to the east in Bangladesh. The west is generally characterised by higher productivity, a higher investment in infrastructure, major use of fertilisers and ground-water for irrigation and an in-migration of agricultural labour. In contrast the east is generally of lower productivity, poorer infrastructure, lower inputs of fertilizer and irrigation water, a high risk of flooding and an out-migration of agricultural labour. These differences are due to both hydrologic and other biogeographical features (see Box 1: Hydrological overview of the IGP), historical reasons relating to irrigation development (see Box 2: Historical development of IGP irrigation) and socioeconomic differences which are in part responsible for the labour migration to earn money for remittance.

Box 1: Hydrological overview of the IGP

The flood plains formed by the Indus and Ganga rivers are termed the Indo-Gangetic Plain (IGP). The IGP encompasses a large section of South Asia covering substantial parts of four countries: Bangladesh, India, Pakistan and Nepal. Together with the Brahmaputra, the two rivers originate around Mount Kailash in Tibet. The Indus drains into the Arabian Sea, while the Ganga, together with its major tributary rivers, flows into the Bay of Bengal. Pakistan and India share the Indus Plain whereas India, Nepal and Bangladesh share the Ganga Plain. Though broadly conceived as IGP the hydro-ecology of the eastern and the western regions are different though both are alluvial deposits. The western region has gently sloping land, fertile alluvial soil, good drainage, a medium to low water table and limited rainfall. In comparison, the eastern region is undulating, and has a high groundwater level. Annual rainfall in the Indus Basin ranges from 39 to 1580 mm with an average of 396 mm while the Ganga Basin ranges from 341 to 2265 mm with an average of 1474 mm. The eastern rivers transport a very high sediment load (167 million ton/year) and they demonstrate meandering tendencies compared to western Indus where sediment load is ca. 100 million ton/year. In the eastern region the distance between the ocean and the mountains is only about 300 km resulting in a steep transect whereas in the west this distance is much greater. These hydrological distinctions contribute to the many differences in the social, economical and cultural systems of the western and eastern IGP.

Box 2: Historical development of IGP irrigation

It is well recorded that major state-sponsored canal systems were built in the plains of the Indus and Yamuna rivers during Moghal India. Later, the East India Company began rehabilitating these canal systems in order to use them to generate revenue for the state. The early efforts in irrigation development by the British focused on rehabilitating existing canals and extending them to irrigate more area. Subsequently, new canal systems were built. This process started with the construction of the Upper Ganga Canal (UGC) supervised by engineers of the Bengal Presidency. The Bhimgoda Barrage was built at Hardiwar to serve the Ganga canal in 1854. Perennial rivers from the Himalayas – the Beas, the Sutluj, the Ravi, the Jhelum and the Sarada – debouch onto the plains of this region. The combination of these factors made the region suitable for developing diversion irrigation systems. After the successful completion of the UGC, British engineers built similar systems in Punjab and Sindh from 1860 onwards. The experiment to build embankments for the river Damodar in West Bengal did not however succeed due to hydroecological conditions. As a result the British desisted from emulating the technology used in the western region in the eastern of the IGP. The predominance of greater irrigation infrastructure in the west is an outcome of the historical legacy.

Against this background of socioeconomic-induced food insecurity, global environmental change (GEC, Box 3) is adding further stress. There is growing concern worldwide that GEC will seriously affect the production and equitable provision of food and undermine efforts aimed at socioeconomic development (IPCC, 2007; Royal Society, 2005). This has been especially recognised in the IGP (Aggarwal et al., 2004), where principal concerns relate to changes in the availability of, and access to, surface and ground water.

The IGP is however one of the areas most prone to degradation of natural resources due to intensive human activities in the region, and there is already evidence of gradual deterioration, particularly in areas that have benefited from the Green Revolution technologies and the extensive development of irrigation networks (World Bank, 1994).

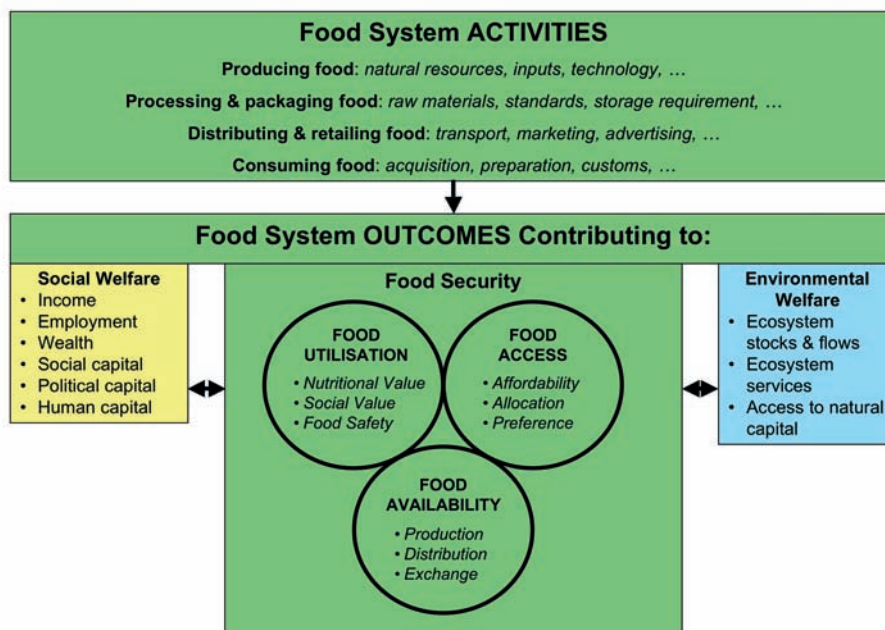
About 25% of irrigated land suffers from various levels of salinity, with over 1.4 million hectares being rendered uncultivable due to excessive salinity levels. In Pakistan alone the estimated mean annual cost of agricultural soil degradation is about \$1 billion (World Bank, 2006).

The historical perspective (Box 2) is important as the introduction of canal irrigation has often resulted in cultivated land becoming saline and/or water-logged. In India, for instance, almost 7 million ha are thus affected (Joshi and Tyagi, 1994) while the rapid increase in the number of tubewells during the last three decades has led to changes in water-table depth, deterioration in the quality of irrigation water and rising salinity. The consequence of these changes for food supply is compounded by factors such as increasing resistance to many pesticides (Sinha et al., 1998).

Box 3: Definitions of GEC, Food Systems and Food Security

Global Environmental Change (GEC) includes changes in the physical and biogeochemical environment, 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. GEC issues of particular relevance for the IGP include variable water availability, changes in snow/glacier melt, rising GHG emissions, seasonal flooding, groundwater depletion, drought and (in Bangladesh) sea level and salt water intrusion.

Food Systems encompass (i) activities related to the production, processing, distribution, preparation and consumption of food; and (ii) the outcomes of these activities contributing to food security (food availability, with elements related to production, distribution and exchange; food access, with elements related to affordability, allocation and preference; and food use, with elements related to nutritional value, social value and food safety). The outcomes also contribute to environmental and other securities (e.g. income). Interactions between and within biogeophysical and human environments influence both the activities and the outcomes (see Figure below from Ericksen, 2007).



Main features of 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 underpinned by food systems and is diminished when food systems are stressed. This stress can be caused by a range of factors in addition to GEC (e.g. population pressure, changes in international trade agreements and policies, migration) and may be particularly severe when these factors act in combination. (*Food security encompasses a wide range of complex and interactive dimensions. A fuller contextual analysis of the food security situation for the IGP region in relation to GEC and other factors, and the role that GEC research can play in helping to alleviate the situation, can be found in Aggarwal et al., 2004.*)

With a need to address the more holistic concept of food security, and the broader set of issues encompassed in GEC, national and state-level policy objectives for the IGP include (i) increased agricultural competitiveness while limiting further environmental degradation; (ii) the establishment of food systems which enhance the social security of the more vulnerable; and (iii) the promotion of rural employment opportunities thereby reducing intra-IGP labour migration. The improved management of water resources is a central aspect to all these policy goals, especially in the context of GEC.

1.2 GEC in the IGP

The food security situation in the IGP will be further complicated by GEC. GEC includes changes in the biophysical environment caused or strongly influenced by human activities. Principal concerns are changes in land cover, atmospheric composition, climate and climate variability, water availability and quality, nitrogen availability and cycling, biodiversity and sea level.

Climate change is a particular environmental concern for the region as there are numerous direct and indirect links to agricultural production. The Inter-Governmental Panel on Climate Change has projected that the global mean surface temperature will rise by 1.1-6.4°C by 2100 (Solomon et al. 2007). Climate variability is also projected to increase, leading to uncertain onsets of monsoons and more frequent extremes of weather, such as more severe droughts and floods. A link has also been highlighted between climate change and glacier melting which will have major bearing on regional hydrology (Singh and Kumar, 1997; Singh and Bengtsson, 2005).

South Asia is expected to be particularly vulnerable to GEC due to its large population, predominance in agriculture and its limited resource base. There is therefore now serious concern regarding the vulnerability of food systems in the IGP and the development of robust adapting strategies are high on the political agenda (Aggarwal et al, 2004).

