Globally Important Agricultural Heritage Systems (GIAHS)

Globally Important Agricultural Heritage Systems: A Scientific Conceptual Framework and Strategic Principles

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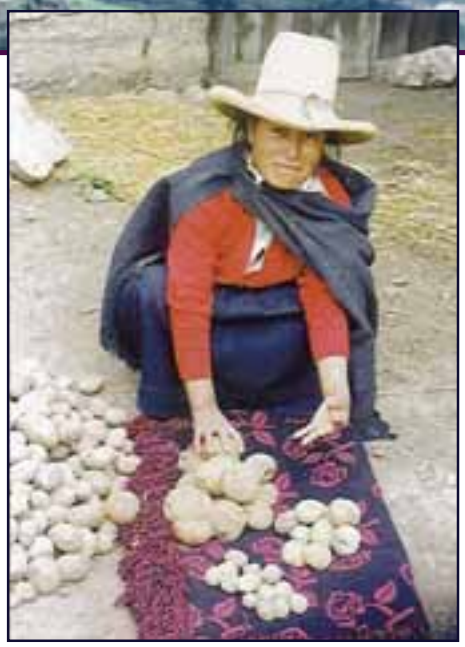

In developing the Scientific Conceptual Framework for the Globally Important Agricultural Heritage Systems (GIAHS) Programme, FAO seeks to accomplish the challenging task of integrating perspectives from those sciences that are most directly concerned with conservation and development: ecology, agronomy and forestry, economics, and anthropology. The goal is to scientifically conceptualise GIAHS as integrated social and ecological systems that are dynamically embedded in larger systems (at regional, national, and global scales), and that are subject to both endogenous and exogenous change drivers at various scales. An adequate scientific framework for the GIAHS Programme should help it to reinforce the capacity of their stewards to sustain and enhance their lifeways and livelihoods, to safeguard against losses in biodiversity and ecosystem services and, as per the objectives of the Programme[1],

allow for the continued evolution and adaptation of these systems at a time when they are under (possibly severe) stress and subject to major disturbances as a result of social, economic and environmental change. Thus, above all, the resilience of GIAHS systems must be assured.

It is clear that our world is changing with a rapidity that is unprecedented in human history. Our impacts on the biosphere, the hydrosphere, and the atmosphere are so great that many scientists are now calling this period in the Earth's history the 'anthropocene'. The Earth's social-ecological systems are also characterised by unprecedented integration and inter-dependency: the actions of populations living in highly developed, urban and industrial parts of the globe have extensive repercussions far across the planet, and it has thus become exceedingly difficult for them to see and understand the ecological and social repercussions. People living in GIAHS-type systems have the advantage that they can still witness and, to a great extent, understand the implications of their actions for their environments, but their great disadvantage is that they have virtually no power to affect those global drivers that are changing their status and the state of their systems so rapidly.

It is in this context, where both scientific and local knowledge are of such great importance, that we have attempted to bring to bear the state-of-the art of scientific knowledge to conceptualise GIAHS. We have sought to exploit those perspectives that are informing global policy debates about means to understand the earth's social-ecological systems and the dynamics of global change. The choice has been made to adopt a social-ecological systems' resilience approach, while integrating into it those perspectives that have contributed most strongly to understanding the nature and dynamics of traditional societies. All of the topics that are addressed herein represent brief summaries of such perspectives, that highlight some of the most important general insights. All of the literature cited represents only a fraction of that which is relevant.

We have drawn on GIAHS background documents, participated in several meetings with FAO staff and GIAHS partners, and consulted with scientific experts who have provided valuable comments and critiques.[2] In this process, much of the early GIAHS thinking has been critiqued and revised, and the current effort, represented in these pages, will in turn be subjected to scrutiny and debate. Invariably there are perspectives and issues that are glossed over or missed entirely. The development of the Scientific Conceptual Framework for GIAHS, like the GIAHS initiative itself, must be understood as a social learning process. As the GIAHS Programme continues to develop, a Scientific Advisory Committee and, as necessary, Working Groups, should have the tasks of validating and updating the Scientific Framework and Strategic Principles. The most crucial forum for validation and adjustment, however, resides at local level within GIAHS project sites, among the stewards of GIAHS who hold the greatest wealth of knowledge about their own systems and whose knowledge and volition must constitute the wellsprings of decision-making.

What is presented in these pages is not a plan of action for the GIAHS Programme, which must draw upon an additional substantial body of knowledge dealing with experiences in supporting traditional communities in adaptive co-management, and which must reflect broad consultation with indigenous and traditional peoples as well as with governments, donors, and the relevant NGO community. Rather, an effort has been made to derive Strategic Principles from the body of scientific knowledge that can guide implementation, and to provide a framework of concepts and issues that need to be considered when developing such plans. To the best of our knowledge, there has been no previous attempt to develop such a comprehensive framework, and therefore errors are inevitable. The authors accept full responsibility for such errors and express our gratitude to FAO, and especially to Parviz Koohafkan and David Boerma, for entrusting us with such a challenging task.

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[1]See FAO / Global Environment Facility Project Document, Conservation and adaptive management of globally important agricultural heritage systems (GIAHS), GCP / GLO / 212 / GFF, May 2008. Rome: Food and Agriculture Organization of the United Nations.

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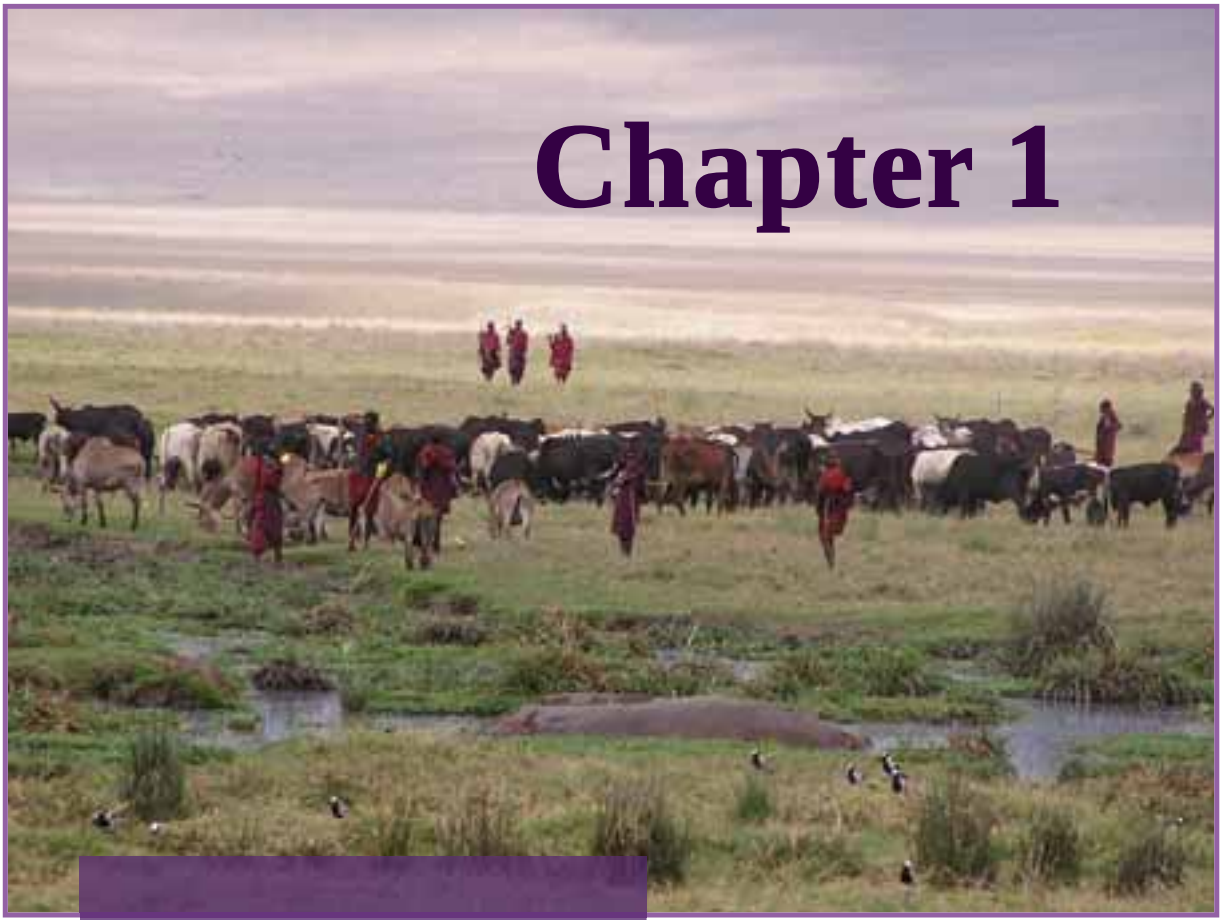
Chapter 1