1.3 The need to integrate GEC science within regional development policy

Current policy-making in the IGP attempts to address many issues related to food security. The policy process is however constrained by (i) insufficient information about how food systems function; (ii) inadequate institutional structures to deal with the failures of the region's food systems to improve food security and environmental integrity; and (iii) fragmentation of current agricultural and environmental policy formulation processes along many dimensions within and between nations. Nevertheless, despite these problems, policy development

needs to respond to the GEC dimension. This is because GEC is bringing added stresses to what is already a food-insecure situation for many. This makes policy-making for food security in the IGP all the more important, but there are three additional factors specific to the GEC dimension.

First, GEC will impact many aspects of the IGP's food systems, e.g. both directly through impacts on locally-produced commodities and indirectly with the reduction of export revenues. Second, limited awareness by many policy-makers of the GEC issues reduces the capacity to consider GEC concerns in the refinement of existing policies and development of new policies aimed at addressing food security, environmental protection and conservation and economic development. Third, GEC will have different impacts across the region meaning that no single adaptation option is likely to be appropriate region-wide.

The improved policy formulation and governance in relation to food security and GEC required in the IGP needs to be based on improved links between science, government and society. Innovative research is needed that builds on, and integrates, the wealth of regional and internationally disciplinary studies and links these to the region's development agenda. This link in the IGP (as elsewhere) has to date not been strong enough despite the fact that development goals and improved environmental management are often closely related.

1.4 Research challenges

Recognising the importance of GEC, and the fact that GEC has a major bearing on regional and national policy formulation and resource management, several national and regional research projects have already addressed some key aspects relating to food production. Major outputs include the recognition of the need for forecast applications with agronomic and financial risk management mechanisms and also greater national-level policy dialog and judicious use of underground water reserves so as to meet the likely severe shortages of water; enhanced capacity of regional agricultural scientists in crop simulation modelling for systematic impact assessments of climate change on crop yield and the enhanced application of climate information to agricultural systems modelling to explore and evaluate options for managing climatic risk. Such studies have contributed substantially to assessing how climate change will affect food production, but food security also depends on key issues related to access to food and food utilisation. Further, food security is also influenced by a wide range of interacting socioeconomic and environmental factors (in addition to climate), all of which are key topics for policy formulation.

As outlined above, the interactions between GEC and food systems are complex and need to be better analysed to assess the implications for food security in the IGP. There is also concern that meeting the region's rising demand for food will further degrade the environment. If careful and appropriate natural resource management is not in place, further degradation of land, water, plant and animal resources is inevitable (Gregory et al., 2002). This will, in turn, further undermine the food systems upon which food security is based. Reversing this negative cycle is key to sustainable development in the region, but there has to date been limited capacity to generate policy relevant information to address GEC effects for development agendas.

GEC/food security research to support policy development in the IGP must provide practical assistance to evaluate options for reducing the region's food systems vulnerability to GEC. It should help the region's policymakers and development planners to appropriately evaluate the necessary responses to improve the region's food systems. This raises three overarching research challenges which bring together concerns relating to food security, environmental conservation and economic development in

the context of GEC. All three issues are of keen interest to scientists and policy makers across the region:

- (i) how GEC will affect the vulnerability of food systems in different parts of the IGP, especially related to changes in flooding and droughts and increasing non-farm demands for water.
- (ii) how IGP food systems can be adapted using technical and policy options to cope with GEC and improve food security, especially related to better water management and improved early warning systems, and considering the social, technical and infrastructural opportunities and constraints to diversifying livelihoods to make more effective use of flood and groundwater.
- (iii) how various adaptation options will feedback on environmental and socioeconomic conditions across the IGP, especially considering the consequences for rural livelihoods, equity, labour migration, employment, intra-regional trade, water resources, greenhouse gas budgets and biodiversity.

2

IGP Research in the GECAFS Context

A three-year consultation and planning exercise identified the need for, and necessary components of, an integrated research endeavour on the links between IGP food security and GEC. The exercise, organised by the international research project Global Environmental Change and Food Systems (GECAFS), involved a diverse group of regional researchers, and regional and international organisations and donors, and culminated in the preparation of this Plan for a GECAFS IGP project (GECAFS-IGP). Recognising and building upon ongoing national and regional GEC and food security research, the Plan provides a strategy to deliver policy-relevant information about the interactions between GEC and the food systems that underpin food security. Research will contribute to a number of major food security initiatives in the region and support both local interests and those of major regional activities (e.g. RWC). It will constitute an integral component of the internationally-endorsed GECAFS agenda.

2.1 The need for a GECAFS IGP regional project

Vision: Improved food security for those most vulnerable to environmental stress in the IGP.

A wide range of national and international projects are already involved in studying the links between GEC and food security in the IGP. Most, however, focus on the impacts of climate change on food production – certainly an important issue – but the wider implications of GEC for food security are insufficiently addressed (Gregory et al., 2005). Furthermore, techniques to assess the environmental consequences of possible strategies to adapt food systems to cope with GEC are poorly developed, and tools to identify the tradeoffs between socioeconomic and environmental goals to support improved policy development are urgently needed (Ingram et al., 2005). While many organisations are involved in the issues, the pathways of communications to make coherent and integrated decisions which simultaneously consider food security and development agendas are not present.

A further feature of most projects is that they are designed at national and sub-national scale, and an approach that considers the IGP as a region is generally lacking. The regional scale is important 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, e.g. in terms of improved intra-regional trade, food storage and transport facilities, water governance. Third, some environmental management issues only manifest at this spatial scale (e.g. 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., 2002), social science theories, methods and data are often better developed at the micro- and macro-scales (Rayner and Malone, 1998). The GECAFS-IGP is designed to address the IGP as a whole (see Figure 4 for map).

A regional research approach will help to develop a more integrated approach at this important spatial scale. However, as there is no institution mandated to set policy at IGP level, research needs to be designed specifically to underpin improved national policy formulation, but in the context of regional issues. Key aspects are raising awareness of, and improving knowledge about GEC issues in the policy process, particularly on how the food security status will be undermined by GEC; and improving understanding by researchers of what the key food policy goals are and the constraints on policy formulation.

To this end, a new framework is needed which:

- (i) brings together research on the vulnerability of the region's food systems to GEC;
- (ii) enhances collaboration with relevant stakeholders in food issues to identify viable options for adapting food systems to the additional stresses of GEC; and
- (iii) assesses how possible adaptation options will affect development agendas, including enhanced environmental management, in the short- and long-term.

These issues need to be analysed within existing approaches to food security so that they are not seen as a different set of problems and also so as to capitalise on, and add value to, ongoing efforts.

To support improved policy formulation on these issues, the science community needs to raise awareness within the policy community of emerging issues, and deliver, communicate and interpret assessments of the consequences of GEC for food security and potential policy responses to GEC. These assessments must address the complexity of food security issues, and no single analytical or disciplinary approach is appropriate. A new regional research approach is needed to help develop more integrated research outputs which will have direct relevance to planning bodies across the IGP.

2.2 GECAFS-IGP project planning

A set of consultative meetings in the IGP (convened by GECAFS¹; Annex 1) highlighted concerns that GEC will further complicate achieving regional food security. While not all GEC research necessarily aims to be policy-relevant, one of GECAFS' guiding principles is to address policy issues. Important aspects of GECAFS therefore include ascertaining the information needs of policymakers, resource managers and other stakeholders, developing with stakeholders relevant science questions, and delivering results so as to help policy formulation. This GECAFS-IGP Science Plan and Implementation Strategy has therefore been developed from the output of a series of coordinated planning workshops and associated activities involving regional researchers, policymakers, resource managers and donors (Annex 2). The regional planning process has also been influenced by developments in the GECAFS conceptual research agenda. This process has followed the general GECAFS method for developing GECAFS regional research to ensure the research questions are closely matched with key regional science interests, policy needs and donor priorities.

¹ Global Environmental Change and Food Systems (GECAFS) is an international research programme involving a wide range of social, physical and biological scientists, investigating the vulnerability of human food systems to, and interactions with GEC. It is sponsored by the Earth System Science Partnership (ESSP) and is being implemented in active collaboration with FAO, WMO and the CGIAR.

3

GECAFS-IGP Goal and Research Agenda

GECAFS-IGP research is identifying the social and geographical distributions of vulnerability of the region's food systems to GEC in the context of other stresses. Based on these new insights it will determine how, when and where adaptations to food systems to reduce their vulnerability to GEC can be instituted in line with long-term national and regional developmental goals. It will also assess the long-term social and environmental consequences of different adaptation measures adopted to enhance regional food security. In addition to addressing regional priorities, proposed research is also fully consistent with the international GECAFS conceptual and methodological research agenda and will be networked with other GECAFS research worldwide.

3.1 Goal

To determine strategies to cope with the impacts of global environmental change on food systems across the Indo-Gangetic Plain and to assess the environmental and socioeconomic consequences of adaptive responses aimed at improving long-term regional food security.

The GECAFS-IGP goal is derived from the regional planning process (Annex 2). Research needs to be designed and implemented so as to help the region take advantage of opportunities that may arise, while contributing to the minimisation of further environmental degradation.

3.2 Overarching GECAFS-IGP research questions and conceptual framework

GECAFS-IGP research is based on the three main issues identified in Section 1.4. These questions are based on the generic GECAFS conceptual framework (Box 4), and were refined during the GECAFS planning process in the region.

- Q1: How will GEC affect the vulnerability of IGP food systems?
- Q2: How might IGP food systems be adapted to cope with GEC so as to enhance food security?
- Q3: How would various adaptation options for IGP food systems feedback on environmental and socioeconomic conditions?