Introduction and Overview

1.1 Change and Resilience: The Significance of GIAHS

Throughout the centuries, generations of farmers, herders, pastoralists, hunters, gatherers, and fisherfolk have developed complex, diverse, and locally adapted livelihood systems managed with time-tested ingenious combinations of techniques, knowledge, and practices that have generally led to community food security, sustainable natural resource management, high levels of biodiversity (particularly in the tropics), and preservation of cultural identity. These microcosms of agricultural heritage can be found throughout the world and together are estimated to cover about five million hectares, and to support about two billion people. At the same time, these systems provide a series of cultural and ecological services to humankind as a whole, such as the management and maintenance of unique landscapes and biodiversity, a wealth of traditional knowledge, local crop, animal and fish species and varieties, myriad other ecological services, and autochthonous forms of socio-cultural organisa-

tion that have evolved to ensure adequate management of local resources and, often, a high degree of social equity. It is no wonder that they have been lately conceived as ***Globally Important Agricultural Heritage Systems (GIAHS).***

In GIAHS, humans are keystone species - they manage, organise and structure the landscape at different scales. Further, GIAHS are 'keystone systems' in various senses. First, they often represent the only means known for humans to occupy specific marginal environments and landscapes without degrading them, while at the same time providing most if not all of the essential goods and services that are required. Second, they are necessary to maintain specific configurations of biodiversity and agrobiodiversity (both above and below ground), and specific landscapes and their ecological services. Third, they are based upon historically evolved and culturally embedded group decision-making processes and related institutions that exhibit capacities for adaptation, innovation, conflict resolution, and transmission of sets of knowledge and values that are also specifically adapted to particular biotic and abiotic conditions. All of these variables - production systems, biodiversity and ecological services, and institutions - are interrelated in complex ways; should any of them change very substantially, their systems would possibly cross thresholds into very different configurations or states.

GIAHS are social-ecological systems in which their ***stewards (the populations who have co-created and sustain them)*** have had to continuously adapt and innovate just to keep up with shocks, disturbances and change of all types – ecological, economic, political and cultural. Many GIAHS have successfully coped with colonialism, major and repeated changes in national and regional governance systems and policies, exploitation of their resources on the part of outsiders, internal and external conflict (including invasion and warfare), as well as substantial changes in local ecology (climate, vegetation cover, soil fertility, water availability). Most GIAHS have exhibited an ability to support substantial demographic change and to increase output over time. Nevertheless, many have also disappeared, and most that remain are under threat due to technological, economic, ecological, and cultural change drivers, which very often are related to government policies that actively seek to transform these systems into different states since their populations are perceived to be 'backward' or 'poor' and their resource base 'undeveloped'.

Change in these traditional systems has been especially rapid since the beginning of the 20th century. In the 21st century, the pace of change has accelerated and the number of shocks and disturbances has increased, and will likely continue to increase in a non-linear and largely unpredictable fashion. GIAHS social-ecological systems are highly dependent upon ecosystem services and accumulated local knowledge and cultural institutions that will be especially stressed given existing global and local change drivers. GIAHS are also generally found in regions that are especially vulnerable to such change drivers: most, for example, are located in regions where biodiversity extinctions are the highest in the world. Major global challenges that GIAHS stewards must confront, often simultaneously, include demographic change, major species extinctions and changes in range of species, increasing climatic variability and shocks together with water stress, increasing energy costs and scarcity of energy resources leading to higher prices for food and other essentials, general economic instability and decreases in welfare; and increasing tensions over resource access and environmental problems, and hence conflict at local, regional, or international scales, all of which can threaten food security and lead to increases in poverty (CBD 2007, IPCC-WGII 2007). In regions where there is substantial scope for intensification or for the development of alternative employment and economic opportunities, adaptation to change for GIAHS stewards may mean crossing a threshold into a different state, which may present an acceptable, or even preferable, alternative. However, it is generally recognised that, for many such traditional systems, such positive alternative states are neither feasible nor likely in the short or medium term.

At the same time, the past resilience of such systems, together with their relative remoteness, may offer better prospects for their continued evolution in comparison with systems that are highly dependent on external inputs (e.g. fossil fuels, chemicals, irrigation) and markets, with high population densities and subsequent high demands on natural resources and ecosystem services that currently function close to ecosystem thresholds. Especially, industrial forms of agricultural and livestock intensification add substantially to land and soil degradation, pollution, CO_2 emissions, biodiversity loss, and water stress (see e.g. Tilman et al. 1996, Steinfeld et al. 2006). It is likely that many intensive systems will be pushed over the threshold into degraded states, or will continue to come under increasing pressure due to their negative contributions to global environmental change.

Identifying, prioritising, and supporting traditional social-ecological systems can be understood as a global insurance policy, so that humans are indeed able to continue to inhabit difficult environments, so that the biodiversity, agrobiodiversity and ecosystem services that are crucial to the world's future continue to exist; and so that a large proportion of the globe's population can continue to provide their requirements for subsistence without exerting additional pressure on the earth's resources, and on other proximate or distant social-ecosystems that are themselves already under threat.

GIAHS not only support an important proportion of the planet's population while sustaining the resource base – they also offer promising models to achieve future sustainability in other contexts since they promote biodiversity, thrive without agrochemicals, and sustain year-round yields (Denevan 1995). Undoubtedly, the ensemble of management practices used by many traditional peoples represents a rich resource for ecologists interested in understanding the mechanisms at work in complex agroecosystems, such as the interactions between biodiversity and ecosystem functions or the use of natural succession as templates for agroecosystem design. The study of such systems and the ways in which traditional peoples maintain and use biodiversity can also considerably speed the emergence of agroecological principles which are urgently needed to develop more sustainable agroecosystems and agrobiodiversity conservation strategies both in industrial and developing countries. Such studies have already helped to create novel farm designs well adapted to circumstances in subsistence social-ecological systems (Altieri 2002).

GIAHS thus represent an ecological and cultural legacy of inestimable importance to humankind as well as to GIAHS stewards and their future generations. Support for GIAHS will represent a reversal of centuries of policies that have both exploited and devalued such systems as well as disregarded the rights of local and indigenous peoples to maintain their lifeways. It is imperative that such traditional social-ecological systems be considered as globally significant resources to be protected so that they may continue to adapt and evolve. The loss of such systems will be irreversible and can only reduce the resilience of local, national and global populations at a period when such resilience is required more than at any other time in human history. GIAHS systems are likely to provide a substantial degree of resilience against such threats on a local as well as a global basis if their stewards are able to continue to adapt to change without losing their capacity to provide the goods and services that make them so valuable.

1.2 The GIAHS Programme

Given the above, the FAO and other international and national partners have established the GIAHS Programme, which was endorsed by the Commission on Genetic Resources for Food and Agriculture (FAO 2002a) as a programme that would support the development of a network of *in situ* conservation areas. In its Ninth Regular Session (CGRFA 2002), the Commission recognised that GIAHS-type systems 'ensure the sustained provision of multiple goods and services, food and livelihood security, and quality of life' of their stewards while promoting the goals of the International Treaty on Plant Genetic Resources for Food and Agriculture (with 116 signatories),[1] Articles 6 and 9, including 'protection of traditional knowledge relevant to plant genetic resources...the right to equitably participate in sharing benefits...[and] the right to participate in making decisions' (Ibid.). The Commission endorsed the initial stakeholder workshop, held in August of 2002, which subsequently recommended the establishment of an international, multi-stakeholder Steering Committee. The decision of the 2nd Steering Committee meeting in 2004 (FAO 2004) was to support the selection of a series of pilot sites located in several countries in the developing world, based in part upon a series of background papers that further developed the GIAHS concept.[2] The pilot efforts will give rise to a social learning process and the

concomitant strengthening of adaptive capacity and related governance structures and policies at various scales that can then be used to extend the Programme over a larger geographical scale.[3]

Several criteria have been developed for recognition of a system as Globally Important Agricultural Heritage that are related to a system's 'inherent qualities' (Box 1.1). The reasons for these criteria, and uncertainties related to them, are drawn out in this paper. Indeed, a major challenge for the GIAHS Programme is to adequately conceptualise GIAHS systems and their services, and a further challenge is to link these concepts to the driving forces that tend to undermine resilience, and to the adaptive capacities that tend to maintain it.

When reviewing global concerns at the end of the 20th century, particularly in relation to the loss of agrobiodiversity but as well in relation to natural resource management more generally, major policies that intrinsically and directly support the GIAHS concept (Harrop 2005) include Agenda 21, which recognises indigenous and other rural peoples as major stewards of natural resources, the Johannesburg Declaration on Sustainable Development (especially Paragraph 40(r)) which promotes 'the conservation, sustainable use and management of traditional and indigenous agricultural systems and indigenous models of agricultural production,' and the Convention on Biological Diversity (Articles 8(j) and 10(c) which include the mandate to

> *Respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity ((8(j))...and Protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements (10(c))*' (CBD, quoted in Harrop 2005).

Further, the World Food Summit set the goal of reducing the number of undernourished people to half their present level no later than 2015 (taken up in the Millennium Development Goals), and recognised that 'Food security depends, *inter alia*, on sustainable management of fish, forests, and wildlife. In many indigenous communities, these resources are the principal sources of protein in the diet. The traditional knowledge within indigenous communities also plays an important role in the achievement of food security for these communities' (FAO 1996).

1.3 Three Founding Principles

In order to maintain much of the world's agricultural heritage, agrobiodiversity, and ecosystem services, much of the world's cultural diversity must also be maintained. The first founding principle of the GIAHS Programme is that the major custodians of the world's agricultural heritage systems are those people who have developed these systems and who continue to depend upon them for their livelihoods and cultural integrity (their stewards) (***GIAHS Principle 1***). This principle has profound implications for all aspects of the GIAHS Programme, not only because this implies that the proprietorial rights of GIAHS stewards must in all instances be respected; as well it acknowledges that GIAHS stewards cannot be compelled by outsiders to maintain their systems and their heritage, but can and shall do so only if this reflects their autonomous will. The principle further acknowledges that the maintenance of the resilience of such systems and the *in situ* management of agrobiodiversity cannot be done without ensuring the well-being of their stewards, where well-being is defined not only according to biophysical absolutes, but as well according to the cultural values that are inseparable from these multifaceted systems and their landscapes.

> ***GIAHS Principle 1***
> *The stewards of GIAHS are those people who have developed these systems and who continue to depend upon them for their livelihoods and cultural integrity. The maintenance of the resilience of such systems and the in situ management of agrobiodiversity cannot be done without ensuring the well-being of their stewards, where well-being is defined not only according to biophysical absolutes, but as well according to the cultural values that are inseparable from these multifaceted systems and their landscapes. The direct benefits of the GIAHS Programme must accrue principally to those who develop and sustain such systems.*

GIAHS Principle 2 contains the overall objective of the GIAHS Programme. The indigenous and traditional peoples in the North and South who have maintained these integral and largely sustainable social-ecosystems have seen their livelihoods and environments disrupted and their cultural and biological diversity dramatically reduced by economic and cultural processes accompanying globalisation and regionalisation (or 'de-localisation) which proceed apace with little input from, or concern with such local cultures, and which generally lead to cultural homogenisation and loss of languages and traditional knowledge and institutions. This agrobiodiversity, these systems, landscapes and lives, and their deep reservoirs of knowledge and natural and cultural capital, are indeed under threat. Concerted global, national, and local action is necessary to change awareness, redirect policies, address negative drivers, and support the capacity of GIAHS stewards to adapt to such change in a manner that ensures the resilience of their systems.

> ***GIAHS Principle 2***
> *The central objective of the GIAHS Programme is to maintain adaptive capacity and resilience within GIAHS so that they are able to continue to provide the products and services that are crucial to their inhabitants, regions and nations, and to the globe.*

GIAHS Principle 3 targets GIAHS Programme action very specifically at negative drivers - at those processes

> ***GIAHS Principle 3***
> *The forces that are driving the disruption of GIAHS by eroding their cultures and the capacities of these systems to provide for human and environmental well-being must, to the extent possible, be addressed by the GIAHS Programme. Human and biological diversity are under threat and concerted global action is necessary to change awareness, redirect policies, address negative drivers, and support the adaptive capacity and resilience of these systems and their stewards.*

BOX 1.1 | Systemic selection criteria for GIAHS (http://www.fao.org/sd/giahs/selection.asp)

Systems' ingenuity and remarkability

This criterion strictly applies to the agricultural systemic level. It brings together several indicators: adaptive capacity, resilience, functional complexity and others:
Diversity and Complexity: Possess functional (for instance risk mitigating) biophysical and socio-cultural diversity and complexity.
Systems Efficiency: Contribute to systems efficiency, minimising negative and maximising positive externalities concerning ecosystem health in terms of actual or potential fluxes or flows in resources and information or knowledge over space and time
Adaptive Capacity: Possess system flexibility and resilience, and adaptive capacity to cope with changing environmental or socio-economic conditions, stresses or opportunities
Integration: Integrate of complex relationships and positive connectivity and linkages between the systems' parts.
Ingenuity/Innovation: Contain ingenious or innovative solutions or adaptations to critical biophysical and socio-cultural constraints
Economic Viability and Sustainability: Possess financial and economic viability, and sustainability over the long term
Human Ecological Sustainability: Sustainability of human-environmental relations and trends in the long term, in the ecological and social sense (nutrient cycles, demography etc.).

Outstanding characteristics

These include five major groups of key resource endowments, goods and services and other features of the system:
(1) Biodiversity and ecosystem functioning,
(2) Landscape and land and water resource management characteristics,
(3) Food and livelihood security,
(4) Social organisation and culture (incl. customary institutions for agroecological management, normative arrangements for resource access and benefit sharing, value systems, rituals)
(5) Knowledge systems and farmers' technologies. (incl. technologies, associated value systems, knowledge transfer, language and oral traditions, arts, philosophy, cosmovisions,)
Optional:
(6) Other goods and services generated by the system (incl. ecosystems services, climate adaptation and other environmental benefits of global importance or specific features such as archaeological/historic value or contribution to political stability

Proved history of sustainability

Criterion on demonstrated value of agricultural livelihood systems for humankind as a heritage handed down through generations.
Economic Viability and Sustainability: Possess financial and economic viability, and sustainability over the long term
Adaptive Capacity: Possess system flexibility and resilience, and adaptive capacity to cope with changing environmental or socio-economic conditions, stresses or opportunities
Human Ecological Sustainability: Sustainability of human-environmental relations and trends in the long term, in the ecological and social sense (nutrient cycles, demography etc.)

Global significance

This criterion brings together the following indicators:
Public Goods: Provide global public goods and heritage which deserve economic valuation
Value-added: Attribute due value of global benefits through global heritage recognition, such as labelling, and World Heritage and Conservation classification

Representation

This criterion includes the following elements:
(1) Ecosystems and eco-regions,
(2) Systemic,
(3) Scalar impacts,
(4) Geography,
(5) Demonstration value

and conditions that are tending to undermine adaptive capacity and resilience (cultural, social, economic, ecological) in GIAHS. This means that such drivers must be first identified and understood by all relevant actors, particularly by GIAHS stewards, and that every effort must be made to address the underlying drivers rather than simply their proximate causes (Chapter 5). Where such drivers cannot be directly addressed (e.g. as is the case with climate change), then it is essential that GIAHS direct attention toward minimising their effects by directing attention toward those factors that compound the negative impacts of underlying drivers, e.g. lack of infrastructure and that enhance adaptation, which should serve to increase adaptive capacity and resilience.

All of these principles taken together make it clear that the GIAHS Programme does not propose that 'poor' traditional and indigenous farmers, herders, forest dwellers and foragers be cordoned off in 'culture-nature reserves' and expected to maintain agricultural systems and agrobiodiversity for the benefit of humankind and of the plant and animal kingdom while the rest of the globe enjoys the genetic, cultural, ecological and aesthetic by-products of their knowledge and labour.

The GIAHS programme is unique in its conceptualisation and it aims at integrating all relevant institutional and jurisdictional scales: global, regional, and local. It requires that everyone involved – policy makers, development agents, conservationists, scientists, and their stewards – participate in adaptive management and innovation. In its inception and implementation, GIAHS requires a very substantial departure from conventional development or conservation thinking and practice. At the same time, GIAHS is based on the cutting-edge of knowledge and on the convergence of many different scientific disciplines and development perspectives which are also at the leading edge of development practice.

Many of the scientific disciplines and international agencies concerned with agrobiodiversity conservation, cultural heritage, traditional agricultural systems, and sustainable futures are arriving at a point of convergence, which are elaborated upon and synthesised in the concepts and strategic principles for GIAHS that are contained in this framework.