The GECAFS approach recognises that research questions for policy and science outputs are not necessarily the same, but that there is great scope for complementarity. Two types of research questions have therefore been developed for the GECAFS-IGP project: those of immediate relevance to food security and environmental management policy objectives as relating to Q1-3 above (Section 3.3); and others aimed at delivering a stronger science foundation for addressing the policy-related questions (Section 3.4). Collectively, these constitute an innovative regional research approach which will: (i) build upon and integrate natural and social science disciplinary studies within a policy context; (ii) link researchers, the regional and sub-regional policy communities, and resource managers to deliver new insights into how GEC will interact with the region's food systems that underpin food security; and (iii) help improve the links between science and development agendas (Figure 1).

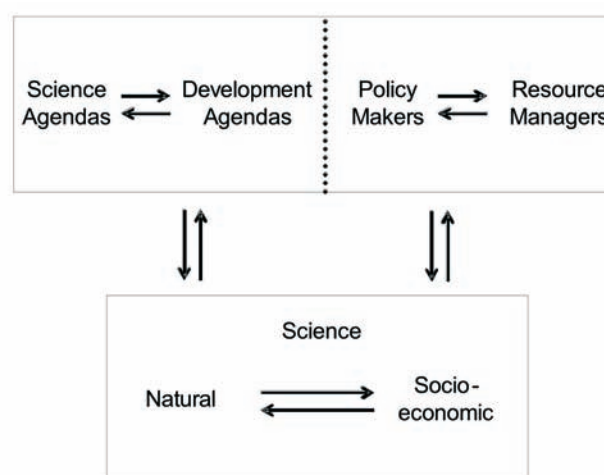
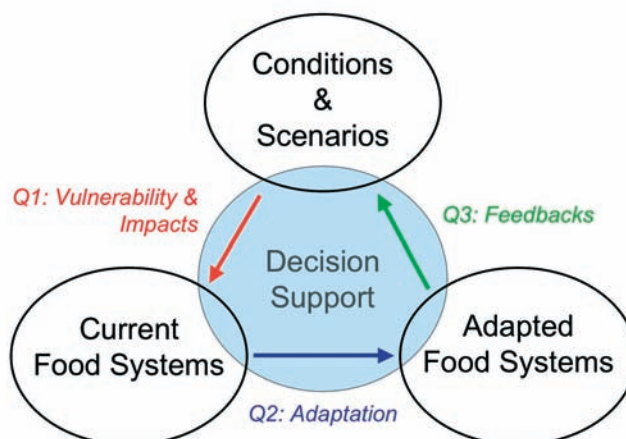


Figure 1: Links engendered by the GECAFS-IGP project.

Box 4: GECAFS conceptual framework for research in the IGP Region

A relationship exists between current socioeconomic and environmental conditions and current food systems. It highlights the importance of their vulnerability to future scenarios of changed socioeconomic and environmental conditions. It also shows how policy and/or technical adaptation options to cope with the added stresses of GEC lead 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 (e.g. minimising damaging feedbacks to carbon budgets, the hydrological cycle and other components of the Earth system) and regional developmental goals (e.g. maximising positive feedbacks to food security, livelihoods and other socioeconomic conditions).

3.3 Research questions for food security and environmental management

Three sets of more detailed questions were developed from the overarching questions (Q1-3) and are summarised below. (A fuller list of questions stemming from the planning exercise is listed in Aggarwal et al., 2004.) Given the varied policy interests of regional stakeholders, and recognising the complex spatial and temporal dynamics in the region, each set of questions were elaborated upon within the region to assess vulnerability, adaptation of food systems to GEC and the feedback of these on food systems and food security in the IGP as follows:

- Local-level questions, researched in a number of case-study districts
- Cross-level questions, which investigate the links between local-level and regional-level issues (bottom-up view of the region)
- Regional questions, to address issues relating to the region as a whole (top-down view of the region)

3.3.1 Vulnerability of food systems to GEC (re Q1)

IGP food systems vary considerably across the region but they are all suffering effects of escalating land and soil degradation, declining water tables and stagnation in yields.

These are indications that technical, policy and institutional strategies are often weak and ineffective. Research is needed to establish how food systems operate and how they are differentially vulnerable to GEC.

Key Q1 local-level questions

- How do socioeconomic and biophysical conditions determine how food systems operate at the local level? *e.g. resource tenure; climatic conditions; natural resource base; market structure; social capital; food preferences; ...*
- Which aspects of local food systems (activities and outcomes) are currently most vulnerable to environmental stress and which aspects of GEC are most threatening? *e.g. producing; processing; distributing; consuming; availability; access; utilisation; ...*
- How do sub-national policies and strategies (or lack thereof) affect the vulnerability of food systems to GEC at the local level? *e.g. decentralisation; land policies; marketing strategies; infrastructure; public awareness policies; ...*

Key Q1 cross-level questions

- How does food system vulnerability to current conditions vary across the region? *e.g. production methods; hydrological distribution; policies; marketing institutions; physical infrastructure; dependence on remittance; quality of resource base; ...*
- How would GEC differentially affect food system vulnerability across the region? *e.g. changes in production; demography; social inequalities; safety nets; ...*
- How do different national policies, strategies and interventions complement each other in reducing vulnerability to GEC across the IGP? *e.g. in terms of being mutually reinforcing or antagonistic; ...*

Key Q1 regional-level questions

- How would regional-level policies and strategies (or lack thereof) affect the vulnerability of food systems to GEC across the region and why? *e.g. early warning systems; trade policies; transport systems and infrastructure to facilitate intra-regional trade; regional marketing infrastructure and intelligence; multi-lateral dialogues; ...*
- How will GEC destabilise food security in the region as a whole? *e.g. wide-scale impacts; proportion of region's response capacity affected; key production areas affected; ...*

3.3.2. Adaptation (re Q2)

Current policy and technical strategies are mainly aimed at coping with the increasingly complex interaction of stresses in the short-term, and little attention is given to longer-term options for adapting food systems to the additional stresses GEC is bringing. Such options will vary across the region, depending on the nature and extent of the inherently-dynamic vulnerability of food systems to GEC.

Key Q2 local-level questions

- What local-level technical, policy and institutional adaptation strategies will reduce food system vulnerability to GEC? *e.g. insurance; local early-warning systems; agronomic, livestock and fisheries technologies; diversification of production systems and other economic activities; physical infrastructure; land-use planning and enforced zoning; disaster management; microcredit; self-help groups; resource tenure; access to information; ...*

- What aspects of local governance affect the development and implementation of food system adaptation options and strategies? *e.g. corruption, accountability and social auditing; vision; popular acceptance; capacity and capability; price stability; food standards; ...*
- What are the current local barriers to implementing adaptation options for increasing local food security in the face of GEC? *e.g. knowledge; perceptions, attitudes and history; institutional capacity and response; depleted ground water levels; limited storage capacity for surface water; spatial, temporal and socially-skewed water distribution; food preferences; ...*

Key Q2 cross-level questions

- What are the key interactions between policy instruments, strategies and interventions set at different levels? *e.g. national insurance policy and local fisheries production; land-use regulation and local disaster management; local distribution infrastructure and intra-regional trade; crop diversification and intra-regional trade; regional vs local early warning systems; ...*
- What approach to implementing national policy instruments, strategies and interventions maximises the effectiveness of local-level adaptation options? *e.g. access to markets; production quotas; political commitment; adaptation strategies at local vs national levels; considering upstream-downstream effects; ...*
- How can the heterogeneity across the IGP be capitalized upon to enhance the effectiveness of adaptation options for given locations? *e.g. localised niche and off-season production; water allocation and management, including planning; market intelligence and marketing infrastructure; ...*

Key Q2 regional-level questions

- What national and regional-level policy instruments and strategies would reduce GEC threats to regional food security? *e.g. water allocation; water quality and effluent management; intra-regional trade; effective participation in global conventions; food banks; reduction of non-tariff barriers; regional disaster management; ...*
- What are the current barriers to reducing potential regional food insecurity in the face of GEC? *e.g. political commitment; knowledge; perceptions; attitudes; non-compliance; lack of debate on a regional food policy; ...*

3.3.3 Feedbacks (re Q3)

Technical, policy and institutional options for adapting IGP food systems to GEC will primarily be aimed at improving food security. There will however also be environmental, and other socioeconomic, consequences ('feedbacks'; see Box 4). New policies and technologies promoted at regional level will affect the capacity to adapt to change at local level. Population change, disease spread, and movements of people between countries influence national food security, and some policy adaptation options might hinder positive demographic aspects or promote negative aspects. Technical adaptation options, such as international trade policy, regional trade policy and intraregional transportation infrastructure, will affect regional self-sufficiency as well as local livelihoods and the environment. Policy and/or technical adaptations will affect greenhouse gas emissions and biodiversity, which could in turn influence decision makers' capacity to formulate and implement adaptation strategies (Millennium Ecosystem Assessment, 2005). Research needs to identify the potential feedbacks of possible adaptation options as identified in Section 3.3.2 and build such feedbacks into policy formulation and resource planning.