This paper provides a first approximation of such a conceptual framework that builds on recent scientific advances. ***The aim of this paper is to generate knowledge on which to base appropriate action.*** A conceptual framework is neither a model nor a theory: rather, it helps to order material, to think, and to reveal patterns, where such pattern recognition often leads to models and theories. A theory or model that can underpin GIAHS is impossible to expound, particularly since the GIAHS approach itself in many ways represents a paradigm shift in thinking about human-environment relations. Social systems and the environment, or Culture and Nature, have to date largely been treated as discrete entities rather than as a system of interactions, and neither the resource management sciences, nor the social sciences, have interacted sufficiently to permit such theory to be fully developed. Scientists and practitioners alike are calling for such a paradigm shift. This shift is already in the making and it is being rapidly propelled by concerns with global phenomenon such as climate change, biodiversity loss, loss of ecosystem services, and threats to human well-being. However, besides developing a scientific conceptual framework for GIAHS, a series of strategic principles that are proposed to underpin the GIAHS approach are laid out which are derived directly from the framework, and which together can constitute the normative basis for the global GIAHS strategy. This framework does not constitute a plan of action for implementing such a strategy. The conceptual framework is based upon state-of-the-art scientific knowledge about contemporary subsistence societies or communities, their human-environment relations, and the driving forces that provoke their erosion and collapse and enhance their resilience, as well as the need for GIAHS communities to be supported to continue to adaptively manage their systems given great complexity and uncertainty.

Chapter 2 provides an overview of the main concepts and inter-relationships, particularly those related to subsistence social-ecological systems, which are seen as complex adaptive systems that exhibit emergent properties and that have to date been resilient with respect to change and uncertainty. A review of the various components of subsistence social-ecological systems, such as subsistence activities, culture, kinship, religious belief systems, traditional knowledge, language, social status and property, and their co-evolutionary interrelations with ecosystems, in particular agrobiodiversity, are presented.

Chapter 3 presents a detailed framework for conceptualising biodiversity and ecosystem resilience and, within these, agrobiodiversity and agroecological systems and their relations with livelihood systems, human well-being, and cultural institutions (identity, religion, traditional knowledge, social status, and rights systems), with various recommendations regarding GIAHS Programme implementation. Chapter 4 examines monetary mechanisms to maintain agrobiodiversity, beginning with an assessment of the utility of economic valuation approaches and then turning to the examination of markets as a double-edge sword, on the one hand tending to undermine cultural diversity and agrobiodiversity, and on the other hand potentially enhancing human well-being and resilience. Alternatives to potentially disruptive market-based mechanisms to increase well-being and resilience of traditional social-ecological systems are also presented and discussed.

Chapter 5 examines the proximate and underlying driving forces of change that are or potentially will affect GIAHS sites, and their effects on agrobiodiversity and human well-being in social-ecological systems, again with recommendations for GIAHS Programme implementation. Drivers are defined, and the principle driving forces that are affecting and will continue to affect GIAHS-type social-ecological systems across the globe are discussed (climate change, biodiversity change, changes in global energy supply and prices, and cultural change, as are some of the major synergies between these drivers. The emphasis is on drawing out some of the most important implications for adaptive capacity and resilience in subsistence social-ecological systems, and needs for research in GIAHS sites are also discussed. New ground is broken by proposing that there are positive forces that might work to maintain social-ecological system resilience and biocultural diversity.

Chapter 6 examines the concept of 'globally important heritage' from both Western and non-Western perspectives, including the some of the conflicts that have arisen over definitions and designations, as well as some of the lessons learned from other attempts to 'conserve' heritage, and concluding with a conceptual approach that is appropriate for GIAHS. Finally, in Chapter 7, the strategic principles derived from this scientific conceptual framework and presented throughout the different chapters are consolidated. The Appendix provides an example of how the concepts developed especially in Chapter 3 can be applied to the topic of food security and agrobiodiversity in traditional social-ecological systems.

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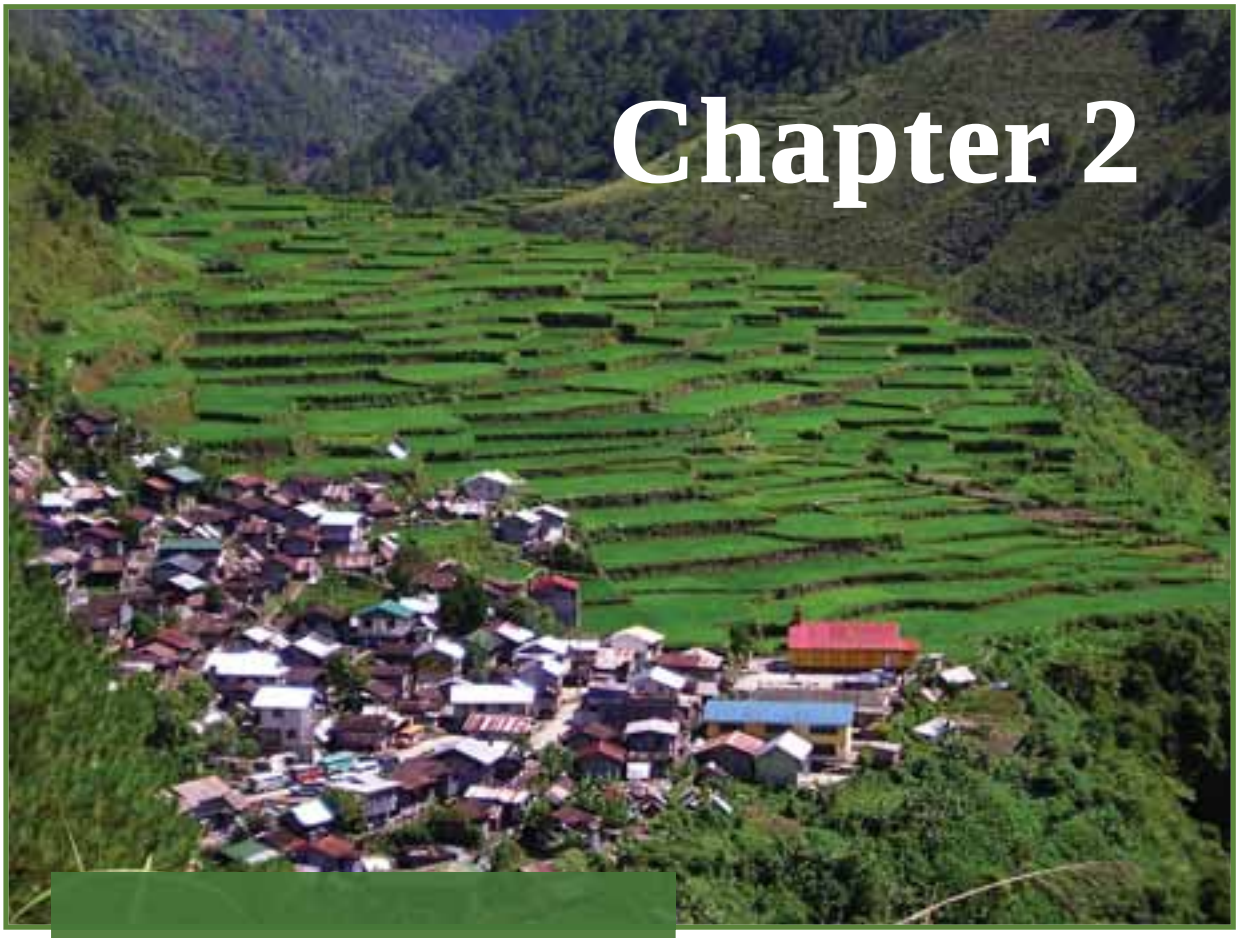
[1]See http://www.fao.org/Legal/TREATIES/033s-e.htm.

[2]Altierri 2004, Altierri & Koohafkan n.d., Boerma & Koohafkan n.d., Dévé 2004, FAO 2002, FAO 2004, FAO 2005, Harrop 2005, Ramakrishnan n.d., Rössler n.d.

[3]See FAO/Global Environment Facility. Project Document. Conservation and adaptive management of globally important agricultural heritage systems (GIAHS). GCP/GLO/212/GFF, May 2008. Rome: FAO.



Chapter 2

Key GIAHS Concepts

2.1 Social-ecological Systems

GIAHS are, as the name indicates, ***systems***. For a multitude of reasons, they are best conceived as specific types of ***Social-ecological Systems (SES)*** that are products of the co-evolution of both cultures and ecosystems. The SES 'framework' or 'approach' has arisen over the past few decades from the contributions of various disciplines and fields, especially ecology, environmental and ecological economics, and political science and, to a lesser extent, geography, anthropology, and sociology, and from networks and studies related to global environmental change (especially climate change, human dimensions, and the Millennium Ecosystem Assessment) (Janssen et al. 2006, Walker et al. 2006) where, unfortunately, to date the con-

tribution of anthropology and other social science disciplines to the conceptualisation of SES has been limited. Over the past few years there has been much energy invested among these involved disciplines in developing a set of shared or transdisciplinary axioms and concepts.