Key Q3 local-level questions

- How would given alternative local strategies and technical options affect local food security? *e.g. availability; access; utilisation; stability; ...*
- How would given alternative local strategies and technical options affect local environmental and socioeconomic conditions? *e.g. rural development; labour migration; biogeochemical cycling; water availability; land use; biodiversity; ...*

Key Q3 cross-level questions

- How would alternative national and IGP-wide strategies and technical options affect local food security, the environment and socioeconomic conditions? *e.g. nutrition; rural development; urbanisation; biogeochemical cycling; intra-regional or extra-regional supply; compliance with international conventions; ...*
- How would local adaptation strategies and technical options aimed at reducing the vulnerabilities of food systems to GEC, if implemented across the IGP, affect food security for the region as a whole, the environment and socioeconomic conditions? *e.g. rural development; export commodities; reliance on extra-regional food supply; labour migration; national GHG budgets; ...*

Key Q3 regional-level questions

- How would IGP-wide adaptation options affect socioeconomic conditions across the IGP? *e.g. changed employment opportunities and changed migration; enhanced intra-regional trade; level of dependence on food banks; ...*
- How would IGP-wide adaptation options affect environmental conditions across the IGP? *e.g. water availability; biodiversity; environmental flows; flooding due to drainage congestion from physical infrastructure; national greenhouse gas budgets; ...*

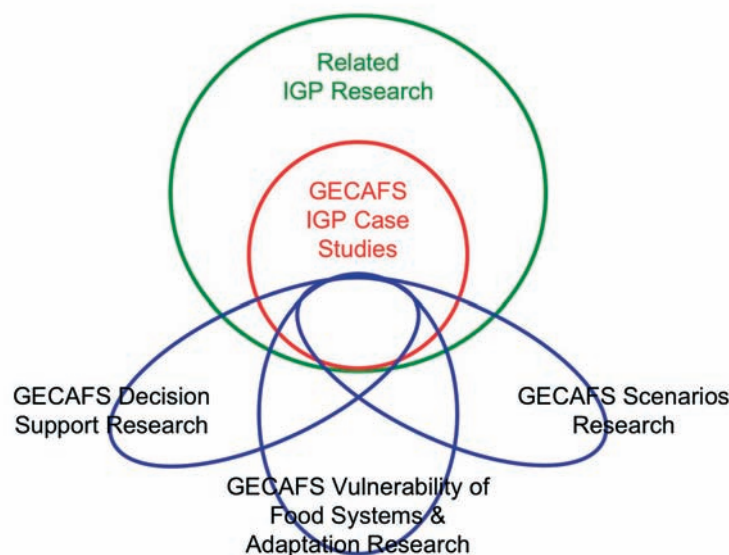


Figure 2: The relationship between GECAFS IGP and conceptual research.

3.4 GECAFS conceptual research in the IGP context

While GECAFS research in the IGP is primarily aimed at the regional project goal, it will also contribute significantly to the three key topics comprising the overall GECAFS conceptual research agenda (Figure 2): (i) food systems concepts (cf. Box 3) and the vulnerability of food systems to GEC and adaptation, (ii) scenario construction, and (iii) decision support. Basic details of each of these research areas are given in the GECAFS Science Plan and Implementation Strategy (GECAFS, 2005); and latest concepts are reported in the GECAFS Working Paper Series (available on www.gecafs.org).

3.4.1 Research on vulnerability of food systems to GEC

GECAFS research has developed a framework to integrate the many research projects investigating GEC impacts on food systems with concepts related to society's capacity to cope with, and/or recover from GEC (Bohle, 2001; Wisner et al., 2004); and also with changes in societal aspects, such as policy options, institutions and resource accessibility (Adger, 1999). This integrated concept will allow GECAFS-IGP researchers to better understand the vulnerability of the food system (as a whole) to GEC, rather than just the impacts of GEC on production. Box 5 illustrates how this research can be further developed within GECAFS-IGP.

3.4.2 Regional scenarios for GECAFS studies

GECAFS-IGP research needs to be set within clearly defined, plausible alternative futures (or scenarios) of biogeophysical and socioeconomic conditions. This is because

uncertainty surrounds both policy development and implementation, and the nature and impact of GEC. Such scenarios will help to: (i) research the interactions between regional food systems and GEC; (ii) assess which adaptation options are most appropriate for different future conditions; (iii) assess the resilience and adaptive capacity (Carpenter et al., 2001; Walker et al. 2004) of food systems under different scenarios; and (iv) raise awareness amongst decision makers about the potential vulnerability of food security strategies under different, and largely uncertain, future conditions. A fully-integrated set of regional scenarios needs to be developed to set the contexts for detailed discussions on adaptation and feedback issues.

3.4.3 Decision support research

Work on assessing the possible strategies for adapting IGP food systems to GEC must include those involved in policy formulation and decision-making. Decision support (DS) platforms can help by providing a structured dialogue between scientists and policymakers. Innovative DS approaches and tools need to be developed, evaluated and refined to help assess potential regional- and national-level policy options. DS tools will help analyse tradeoffs between feedbacks 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 food security, potential markets, livelihoods) arising from potential adaptation options (Q3, above). Advances in DS concepts from GECAFS-IGP research will contribute to international GECAFS agendas on DS development. Figure 3 (from Henrichs, 2006) shows how the various components of GECAFS research (vis. on food systems and their vulnerability to GEC; adaptation options; scenario construction; and trade-off analyses) can be brought together in a structured dialogue between scientists and stakeholders. It also shows the critical aspect of joint agenda setting.

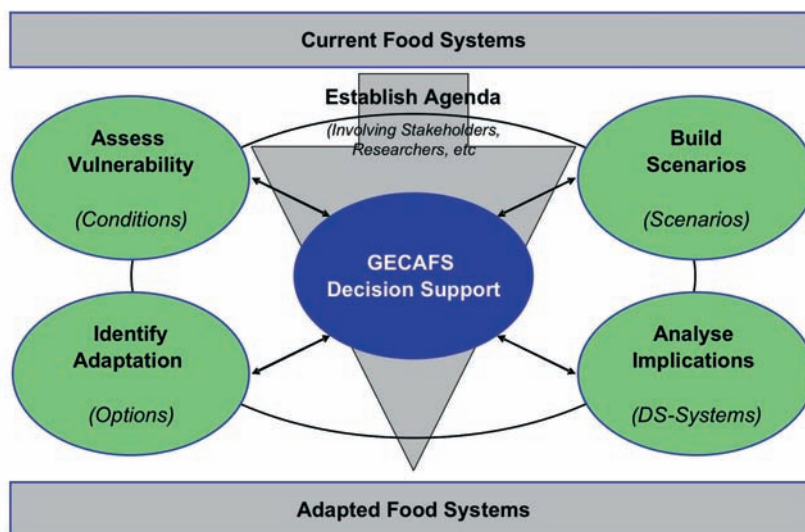
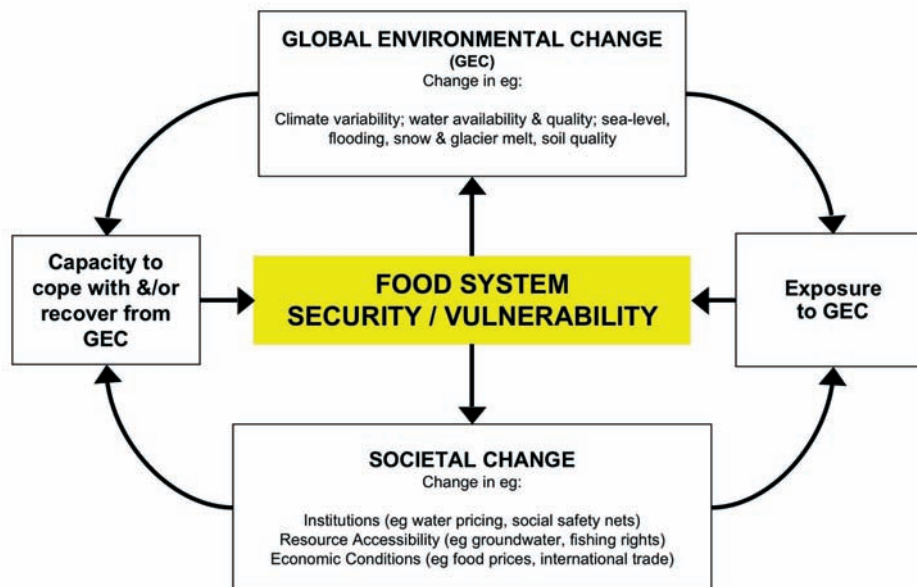


Figure 3: The various components of GECAFS research are brought together in a structured dialogue between scientists, policy makers and other stakeholders.

Box 5: Integrated concepts of food system vulnerability with GEC science

GECAFS is interested in the vulnerability of food systems to global environmental change. Vulnerability is defined as 'a function of exposure, sensitivity to impacts and the ability or lack of ability to cope or adapt' (The Global Environment Outlook 4, UNEP 2007). Vulnerability thus has two sides: an external side of risks, shocks and stress, and an internal side which is the means for coping without damaging loss (Chambers, 1989).

The capacity to cope with, and adapt to stress is, in many cases, deteriorating in the face of multiple, interacting shocks (e.g. climatic catastrophes) and transformations (e.g. political and economic developments). Furthermore, negative outcomes for large numbers of people affect in turn, the context itself. A dynamic cycle results, where vulnerability is generated by both exposure to change, by responses to change, and by the outcomes of these processes (Gillespie and Kadiyala, 2005; Leichenko and O'Brien, 2002).



*Factors determining the vulnerability of IGP Food Systems to GEC.
(Adapted from Ingram and Brklacich, 2002)*

GECAFS is integrating social vulnerability concepts with those from natural science to provide a more holistic approach to vulnerability studies in the context of GEC in the IGP. Regional networks will bring together researchers to assess existing paradigms and approaches. For the conceptual research on food systems and vulnerability for instance, studies could include livelihood-based food security assessments and future vulnerabilities; multiple stresses (Quinlan et al., 2005; Misslehorn, 2005) and climate vulnerability hotspots (Adger et al., 2005); multi-level modelling (Downing et al., 2004) linking vulnerability to food security. Merging vulnerability assessments with adaptation and resilience research provides an opportunity to demonstrate explicit links between vulnerability assessments and the formulation of policies supporting future food security (Adger et al., 2003).

4

GECAFS-IGP Implementation

GECAFS-IGP is being implemented over five years. Key aspects are: (i) five Case Studies, each addressing the food systems questions relating to GEC vulnerability and impacts, adaptation options and feedbacks at district level; (ii) Regional Scientific Networking linking GECAFS Case Studies with other relevant research in the region and internationally; (iii) Regional Synthesis and Integration to add value to individual research endeavours; and (iv) building Science-Stakeholder Interfaces linking national researchers with policymakers, the private sector, civil society and representatives of regional food security programmes. Research is organised in defined phases with clear outputs at each stage. When integrated, outputs will provide policy-relevant information at both local and regional levels with the communications strategy underpinned by stakeholder engagement at all research stages. Research will thereby support both local and national interests. Research capacity will be developed by collaborative research within the international GECAFS project.

GECAFS-IGP is being implemented in four principal ways:

- Case Studies, designed to address the food systems questions relating to GEC vulnerability and impacts (Q1), adaptation options (Q2) and feedbacks (Q3) areas of this Plan (Section 4.1; cf. Section 3.3)
- Regional Scientific Networking, to build on and add value to other research in the region that relates directly to aspects of this Plan; and which can contribute to the underpinning science in the GECAFS conceptual research agenda (Section 4.2; cf. Section 3.4)
- Regional Synthesis and Integration, to add value to individual research packages and to address the cross-scale and regional research questions (Section 4.3; cf. Section 3.3)
- Science-Stakeholder Interfaces, linking research output with policy formulation (Section 4.4; cf. Section 1.3) as part of a broad consultation with civil society, market institutions, etc.

4.1 Case Studies

4.1.1 Rationale for a Case Study approach

The IGP encompasses wide-ranging socioeconomic and environmental conditions (cf. Section 1.1). Many of the food security issues are based on socio-ecological interactions that are complex and warrant dedicated research to assess how they will interact with GEC. GECAFS-IGP planning identified interest in describing how the food systems vary

across the region as a result of this heterogeneity (cf. Section 3.3.1). By using standard characterisation techniques at a number of sites across the IGP it would be possible to understand commonalities and differences, and trends or gradients, in food systems. Their vulnerability to GEC could be assessed along the gradient resulting in a set of parameters which collectively describe the links between food systems and e.g. water stress for the region as a whole. Another advantage of the case study approach is that analyses can determine the presence or absence of connections among the case studies and evaluate their importance to the food systems. This will help in understanding the utility of a regional-scale evaluation for resources other than water, such as labour and food stuffs, which also move across and within the IGP.

4.1.2 Case Study site selection

The Rice-Wheat Consortium has identified five zones within the IGP based on major agroecological and socioeconomic differences. Based on this the GECAFS planning process identified one site in each zone based upon a number of criteria. These ranged from how representative of the larger zone the site was to the potential for data availability. Key criteria included identifying where the effects of various GEC drivers will be maximum; identifying where the poor will be worst hit; representativeness of the sub-region; ease of access; and data availability. Five districts were selected representing the wide-ranging environmental and socioeconomic conditions across the IGP (Figure 4).

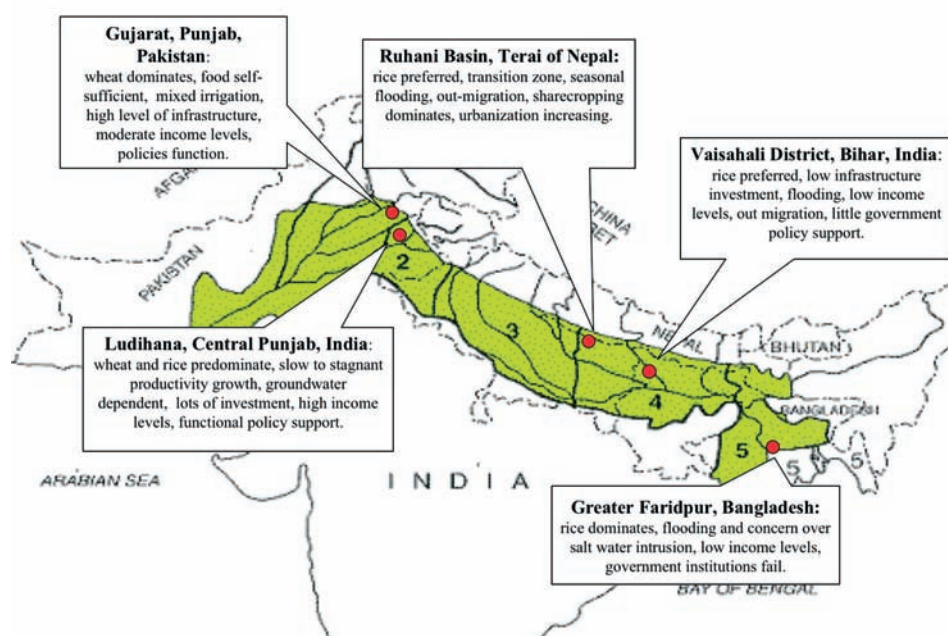


Figure 4: Location of GECAFS-IGP Case Studies identified in relation to the main rice-wheat growing area.

4.1.3 Implementation strategy for case studies

Each Case Study provides a focus for collaborative GECAFS-IGP (Q1-3) research involving national researchers closely linked to policymakers, the private sector and civil society (NGOs). These form the basis of the ongoing GECAFS research funded by the CGIAR CPW&F and APN (and supplemented by GECAFS conceptual research input) which is describing the food systems, and how each is vulnerable to changes in water availability, using a standard GECAFS methodology. Using further standard GECAFS methods which facilitate integration, research is already giving insights into how diversity affects food security across the region, especially in relation to water availability. This will form the basis for determining what possible adaptation strategies can be considered both locally and for the region as a whole. Regional researchers will work closely with GECAFS Science Officers to develop proposals for funding such studies on adaptation and feedbacks.

4.2 Regional scientific networking

There are many national research projects in social, agronomic, fisheries, policy, economics, ecological and climate sciences which could be very relevant to the GECAFS objectives. Where appropriate these will be drawn upon to contribute to case studies, but a key GECAFS principle is also to network and synthesise ongoing research in the region relevant to GEC and food systems but which may not be directly involved in the case studies. This will (i) help address the stated research questions by including a wider range of researchers; (ii) add value to the individual case studies by integrating them with other work to address

questions the case studies alone cannot address (e.g. of a regional nature); and (iii) link regional research to the international GECAFS conceptual research agenda. Funds for regional networking activities (e.g. at GECAFS-IGP synthesis workshops) will be the subject of specific proposals.

In addition to intra-regional networking, researchers addressing issues that can contribute to GECAFS conceptual research (Section 4.5) would be invited to join the relevant GECAFS international networks. This would contribute to GECAFS' overall integration by placing the regional work in a broader international context, and would also help in regional capacity building. Such contributions would be endorsed as formal inputs to the respective international network.

4.3 Regional synthesis and integration

Regional synthesis and integration will be implemented by closely linking the Case Studies and other networked research in the context of key questions as outlined in Section 3.3. The GECAFS-IGP Regional Coordinator (see Section 5.2.2), assisted by the GECAFS Science Officers, will liaise between sites to ensure consistent approaches are followed across the region to facilitate this process. GECAFS-IGP synthesis workshops will add value to individual research packages and address regional-level and cross-scale questions. These exercises will be designed to help meet both the overall objective of the GECAFS-IGP Project and also add value to the individual Case Studies.

A number of recently-completed, ongoing and/or imminent region-wide studies could be very relevant to the GECAFS-

IGP goal. Annex 2 lists some of these, and indicates which aspects of the GECAFS-IGP agenda would support collaboration to best mutual advantage. The GECAFS-IGP workshops will also include output from such studies to ensure that there is no duplication of effort, and that GECAFS-IGP and other projects can mutually benefit from advances made outside the Case Studies.

A major GECAFS-IGP synthesis workshop and reporting exercise will be held in the final months of the five-year project in collaboration with other, major regional efforts.

4.4 Building science-policy interfaces

One of the fundamental aims of the GECAFS research agenda in the IGP is to assist regional policymakers and development planners to develop an IGP perspective on responses to GEC (cf. Section 1.3). To ensure strong linkage between scientific research and food systems development, GECAFS-IGP is based on the participation of stakeholders in all stages of research planning and will maintain this during research implementation. This has been a valuable awareness-raising exercise in its own right, and will also pave the way for fruitful collaboration during the implementation phase. GECAFS-IGP will ensure that the wide range of regional policy-making institutions, researchers and development agencies engaged in the planning stage will continue to be involved in the research implementation cycle.