The key shared axiom underlying this framework is that there is an intimate interaction and mutual influence between local ecosystems and their dynamics, and the social, cultural, and economic characteristics and dynamics of communities and societies. These are ideas are not particularly new to the social sciences, having been expounded by cultural and human ecologists in the 1950s and 60s (Ellen 1982).[1] The SES framework as it is currently expounded initially arose from ecology (Holling 1973, Gunderson & Holling 2002, Jansen et al. 2006, Scoones 1999), and was distinguished from mainstream ecological thinking by the emphasis on including humans as agents of ecosystem change (Folke 2006). The framework recognises that the capacity of ecological systems to provision goods and services depends critically upon human practices, whereas human subsistence depends critically upon the stability and capacities of such ecological systems. Further, it is considered that **social systems and ecological systems *co-evolve*** – humans shape their environments to meet their cultural and material needs, whereas environment and ecology fundamentally shape these needs as well as the means by which humans meet these needs through culture and social organisation. It recognises that humans occupy virtually every ecological system on earth: we are generalists – able to adapt to and subsist from a very wide variety of environments. We have directly shaped most ecosystems that we have occupied to meet our needs and have indirectly influenced all other ecosystems on earth. Thus, many researchers are now seeking to overcome centuries of scientific and popular thinking that has separated 'nature' from 'culture', or 'landscapes' from 'communities', as if they evolved or existed independently.

Recently, Anderies et al. (2006) defined SES and pointed out important caveats:

> *At their core, SESs are composed of (1) agents ranging from microbes to plants to humans, each with a different degree of information-processing capacity; (2) a set of allowable actions related to their physical or behavioral characteristics; and (3) a physical substrate that includes chemicals, light, and water. The interactions among these agents and their interactions with the substrate generate dynamic social-ecological systems. Any theory devised to understand SESs must thus account for the relationships between information processing, the actions of agents, and the effects of those actions on other agents and on the environment...This presents a major problem for the study of SESs ...SESs are so complex that the idea of developing a theory to explain their behaviour becomes questionable. Because of this extreme level of complexity, there are...many theories that are capable of explaining some aspects of the aggregate behaviour of SESs* (2006).

We return below to some of the dilemmas posed by the SES framework when attempting to apply it to GIAHS, but first we review some of the key concepts that have been used to characterise SES, although these concepts have been developed within different disciplinary contexts and by different scholars and are therefore the subject of much debate and theoretical development as well as empirical inquiry.

It is simple to illustrate the fact that GIAHS are systems rather than discrete objects (e.g., agricultural fields). In many rural areas across the globe, agricultural fields represent amalgams of a wide range of species, from wild to domesticated. This diversity provides much protection against pests and disease, climatic vagaries, and seasonal food shortages. The quality and mass of plant growth depends upon mulch gleaned from brush, forests, or coastlines, and the dung from animals that are grazed and fed fodder that is gathered in 'wild' areas. Such biologically diverse field production would often not be possible without its homologue and counterpart, the homegarden, that acts as an indigenous experimental station and gene bank. It contains many semi-domesticates transplanted from the wild and from interstices of fields, and provides a large number of other plant products that are required for life in smaller quantities throughout the year. Nor are the boundaries of 'agriculture' to be seen at the hedgerow or living fence. Beyond this, in 'wild' areas, plant management goes on, gathering plots are marked out, and the cultivation of roots, and encouragement of growth and selective harvesting ensure, generation after generation, the wild foods and medicinal plants for humans and animals, and the fibres, fuel, and other plant resources that meet both material and cultural needs. These 'wild' areas, together with fields and borders and pastures and homegardens, constitute the productive basis and cultural heritage of myriad human lives, as well as the habitat for a multitude of animal and insect species (Howard 2003b). While the produce obtained from this network of niches does not provide all goods that local populations require, it provides surpluses of certain goods that are then bartered or sold to other populations that provide missing essentials

in return. Such SES entail co-operative social relations and institutions, cultural beliefs and rituals, language, knowledge, and technologies that have developed over long time frames to manage these interrelated sets of resources and niches, and to ensure that they meet the cultural and material needs of their stewards.

First, because of the nearly inestimable degree of ***complexity*** and interactions at different scales of time and space, SES are considered to be ***complex adaptive systems*** (e.g. Abel & Stepp 2003, Holland 1992, Lansing 2003, Janssen 2002). SES are constituted of a wide variety of energy and material sources and information feedbacks and flows, and thus are highly integrated: not only do different parts of the biophysical system depend upon flows of material, energy, and information from other parts of the system (the 'ecological' side); as well, changes in ecology reverberate throughout the social and cultural side, and changes within the social and cultural system may also reverberate throughout the ecosystem. Complex adaptive systems are not deterministic, predictable, or mechanistic, but rather are process-dependent organic systems that contain feedbacks among multiple scales that permit these systems to ***self-organise*** (see below). As self-organising systems, each SES has a unique history and also functions uniquely.

In spite of the fact that SES are so complex, it is thought that there are a number of key variables and dynamics that have a determining role in the organisation of the systems, or ***state variables***. Such variables may be, for example, phosphorus levels in lake sediments, soil nitrogen content, population densities of key species such as elephants, or rates of deforestation or of groundwater recharge and extraction, where changes in these variables have major implications for a system's state. Variables represent dimensions of n-dimensional space, where the ***state of the system*** is 'the particular combination of the amounts of each of the n variables the system currently has...If there were many more variables involved the system would be in a mode of constant regime shifts (state flips), each involving losses of resources (nutrients, organisms, species, etc.) and could not persist' (Walker & Salt 2006). Within any given system, there are ***alternative stable states*** (or 'stability regimes'): for example, shallow lakes may be at equilibrium with clear water and aquatic plants present, or at equilibrium where turbid water and a lack of vegetation persist (Scheffer et al. 2002). Beyond some limit, if there are very major changes in the system, it can move over a ***threshold*** (or 'tipping point') into an alternate stable state which may be desirable or undesirable from the standpoint of the goods and services that it provides.

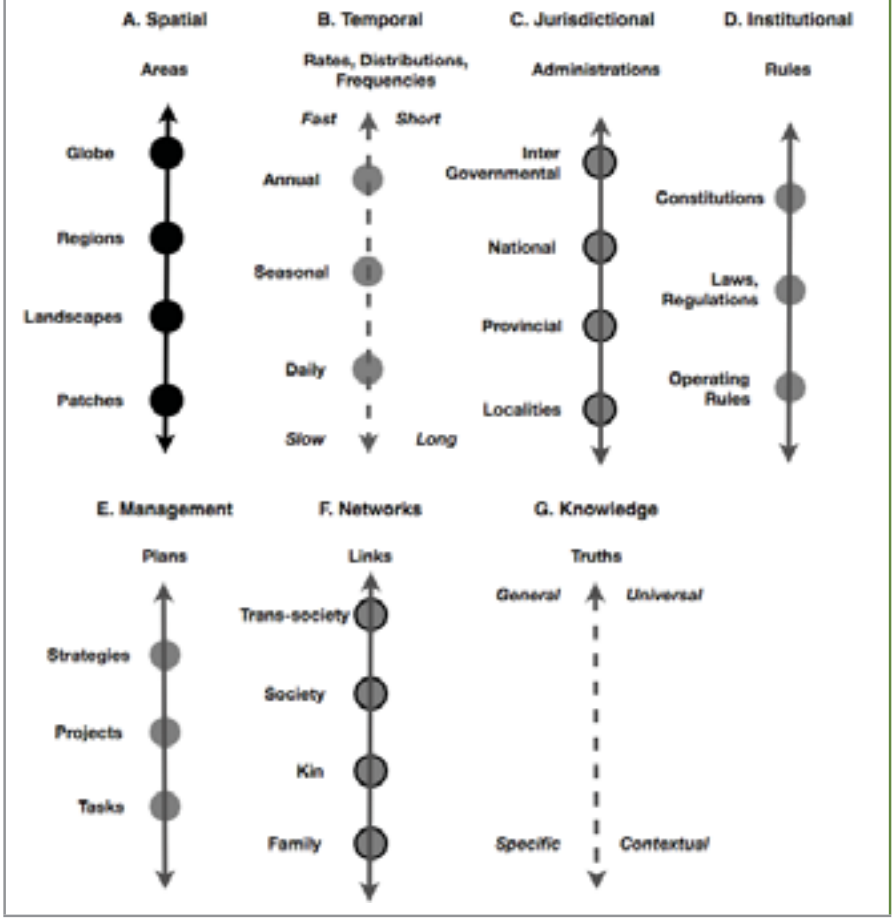
All SES are subject to disturbances and crises, some of which are predictable to some degree and some of which come as surprises. In much of the SES literature, change and adaptation are clearly conceived in ecological terms, after Holling (1973) and Gunderson & Holling (2002). In this perspective, while SES tend toward an equilibrium state, the system state is always changing so that no SES is ever in an equilibrium state, but rather is constantly adapting. State variables and processes function at 'radically different rates that span several orders of magnitude' in response to internal or external disturbances (Ibid.). ***Adaptation*** is considered to be anything other than smooth or linear: rather, it is episodic (an ***adaptive cycle*** – see below), and it may also be abrupt and catastrophic. Essentially, an adaptive cycle in ecology is characterised by a phase, early in the cycle, of rapid growth (the r Phase), where 'r strategists' (pioneers) exploit new opportunities and all possible resources and niches, and the system's components are connected and regulated only weakly. There is then a transition (where energy is stored and materials accumulate) to a conservation (or K) phase, when specialists (K strategists) take over the position of r strategists, which strongly compete and are more efficient in resource use; the components of the system are more strongly interconnected and regulated, growth rates slow (moving towards 'carrying capacity'), and the system becomes more rigid. Then, when a disturbance occurs that is sufficiently strong to break down the interactions of the K phase, the system enters the Release (or Ω) phase, where resources that had been sequestered are released (e.g., with fire, accumulations of biomass and nutrients are released), resulting in 'creative destruction and leading quickly to the Reorganisation (Alpha) phase. In this last phase, reorganisation and or renewal, innovation and novelty revive e.g. new species can enter the system' (Walker & Salt 2006). However, the adaptive cycle framework, when applied to SES, must be understood as 'a metaphor to help interpret events and their gross causes' (Gunderson & Holling 2002). As discussed below, the uncritical use of such an ecological concept for characterising change in social systems or in SES as a whole can be highly problematic; indeed some ecologists consider that the concept is also problematic when applied to ecosystems.[2]

An invasive species of earthworm that is undermining rice terraces in Ifugao.

Another key concept in SES that contributes to and explains complexity as well as change dynamics is that of ***scale***. The entire globe can be considered as an SES, as can a local system of lakes and rivers and their respective populations, and these scales are clearly inter-connected. SES are therefore nearly impossible to define other than pragmatically: 'the scale in which we are interested is connected to and affected by what's happening at the scales above and below, both in time and space', so that SES are not only complex, they are as well 'open-ended', where 'The structure and dynamics of the system at each scale is driven by a small set of key processes and, in turn, it is this linked set of hierarchies that govern the behaviour of the whole system' (Walter and Salt 2006). There are also many types of scales and levels within scales: one recent typology has identified spatial, temporal, jurisdic-

tional, institutional, management, network, and knowledge scales and their corresponding levels (Figure 2.1). Cross-level interactions are themselves catalysts of systemic change: for example, 'Cross-level interactions among scale-dependent environmental and resource regimes can play a role...in bringing about larger changes that have the effect of restructuring broader institutional landscape within which such interactions take place' (Cash et al. 2006, Young 2006). Scholars have recently identified three common ***scale challenges*** for SES management: 1) 'the failure to recognize important scale and level interactions ('ignorance'); 2) 'the persistence of mismatches between levels and scales in human-environment systems ('mismatch')'; and 3) 'the failure to recognize heterogeneity in the way scales are perceived and valued by different actors ('plurality')' (Berkes 2006).

FIGURE 2.1 | Schematic illustrations of different scales and levels that are critical in understanding and responding to human-environment relations
(Cash et al 2006, Fig. 1)



Indeed, the definition of an SES is scale-dependent and, at any particular scale, the system is 'open' in the sense that processes and variables at one scale influences processes and variables at other scales. The designation of any particular cultural landscape or other geographical, political or social (e.g. ethnic) boundary as an SES is therefore ambiguous, although it certainly should not be arbitrary – it should be based on knowledge of key social-ecological variables and processes and their scale relations.

As an SES evolves, responding to disturbances and crises from within and from outside, certain stable patterns of interaction begin to emerge (some of which make systems more resilient than others), which in the SES literature are termed ***emergent properties.*** For instance, the water temple networks with which Balinese farmers manage their centuries-old irrigation systems and rice terraces are said to have developed, or emerged over time, to optimally balance the trade-offs between the scheduling of water delivery for planting, and the scheduling of fallows for pest reduction, as a result of the individual decisions of generations of farmers who have been adjusting their scheduling to maximise yields (Lansing 2003, 2006). These aggregate functions were not planned by individual farmers nor are they recognised by them, that is, the system operates at a higher level: farmers only know that they must follow the ritual cycle of the temples in order to achieve the best harvest possible. During the 1970s, agricultural planners were unaware of the Balinese system when they introduced Green Revolution technologies. These technologies led to huge pest outbreaks, devastated harvests, and conflicts among farmers over water rights. Lansing's (2003) simulation model, which illustrated how the Balinese system emerges and organises toward an optimal solution, convinced the Asian Development Bank to drop its opposition to the water temples as the means to control the agricultural system. GIAHS sites are certain to also have similar emergent properties that arise from the self-organising behaviour of their stewards who are all trying to organise activities in such a way as to maximise their individual interests and reduce their risks. Supporting local knowledge and management regimes is therefore critical.

There are many consequences of such an approach for management. As complex adaptive systems, it cannot be assumed that SES are in equilibrium and that therefore it is possible to study isolated parts of the system and predict outcomes (Janssen 2002). Likewise, the concept of ***sustainability*** that is common in mainstream science and policy making must be jettisoned, since it considers that sustainability depends on optimising the use of isolated components of a system (improving their 'efficiency'), which can actually jeopardise sustainability: 'the more you optimise elements of a complex system of humans and nature for some specific goal, the more you diminish that system's resilience' making it more vulnerable to shocks…The key to sustainability lies in enhancing the ***resilience*** of SES, not in optimising isolated components

of the system' (Walter and Salt 2006). Many other concepts are important to understanding SES, but resilience is perhaps the most important (see e.g. the Resilience Alliance, Resilience Thinking, Resilience 2008).[3] Some argue that resilience is actually a framework or approach 'for systematically thinking about the dynamics of SESs...[that] sits on top of other theories, i.e. general systems theory, and seeks to use them to view SESs in creative ways to gain new insights' (Anderies et al. 2006).

The concept of resilience as it is advanced in SES frameworks is distinguished from what is termed 'engineering resilience' (or 'recovery'), which emphasizes the time that it takes for a system to return to a particular equilibrium state after disturbance, and which is therefore related to resisting change and to conserving what exists (Folke 2006). Rather, in SES terminology, 'resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist' (Folke 2006, citing Holling 1973). The Resilience Alliance has proposed that SES resilience has three defining characteristics: (1) the amount of change the system can undergo and still retain the same controls on function and structure, or still be in the same state, within the same domain of attraction; (2) the degree to which the system is capable of self-organisation; and (3) the ability to build and increase the capacity for learning and adaptation (Olsson et al. 2003). Folke continues to explain how resilience is related to ***adaptive capacity***:

> *resilience is not only about being persistent or robust to disturbance. It is also about the opportunities that disturbance opens up in terms of recombination of evolved structures and processes, renewal of the system and emergence of new trajectories. In this sense, resilience provides adaptive capacity that allow for continuous development, like a dynamic adaptive interplay between sustaining and developing with change. Too much of either will ultimately lead to collapse. It does not imply that resilience is always a good thing* (2006).

In GIAHS, resilience is a good thing, whereas it is not good if one is referring to SES that are unable to provide essential goods and services for humans, e.g. in desertified areas where it is has become very difficult to achieve re-vegetation. The importance of such a concept to the GIAHS initiative should be clear, since GIAHS seeks to ensure the integrity of the relevant SES (e.g. the long-term, sustainable provision of the specific types of goods and services that GIAHS currently provide) while at the same time recognising that such systems clearly are adapting and must continue to adapt to change, or what is referred to in the background documentation for GIAHS as 'dynamic conservation'.

It is not surprising, given its origins, that the SES concept to date has been elaborated essentially to capture ecological dynamics (albeit many of which are provoked or strongly influenced by humans), while assuming that such dynamics are equally applicable to social, economic, and cultural phenomenon. The tendency is toward a sophisticated form of ecological determinism where 'the incidence of cultural and social phenomena is treated as if they too had the same kind of objective existence' as ecological phenomena (Ellen 1982). This is perhaps nowhere so apparent as in the concept of change as an adaptive cycle (e.g., with its respective phases of rapid growth, conservation, release, and reorganisation). Most SES literature suggests that this concept can be unproblematically extended to characterise the process of social, cultural and economic change, referring for example to the idea of economic (more precisely, business) cycles as substantiation, but otherwise having a very limited theoretical or empirical basis and highly questionable assumptions (such as in e.g. Scheffer et al. 2001; Walker & Salt 2006; Walker et al. 2006). This fundamental conceptual weakness has substantial implications for the applicability and usefulness of the SES framework for GIAHS, including the usefulness of concepts such as resilience and adaptive capacity that are thus far conceptually strongly linked to adaptive cycles, and which are also derived from ecology and depend for their validity on establishing direct parallels between social and biophysical phenomena. While much work is currently underway to develop more sophisticated social-cultural analysis within the SES framework, particularly in relation to the topics of governance, adaptive capacity, vulnerability, social capital, and social networks, these tend to be constrained by the orientation of the disciplines that predominate in SES scholarly networks (Janssen et al. 2006).