The direct engagement of local and national policy making institutions, development practitioners and the research community from the early stage of defining the research themes has ensured that the research agenda focuses on issues of practical interest to policymakers in the IGP.

GECAFS-IGP will continue to develop interfaces between scientists and regional policy-makers by holding regular

meetings and developing a project website. These activities will be used to discuss the research proposals and disseminate results. The GECAFS-IGP Steering Committee will aim to meet key regional policymakers on an annual basis linked to scheduled meetings in the region, such as the Policy Advisory Network for Agricultural Production (PANAP) and the Policy Analysis and Advisory Network for South Asia (PAANSA). Major organisations will be invited to nominate focal points to work closely with the Regional Coordinator.

The science/policy interface is an ongoing dialogue based on several activities:

- (i) GECAFS-IGP approves and posts the research themes on the GECAFS website and also develops a publication on the research agenda for circulation to scientists and policymakers. This would be prepared by a specialist in science communication.
- (ii) Biennial GECAFS-IGP science fora discuss the technical content of the research proposals, in the light of the GECAFS planning exercises.
- (iii) The biennial science fora are followed immediately with a policy- and decision-makers meeting to discuss how well the research plans are contributing to information needs for development (as identified during the planning/earlier phases).
- (iv) GECAFS-IGP adapts research proposals in the light of the policy dialogue.

The GECAFS-IGP website will have an area for the scientific publications and another area for disseminating policy and development related products; and summary policy briefs will be circulated to principal agencies in the region.

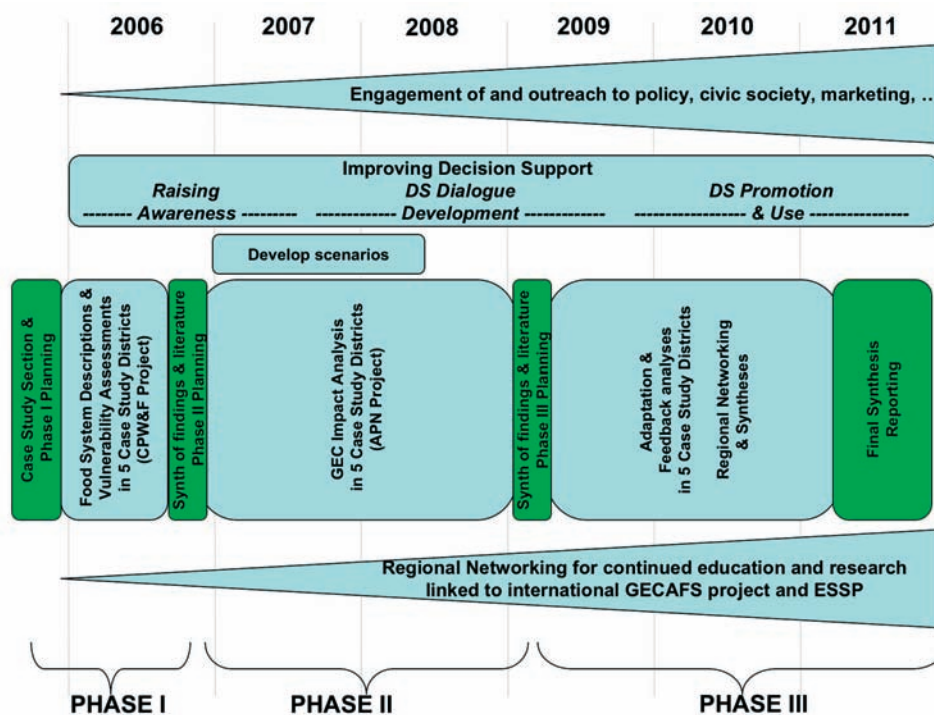


Figure 5: GECAFS-IGP timeline.

4.5 Phased approach

Planning for the GECAFS-IGP project has been conducted over several years and a wide range of regional scientists and policymakers have been involved (Annex 3). This planning process, which was supported by a wide range of donors, culminated in the preparation of this Plan and the launch of initial studies in 2006 supported by the CPW&F.

Overall, the implementation phase will cover a five-year period conducted in three Phases (Figure 5). Regular capacity building workshops for regional collaborators will be held, with input from GECAFS Science Officers. These workshops will update collaborators in latest GECAFS methodology to establish a standardised approach across case studies and initiate/strengthen collaboration.

4.5.1 Phase I implementation (1.5 years)

Key activities:

- Launch workshops were held involving a wide range of regional researchers, policy makers, resource managers and donors
- Initial Case Study research was undertaken on food system descriptions and their vulnerability to changes in water availability and access (funded by CPW&F)
- Available data was reviewed and supplementary data needs identified

Key products:

- Five Case Study sites were selected
- Standardised food system descriptions were prepared for each Case Study as a foundation for GECAFS regional research
- Potential intra-regional research network members were identified

4.5.2 Phase II implementation (1.5 years)

Key activities:

- Undertake GECAFS Case Study research on vulnerability of food systems to GEC and decision support (funded by APN)
- Undertake comprehensive scenarios exercise
- Launch and promote intra-regional research networks and link to GECAFS international networks
- Establish GECAFS-IGP Regional Steering Committee (RSC) through links created from the GECAFS-IGP planning phase and appoint a GECAFS Regional Coordinator (see Section 5.2.2)

Key products:

- Regional GECAFS Steering Committee and Coordinator established in appropriate institution
- Improved understanding of IGP food system vulnerability to GEC

- New insights of regional hotspots for food systems vulnerability to GEC based on analyses of changing food supply and trade, wealth, food preferences and interactions with GEC
- Comprehensive, regional scenarios of future socioeconomic, environmental and ecological conditions involving the food system
- Preliminary decision support approaches mapped out to aid policymakers' decisions in response to GEC
- New insights in research design for 'science to aid policy development'

4.5.3 Phase III implementation (2.5 years)

Key activities:

- Undertake GECAFS Case Study research on adaptation and feedbacks and refine decision support approaches
- Extend intra-regional research networks and synthesis activities and link further to GECAFS international conceptual research networks (cf. Figure 2)
- Final synthesis workshop and plan follow-up activities
- Reporting

Key products:

- Improved understanding of IGP food system vulnerability to GEC, based on case studies
- New insights of regional hotspots for food systems vulnerability to GEC based on analyses of changing food supply and trade, wealth, food preferences and interactions with GEC
- Increased awareness of potential environmental feedbacks from adaptation options
- Decision Support approaches and tools to aid policymakers' decisions in response to GEC
- Increased awareness of potential environmental feedbacks from adaptation options

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

The sustainability of the GECAFS-IGP initiative will result from local and national policy bodies using GECAFS-IGP research products and from incorporating new insights into national development plans.

4.6 Communications strategy

Achieving the objectives of the proposed research relies on a mechanism or system to facilitate communication between researchers and policymakers at each step. The involvement of researchers and policymakers throughout the planning phase and the regional scenarios development raises awareness of GEC issues and what needs to be considered in decision-making (Zurek et al., 2004), and thus is a key part of the communications strategy. To expand the system, adaptive management approaches (Lee, 1999; Gunderson, 2002) will be built upon, with specific support for key decision makers at national and regional levels as outlined by Lal et al. (2001).

In addition to the active participation of stakeholder groups, the communications strategies will also employ presentations at regional and international workshops and conferences; submissions to the international, peer-reviewed literature; policy briefs, other publications; and the web. Close liaison with major regional programmes (e.g. TERI, RWC) will be maintained throughout. Key findings will be published in local languages to help reach out to local government and civil society.

Decision support (DS) development will play a major role in the communications strategy. It will be based on research on how best to determine stakeholder information needs, and on communicating and interpreting research findings (ODI/RAPID, 2004; see www.odi.org.uk for details about this approach). This will allow the DS process to be used to help retrieve information and evaluate scenarios in policy exercises that depend on multi-stakeholder negotiations. GECAFS conceptual research in DS will also contribute to regional communications by, for example, demonstrating the Questions and Decisions (QnD) system (Kiker et al., 2005; Kiker and Linkov, 2005). QnD is a structured platform for modelling environmental processes and management decisions as a means to stimulate GECAFS discussions and analysis amongst stakeholders.

4.7 Capacity development

GECAFS-IGP will help build regional capacity in both science and policy-making. This will be achieved in a number of ways.

Science capacity will be built by:

- networking scientists across the region and across disciplines to jointly address common research issues
- inception workshops run by GECAFS science officers to bring regional researchers up to date on latest GECAFS methods
- linking regional researchers with scientists world-wide through the GECAFS international research networks
- meetings with regional policymakers so that the science community are more aware of the key issues facing policymakers and the constraints under which they have to work

(cf. Section 3.4.3; Section 4.8 The need for continued education)

Policy capacity will be enhanced by:

- involving local and national policymakers in scenarios exercises to raise their awareness of GEC issues and the consequences of given scenarios for development
- working with policymakers to interpret research findings in the context of policy formulation
- providing decision support tools to help with analysing tradeoffs between socioeconomic and environmental goals for given adaptation options

4.8 The need for continued education

Basic education is an important factor in improving food security in the face of GEC. Gasperini (2000) shows that farmers with four years of elementary education are, on

average, 8.7% more productive than a farmer with no education. Education is important not only to help increase production but also for post-harvest handling and food utilization. Therefore curricula should be modified to give people a better integrated understanding on issues related to food security. Studies in Pakistan (Alderman, 1992; Alderman and Garcia, 1993) show that education of mothers significantly influences child nutrition status. Along with researchers, civil society should also be involved, and the exchange and sharing of views and practices needs to be encouraged between academicians and civil society.