This does not mean that all or even most of the conceptual underpinnings of the SES concept are invalid in relation to social, cultural, and economic phenomena. The SES framework is utilised here in very general terms not because it represents the most adequate answer to the question of 'how are nature and culture inter-related', but rather because it represents a point of departure for framing human-nature relations in a way that recognises their co-evolution, adaptation, complexity, indeterminacy, scale dependence, lack of equilibrium and constancy of change. If the biophysical world is inestimably complex, social-biophysical interactions are more-so. The fundamental problem is that, for the concept of SES to be useful and applicable, far more attention must be given to the cultural, social, and economic dynamics of SES, and to human-environment relations.

The utility of an SES-like framework has recently been demonstrated by Jared Diamond in his seminal work entitled *Collapse: How Societies Choose to Fail or Survive* (2005). While he did not explicitly adopt the SES approach, he carefully and comparatively analysed contemporary and historical societies that have collapsed or, conversely, that have demonstrated resilience in the face of phenomena that have led to collapse in other societies. In this analysis he derives a five-point framework of 'possible contributing factors': 1) environmental damage, 2) climate change, 3) hostile neighbours, 4) friendly trade partners, and 5) society's response to its environmental problems. The title of the book clearly indicates that it is not ecological factors alone (e.g. deforestation, depletion of soil nitrogen) that lead to collapse; rather he demonstrates through case studies how societies' powerful leaders and cultural attitudes both generate and respond (or fail to respond) to particular types of ecological threats. In effect, Diamond is confirming the possibility to identify phenomena conceptualised in the SES framework such as 'state variables', 'thresholds' or 'tipping points', 'sensitivity', 'adaptive capacity', and 'resilience'. The difference is the in the degree of emphasis that Diamond places on 1) context, and 2) factors such as culture, governance, and trade. We suggest in the conceptual framework presented in this document that it is possible and necessary to identify the same or similar dynamics in the context of GIAHS and to act upon them in ways that can support resilience.

2.2 Social-ecological Systems and Culture

Given what may be termed the disciplinary biases evident in the SES framework as developed to date, we turn to the conceptualisation of human-environment relations which has been much more elaborated particularly in the sciences of anthropology, cultural ecology, and human evolution. The central axiom here is that the unique symbol-making and information-processing abilities of humans, our ability to communicate knowledge and experience socially, and to develop language, value and belief systems, and accumulate knowledge over time – that is, our ***culture*** – has given us the capacity to both adapt to and change the way that ecological systems function (see Chapter 3.5). While culture permits humans to change both their own behaviour and relations as well as the ecosystems of which they are a part, it is mistaken to assume that cultural traits (such as beliefs about nature and the rules of resource exploitation) are simply 'adapted to' or arise out of specific ecosystems: theories that expound these ideas have been termed 'ecological functionalism' (Ellen 1982). Rather, it is recognised that cultures also evolve in relation to other dynamics, endogenous and exogenous, which gives rise to much cultural diversity, including diversity of worldviews, beliefs, and institutions, even where ecological circumstances and production strategies are similar. Further, not all cultural adaptations are adaptive: some are clearly maladaptive, and this concept of maladaptation is also important to understanding GIAHS and resilience.

An emerging concept of ***cultural evolution*** defines it clearly within an SES-type framework. In this concept, elaborated by Richarson & Boyd,

> *culture is highly adaptive. It allows human populations to accumulate complex, highly adaptive tools and institutions that in turn have allowed people to expand their range to every corner of the globe...By cumulative cultural evolution, we mean behaviours or artefacts that are transmitted and modified over many generations, leading to complex artefacts and behaviours* (2005).

Essentially, if individuals had to learn everything in order to adapt to an environment on their own (e.g., through trial and error), this would be far too costly in terms of energy, information, and errors. Rather, humans, like animals, imitate each other. But, unlike animals, humans use 'fast and flexible' heuristic devices to learn from others, such as copying the most common variant ('conformism'), seeking out and copying rarer variants that exhibit more successful strategies ('content bias'), and emulating more successful people ('prestige bias'), which result in the biased transmission of knowledge (a 'culling' process) and which make knowledge acquisition and transmission more efficient. 'Biased transmission results from the comparison of different cultural variants already present in the population', whereas another form of decision-making, called 'guided variation', doesn't require the presence of such variants. 'Individuals modify their own behavior by some form of learning, and other people ac-

quire their modified behavior by imitation' (Ibid). Both types of transmission are called 'decision-making forces'. Decision-making forces may be weak or strong, depending on the context (e.g. the pressures to adapt). The human brain and psychology have evolved in such a way as to permit such complex learning and transmission processes to occur. Such ***social learning processes*** are essential to human populations' ability to respond to environmental feedbacks and direct SES into sustainable trajectories (Berkes et al. 2003, Olsson et al. 2003).

The same decision-making forces and human psychology that allow people to take on board new knowledge and forms of behaviour in ways that are adaptive also mean that knowledge and forms of behaviour can be learned that are ***maladaptive***. Maladaptation is not, in this framework, simply a product of the fact that the environments in which we live are very different than those in which our ancestors evolved – it is also an

> *unavoidable byproduct of cumulative cultural adaptation…Acquiring information from others allows people to rapidly adapt to a wide range of environments, but it also opens a portal into people's brains, through which maladaptive ideas can enter – ideas whose content makes them more likely to spread, but do not increase the genetic fitness of their bearers. Maladaptive ideas can spread because they are transmitted differently from genes…Selection cannot eliminate the spread of maladaptive cultural variants because adaptive information is costly to evaluate. If this costly information hypothesis is correct, culture capacities will evolve in ways that optimize the acquisition of adaptive information, even at the cost of an appreciable chance of acquiring evolved maladaptations* (Richarson & Boyd 2005).

Maladaptation can lead to environmental or social collapse, as Diamond (2005) showed; Richarson & Boyd (2005) argue that the scope for maladaptation has increased particularly as mass media and formal education have exposed people to much greater cultural variation, whereas the predisposition toward imitation of prestigious people 'will tend to cause people to acquire the whole modernist corpus of values and attitudes' (Ibid).

The fact that a particular SES exists today does not necessarily indicate that it is resilient, or that human-environment relations within it are necessarily adaptive. A corollary is that the simple characterisation of all such social relations or beliefs as inherently 'conservationist' or as manifesting 'stewardship', as is popular in many circles today, is both reductionist and naïve; on the other hand, characterising them as inherently degrading or unstable, which many policy makers and scientists have done for many decades, could not be farther from the truth. The relationship between culture and environment is highly complex. There is a long standing dispute among conservationists, and anthropologists, as well as among indigenous peoples themselves, as to whether small-scale societies are either essentially conservationist or destructive in their attitudes and behaviours toward the environment (see e.g. Alcorn 1996, Posey 1985, Redford 1991, Stearman 1994). Much of the debate hinges on whether conservation requires intentional and altruistic behaviour (sacrificing benefits in terms of income, calories, etc.), or rather is 'natural' (i.e. unconscious) behaviour that does not lead to resource depletion or land degradation (Alvard 1995, Smith & Wishie 2000). Most conservationists agree that most swidden agricultural or hunter-gatherer populations are simply too small to have dramatic effects on the sustainability of resource extraction, but when they increase in population, become market-oriented (which increases extractive demand), or are displaced onto limited or marginal environments, their behaviour can become destructive and thus maladaptive (see e.g. Bennett and Robinson 2000).

Richarson & Boyd (2005), on the other hand, see adaptation and maladaptation as two sides of the same coin, and argue that 'culture is sometimes adaptive, sometimes maladaptive, and sometimes neutral.' However, in the presence of a somewhat stable or predictable environment, a functioning, evolving SES that has developed a deep store of ecological knowledge and understanding is likely to be as sustainable as possible, as long as the environment (ecological, social, political, and economic) does not change too rapidly. The stewards of these systems might be considered 'conservationist' simply because they perpetuate their 'way of life', as many Australian Aboriginal groups had done for a continuous 50,000 years until Europeans arrived.

Although there is as yet little understanding of the mechanisms and outcomes of cultural adaptation, there is much interest in emulating such processes, which is captured in the term ***adaptive co-management,*** defined as a combination of 'the dynamic learning characteristic of adaptive management with the linkage characteristic of co-operative management' (Berkes 2004, see also Armitage et al. 2007). Adaptive co-management is considered to be a natural self-organising process that has the potential to increase the resilience of SES given change. As a result of continued failures to achieve conservation objectives in and around protected areas and their buffer zones, and the failure to integrate people and their needs into conservation and related development initiatives through programmes such as Integrated Conservation and Development (ICDPs), Community Based Natural Resource Management (CBNRM), Enterprise-based Conservation, and various forms of community forestry and Community-based Conservation (CBC), conservation programmes around the world have been adopting Adaptive

Co-management as their newest guiding conceptual framework (Olsson et al. 2003, Sheil et al. 2006, Turner 2004, Walters 1997, Wells & McShane 2004).