A variety of education tools can be used to help improve food security and sustainable development. Participatory Curriculum Development (Hermsen, 2000) may be used for effective dissemination and raising awareness in society, while for bringing about an overall change in behaviour within the community or society other approaches can be developed based on different theories such as “Learning Theory”, “Social Cognition Model”, and the “Organisational Change Model” (NHS, 1999). An integrated approach may be used by applying different tools (Suurla and Markkula, 1999). There is also a need to encourage awareness and capacity building of various stakeholders.

The dissemination of acquired knowledge is also important for creating awareness amongst all levels of stakeholders. Different methods like media, small pamphlets or short summaries of research output and reports in local languages should be encouraged.

Food security issues should also be included in the research education and dissemination system to encourage a sustainable linkage between research and policy. The institutionalisation of mechanisms to develop the capacity of young researchers and policy makers will ensure that new capacities will be much more widespread. Targeting young researchers at early stages to employ interdisciplinary and participatory approaches will facilitate a shift in the way research is done, so that ‘beneficiaries’ can become ‘actors.’ Such capacity development strategies should also recognize that researchers need support not only in concepts and approaches, but also in outreach where they are faced with on-the-ground challenges of implementation.

4.9 Linking GECAFS-IGP research with GECAFS international networks

GECAFS-IGP will undertake research on impacts, adaptation and feedbacks (Q1-3) relating to the policy issues identified in the planning process. Such research is conducted in close association with GECAFS conceptual and methodological research worldwide on generic topics derived from science questions and policy issues. In addition to directly addressing Q1-3, GECAFS-IGP case study and other regional research will be networked with the worldwide GECAFS conceptual research agenda (cf. Figure 2).

Regional scientists can contribute to a global undertaking and build contacts with scientists working on similar

issues in other parts of the world. This approach relates to all GECAFS conceptual research. Regional researchers will be invited to join worldwide GECAFS research networks via the GECAFS Forum (see www.gecafs.org) and participate in international integration and synthesis activities.

4.10 Links to IGBP, IHDP & WCRP Core and other ESSP Joint Projects

Research at a sub-continental level is important in its own right and it also brings possibilities for collaboration with other GEC programmes working at similar spatial levels. These include research in other GECAFS regional projects; in other ESSP Joint Projects (Table 1).

Table 1: Examples of potential collaborative activities with other International Projects

International Project	Potential collaboration with GECAFS-IGP
IGBP/IHDP-GLP	FS policy/LUC links; vulnerability/resilience concepts
IGBP/IHDP-LOICZ	Bay of Bengal coastal zone dynamics
IHDP-GECHS	Concepts of vulnerability
WCRP-CLIVAR	Extending and improving ENSO predictions
WCRP-GEWEX	Land surface changes in the hydrologic cycle
ESSP-GWSP	Impacts of dams on water availability and access
ESSP-MAIRS	Changes in Monsoon Asia
ESSP-ESG	Developing improved regional food system governance

5

GECAFS-IGP Funding Strategy and Governance

GECAFS-IGP research projects will apply for funding from regional and international funds, making reference to this Plan. Coordination funds will be raised to cover general regional networking activities, the science-policy interface and research management. A GECAFS-IGP Regional Steering Committee (RSC) will be established and a Regional Coordinator appointed. The RSC will provide scientific oversight of GECAFS-IGP, supported by the Regional Coordinator.

The GECAFS-IGP agenda is largely aligned to development issues related to the region as a whole, so development agencies are expected to be the principal funders for the case study (Q1-3) research. However, because the innovative research agenda also contributes to – and is strengthened by – GECAFS conceptual research (for instance regarding improved insights into food systems vulnerability and scenario analyses), additional support can be sought from science agencies (the traditional investors in GEC research). This means that a wider range of funding sources can be engaged, a fact which the donor community welcomes because it helps them to work towards common goals.

5.1 Funding strategy and indicative budget

The GECAFS-IGP funding strategy will be developed by the GECAFS-IGP RSC (see Section 5.2.1) and the GECAFS IPO.

5.1.1 Regional research

Specific funding applications will be prepared for research components related to:

- Case Studies (building on the already-secured grants from CPW&F and APN)
- Scenarios exercise
- Training and outreach workshops
- Regional networking and synthesis

The conceptual research aspects will be developed in close collaboration with the GECAFS international networks. Proposals prepared to science funding agencies for specific activities (e.g. regional scenario methodological development) will thereby complement the activities covered by the core fund.

5.1.2 Regional coordination

Donors will also be approached to establish a GECAFS-IGP coordination fund. An indicative budget for the 5-year project is US\$200k per year which will cover:

- Regional Steering Committee travel (\$30k)
- Regional Coordinator post and operating costs (\$100k + \$30k)
- Seed funds for regional networking and synthesis exercises (\$40k)

Establishing this fund will be critical to the successful implementation of GECAFS-IGP. It will allow for the integrated package of case studies, regional synthesis and communication with stakeholders to be coordinated from within the region, overseen by leading regional scientists. This will encourage regional collaboration and help ensure wide scientific and policy contributions and capacity building.

5.2 Governance

5.2.1 Regional Steering Committee

The GECAFS Executive Committee, in consultation with the GECAFS SAC member responsible for the region, will establish a small GECAFS-IGP Regional Steering Committee (RSC) comprising:

- Chair: GECAFS SAC member with responsibility for GECAFS-IGP region (*ex officio*)
- ca. four members representing regional and skills coverage and science/policy balance
- host institution representative (*ex officio*)
- the GECAFS-IGP Regional Coordinator (who will serve as Secretary).
- the GECAFS Executive Officer (*ex officio*) (who will attend key meetings to help ensure links with the overall GECAFS project).

The RSC (Figure 6) will:

- provide overall scientific guidance for GECAFS-IGP
- help prepare funding proposals for Case Studies with the GECAFS IPO
- maintain financial oversight of the project and report to donors
- identify relevant regional research to network within the region and with GECAFS internationally
- organise regional synthesis workshops
- be served by a Regional Coordinator based in an appropriate regional institution administered by a regional institute
- establish and maintain good links with the RWC and other relevant regional research bodies
- establish and maintain good links with regional, national and district policymakers
- report via the Chair/Regional Coordinator to the GECAFS SAC and to donors

Further details will be established with potential donors.

5.2.2 GECAFS-IGP Regional Coordinator

A Regional Coordinator will be appointed, funded as a specific budget line in the coordination proposal. Working to support the RSC, and especially the Chair, the position will coordinate all aspects of the GECAFS-IGP project, and in particular:

- help launch and facilitate all aspects of GECAFS-IGP research
- plan and facilitate integration and synthesis exercises
- maintain close working links with strategic partners and donors
- develop an external communication (or outreach) programme
- manage the project office on a day-to-day basis
- report to the RSC.

5.2.3 Host institution

The project office needs to be based in an appropriate regional institution which will: (i) host the Regional Coordinator and RSC meetings; (ii) provide effective communication and administrative support, and credible finance management; (iii) already have a mandate to cover GEC and/or food issues for the region; and (iv) be willing and able to promote GECAFS in the region.

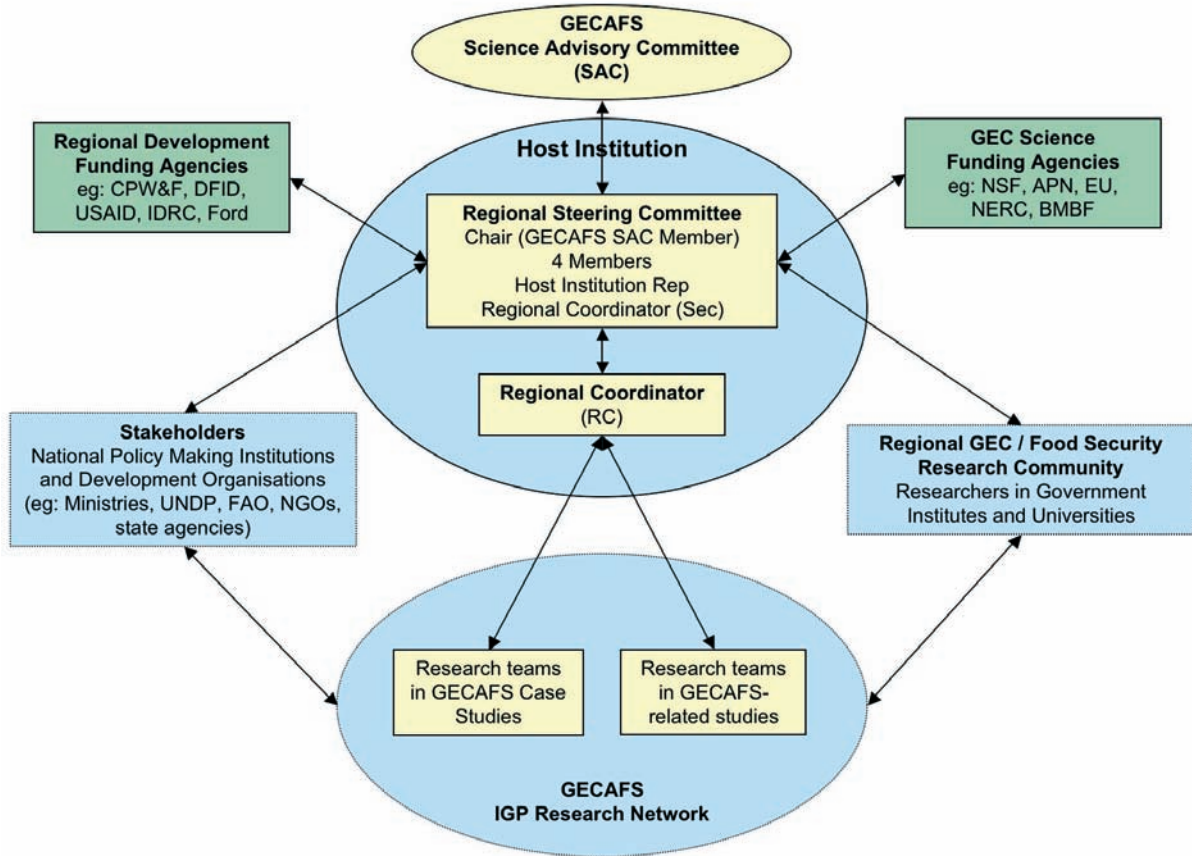


Figure 6: GECAFS-IGP Governance and Management Structure.

6

Conclusions

The GECAFS-IGP Science Plan and Implementation Strategy offers an innovative and timely research framework on improving regional food security in the context of environmental stress. This is an issue of growing importance for the region.

This Plan:

- provides an integrated approach to food security and GEC research in the IGP
- is based on a comprehensive set of research questions derived from wide regional consultation
- directly addresses the stated information needs of regional policy and development agencies
- builds on, and adds value to, existing research findings and infrastructure
- networks researchers both regionally and internationally
- contributes to an internationally-endorsed research agenda.

Principal outputs will include:

- improved understanding of how GEC will additionally affect food security across the IGP and among different socioeconomic groups
- assessments of how adaptation strategies designed to cope with GEC and changing demands for food will affect the environment, societies and economies
- enhanced regional capacity in food security and environmental research
- a strengthened regional policy formulation capacity for food security and environmental governance
- policy recommendations for adaptation options.

1

Annex

Global Environmental Change and Food Systems (GECAFS): A summary

Global Environmental Change and Food Systems (GECAFS) is an international, interdisciplinary research project focussed on understanding the links between food security and global environmental change. GECAFS was launched in 2001 as a Joint Project of what is now the Earth System Science Partnership (ESSP), and has formal research partnerships with the Consultative Group on International Agricultural Research (CGIAR), the UN Food and Agriculture Organization (FAO) and the UN World Meteorological Organization (WMO).

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. GECAFS undertakes research that not only studies food security in the context of GEC but also feedbacks of adaptation strategies to the Earth system.

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

1. How will global environmental change affect the vulnerability of food systems in different regions?
2. How can we adapt food systems to cope with global environmental change and improve food security?
3. How will various adaptation options feedback on environmental and socioeconomic conditions?

To answer these questions, GECAFS is developing a worldwide 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:

- Food systems research: to improve understanding of food systems suitable for GEC research
- Vulnerability research: to integrate social science and natural science concepts of what makes a food system vulnerable
- Scenario research: to determine how to construct the comprehensive scenarios needed for GECAFS regional research
- Decision support research: to determine how best to improve dialogue between scientists and policymakers 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 in the *Indo-Gangetic Plain*; *Southern Africa*, and the *Caribbean*.

More information on GECAFS is available from www.gecafs.org

2 Annex

Development of GECAFS IGP Research

An important aspect of the GECAFS regional approach is to ensure that the research agenda closely matches major regional GEC science interests, policy needs and donor priorities. The process to achieve this constituted the project planning phase and involved workshops, informal conversations and discussions with a wide range of potential stakeholders in the region.

IGP scientists and policy makers have been in consultation with the GECAFS Executive Committee to develop a GECAFS food systems project for the IGP. Recognising the complexity of the research issues, the development of the GECAFS-IGP project was seen to involve a preparative stage followed by the implementation stage:

- Stage I Preparation and scoping – identifying the issues; defining research agenda, and initial drafting of this Plan.
- Stage II Project start up – synthesis and assessment of existing information and current conditions; food systems case studies; development of GEC and food systems vulnerability assessment, scenarios and prototype decision support systems.

Stage I consisted of a series of scoping meetings with regional scientists and policy-makers. These both crystallized the nature of regional policy issues relating to food security and helped raised awareness of GEC issues within the region generally. Specifically, Stage I initiated dialogue within the GECAFS framework between national scientists & policy makers to determine overall GEC issues in the region and identified GECAFS scientific objectives and potential collaborators.

Key overarching questions were also determined.

Follow-up discussions refined these into a coherent set of researchable questions relating to the national issues and the region as a whole. A small, ad hoc planning group oversaw the development of Phase I and prepared this Plan.

The development of the GECAFS-IGP Science Plan and Implementation Strategy has followed the overall international project approach for developing GECAFS regional research. Figure A1 shows the main steps in this process, and the publication of this Plan is the culmination of planning phase (Steps 1-3). Steps 4-6 constitute research implementation as described in Section 4.

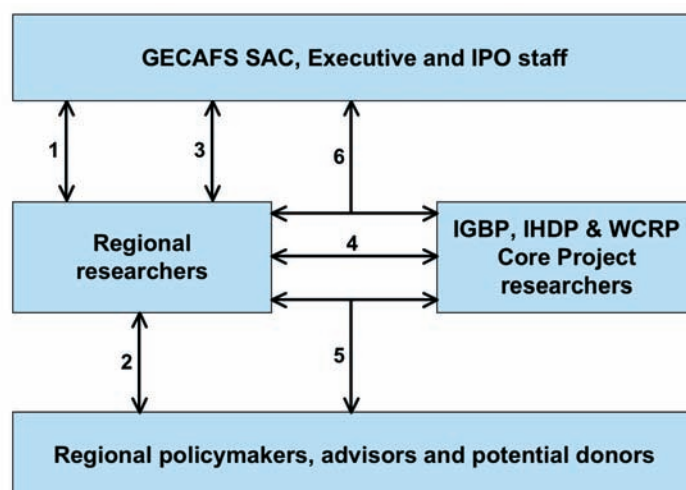


Figure A1: Key steps in design (Steps 1-3) and implementation (Steps 4-6) of GECAFS-IGP food systems research

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Annex

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Annex

Acronyms and abbreviations

APN	Asia Pacific Network	IGP	Indo-Gangetic Plain
BMBF	Federal Ministry of Education and Research	IHDP	International Human Dimensions Programme on Global Environmental Change
CARICOM	Caribbean Community and Common Market	IPCC	Inter-Governmental Panel on Climate Change
CGIAR	Consultative Group on International Agricultural Research	IPO	International Project Office
CLIVAR	International Research Programme on Climate Variability and Predictability	LOICZ	Land-Ocean Interactions in the Coastal Zone
CPW&F	CGIAR Challenge Program on Water and Food	MA	Millennium Ecosystem Assessment
DFID	Department for International Development (of the UK)	MAIRS	Monsoon Asia Integrated Regional Study
DS	Decision Support	NERC	Natural Environment Research Council of the UK
ESG	Earth System Governance	NGOs	Non-Governmental Organisations
ESSP	Earth System Science Partnership	NSF	National Science Foundation of the United States
EU	European Union	ODI/RAPID	Overseas Development Institute / Research and Policy in Development
FAO	United Nations Food and Agriculture Organisation	PAANSA	Policy Analysis and Advisory Network for South Asia
GEC	Global Environmental Change	PANAP	Policy Advisory Network for Agricultural Production
GECAFS	Global Environmental Change and Food Systems	QnD	Questions and Decisions
GECHS	Global Environmental Change and Human Security	RSC	Regional Steering Committee
GEWEX	Global Energy and Water Cycle Experiment	RWC	Rice Wheat Consortium
GLP	Global Land Project	SAC	Scientific Advisory Committee
GWSP	Global Water Systems Project	TERI	Tata Energy Research Institute
HDI	Human Development Index	UGC	Upper Ganga Canal
IDGEC	Institutional Dimensions of Global Environmental Change	UNDP	United Nations Development Programme
IDRC	International Development Research Council	WCRP	World Climate Research Programme
IGBP	International Geosphere-Biosphere Programme	WMO	World Meteorological Organisation

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Annex

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Cover Photographs:

Left Food Availability: in addition to destroying production, flooding disrupts food distribution and exchange

Middle Food Access: affordability, allocation and preference are key determinants of food access

Right Food Utilisation: food can have important social and religious values, in addition to nutritional aspects



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

GECAFS: A joint project of



International Geosphere-Biosphere Programme



IHDP

International Human Dimensions Programme on Global Environmental Change

International Human Dimensions Programme on Global Environmental Change



World Climate Research Programme

World Climate Research Programme

In collaboration with:



Consultative Group on International Agricultural Research



Food and Agriculture Organisation of the United Nations



World Meteorological Organisation of the United Nations