In the case of GIAHS SES, it is clear that it is traditional management, rather than external intervention, which is responsible for the existence and resilience of the systems, which gives rise to ***GIAHS Principle 5***. One of the greatest challenges that those involved with the Programme face is in fact to establish an environment conducive to exchange between local inhabitants and external actors that respects traditional management institutions and facilitates mutual learning oriented.

Diversity is another essential aspect of cultural evolution. Cultures differ from each other in part because they have different environments in which they evolve, and there is evidence to show that genetic and cultural evolution are also linked: for example, the genetic ability to produce enzymes in adult populations evolved in dairy producing cultures and not in other populations (Richarson & Boyd 2005). Diversity (variants) within groups provides an important source of adaptive social learning and hence resilience. We can also think of ***biocultural diversity*** as an emergent property of evolving SES, a result of the interaction of ecological systems and the properties of resources with human motivations, cultural behaviour patterns, knowledge systems, and technology (Hunn 2001, Maffi 2001, Smith 2001). Some of this diversity is consciously developed (such as local varieties of domesticated crops and animals or the distribution of gardens, fields and orchards to reduce risk of failed harvests due to climatic variation) while other diversity develops so slowly and at larger scales that it may not be easily recognised by individuals, such as the changing floristic composition of forests or the emergence of a mosaic of land cover and land use types, or the regional and global correlations of linguistic and biological diversity (Harmon 1996, Maffi 2005, Moore et al. 2002, Pagel & Mace 2004). There is now considerable evidence to show that a high level of ***agrobiodiversity*** (see Chapter 3) is probably more strongly linked to cultural diversity than to ecosystem diversity, given that great cultural diversity exists within similar biophysical environments, and it is culturally defined needs that give rise to practices, knowledge, and use of a wide range of species and much intra-specific crop and animal diversity (see Chapter 3.5 and Appendix).

Biocultural diversity, like SES, occurs in a nested hierarchy of scales: genetic, species, habitat, landscape, and global levels. GIAHS may contain examples of the first three levels of biocultural diversity, but they are firmly embedded in broader systems. Human-environment interactions are clearly entailed in the biological evolution of species which at times can be accurately characterised as ***biological co-evolution*** (the mutual adaptation of species to one another). The evidence, however, is generally that biological co-evolution occurs only over very long periods and over relatively large geographical areas (see e.g. Tarazona-Santos et al. 2001). Sequential biological evolution is, however, clearly evident in reference to much smaller spatial scales and over very short time frames, insofar as humans clearly exert selective and other types of pressure on non-human organisms, resulting in both intentional and unintentional changes in local species and in agrobiodiversity. If co-evolution cannot be used in a strictly biological sense when referring to SES that may have existed as such for only a few centuries, it may nevertheless be fruitfully applied in reference to the interrelationship between biological evolution and cultural evolution (see e.g. Alvard 2003, Richarson & Boyd 2005).

The species and genetic diversity of indigenous farming systems is not the result of a random adaptive process. Traditional agroecosystems are the result of a complex co-evolutionary process between natural and social systems, which resulted in ingenious strategies of ecosystem appropriation. In most cases the indigenous knowledge behind the agricultural modification of the physical environment is very detailed (Brokenshaw et al. 1980). Ethnobotanies are the most commonly documented folk taxonomies: in Mexico the Tzeltal, P'urepecha, and Yucatan Mayans can recognize more than 1200, 900 and 500 plant species, respectively (Alcorn 1984). Farmers also discriminate in detail soil types, degrees of soil fertility, and land-use categories. Soil types are usually distinguished by colour, texture, and even taste. Shifting cultivators usually classify their soils based on vegetation cover (Williams & Ortiz Solorio 1981). Information is extracted from the environment by special cognition and perception systems that select for the most adaptive or useful information and successful adaptations are preserved and passed from generation to generation through oral or experimental means. Indigenous peoples' knowledge about ecosystems usually results in multidimensional productive strategies (i.e. multiple use ecosystems with multiple species), and these strategies generate (within certain ecological and technical limits) the food self-sufficiency of farmers in a region (Wilken 1987).

At a larger scale, biocultural diversity may be said to take the form of ***cultural landscapes***, containing a mosaic of geomorphological, hydrological, and ecological forms, vegetation types, and land uses, as well as the material (non-organic) elements or artefacts that have been adapted or built by humans over time (e.g., canals, terraces, temples) (see e.g. Balée 1998). SES are identifiable spatially and visually in cultural landscapes although they are not equivalents, just as ecosystems and landscapes are not equivalents. The question of scale is again extremely important since most subsistence SES have been integrated at regional scale for centuries, and the well-being of a particular population often depends crucially on SES and cultural landscapes that exist beyond their geographical territories or boundaries.

It is often at the landscape level that the emergence of maladaptive behaviours becomes manifest, evident in land degradation processes such as deforestation, desertification, soil salinisation, erosion, and phenomena such as eutrophication. Some would argue that the simplification of the landscape, from a diverse mosaic to a homogeneous one (e.g. of mono-crop agriculture), is also indicative of negative processes at work in a SES. Of course there are many other such processes that are less easily visible at that scale, such as the simplification of agrobiodiversity in gardens and orchards, the loss of specific wild plant and animal species due to over-harvesting, or the invasion of alien species. One may also not be able to detect the gradual loss of family members to wage labour outside of the community, the resulting loss of traditional knowledge as the young are educated in schools away from their homelands, or declining nutrition and health among the elderly, women, and children as agricultural simplification, wild resource depletion, and dependence on manufactured food stuffs all increase (see Appendix). Yet all of these processes can occur simultaneously as population

pressure increases, political-economic contexts change, and cultural values shift through the introduction of markets and modern communication technologies and educational systems that link traditional SES to the globalised human-biosphere. We discuss these indirect drivers of change in greater detail in Chapter 5: here it suffices to warn that the impacts of external change or interventions on SES are the most complicated and difficult to predict of all complex adaptive systems phenomena.

Every SES is different, and none are necessarily changing and developing in the same way for the same reasons. That said, there are patterns of similarity among these systems and in certain components, in part due to similar historical, cultural, and environmental contexts, and there are plenty of examples of convergent cultural evolution occurring, such as the independent emergence of agriculture in several locations. Thus, depending on the scientific discipline or sub-discipline, SES may be classified in a variety of ways, with cultural ecologists tending to organise them around a social group's dominant means of subsistence or resource utilisation - hunting and gathering, pastoralism, horticulture (including swidden cultivation), intensive (small holder) agriculture, industrial market economies - while ecological anthropologists prefer to organise them by dominant biophysical environments: tropical wet and dry forests, savannah grasslands, temperate woodlands, deserts, arctic tundra, mountainous/high altitude, or coastal/seafaring systems. Still others, ignoring environmental context altogether, might organise them by their level of socio-political integration: band societies, tribal societies, chiefdoms, states, nation-states, regional organisations (e.g., ASEAN, EU), or international systems. While none of these is capable of capturing the variety of combinations that interacting social and ecological systems can and have produced over time, they do emphasise some of the key descriptive components such as biophysical and resource setting, economic production, social organisation, and political control. These components, and others, and the interrelationships that characterise SES, can be modelled as in figures 2.2 and 2.3. Note that the first diagram illustrates a cultural ecological approach, where resource utilisation is seen as fairly deterministic, while the second illustrates a more systems ecology approach, where no particular set of cultural institutions are given causal priority.

Thus, the conceptualisation of SES suggests that what is required is both an in-depth understanding of ecosystems and how they work, together with an in-depth understanding of the complex social relations and forms of social organisation (kinship, territoriality, settlement, group membership and identity, gender relations, leadership and political organisation), culture (worldviews, language, values, rights, knowledge, aesthetics), modes of production, labour allocation, technologies and practices, as well as their outcomes in terms of SES well-being and resilience. While there is a significant body of past research, anthropological and other, to draw on, and there are a series of rapid appraisal and other methods that have been developed to be able to describe and assess social, cultural, and ecological characteristics, at least in a preliminary way (see e.g. Kok et al. 2007, Lynam et al. 2007, Peterson et al. 2003), a full understanding of any complex adaptive system is probably impossible, and possibly unnecessary. Sometimes this doesn't require a tremendous effort (a small change can make a big difference – see Chapter 4.5), but in all cases it does require

FIGURE 2.2 | Social-ecological system (Marten 2001)

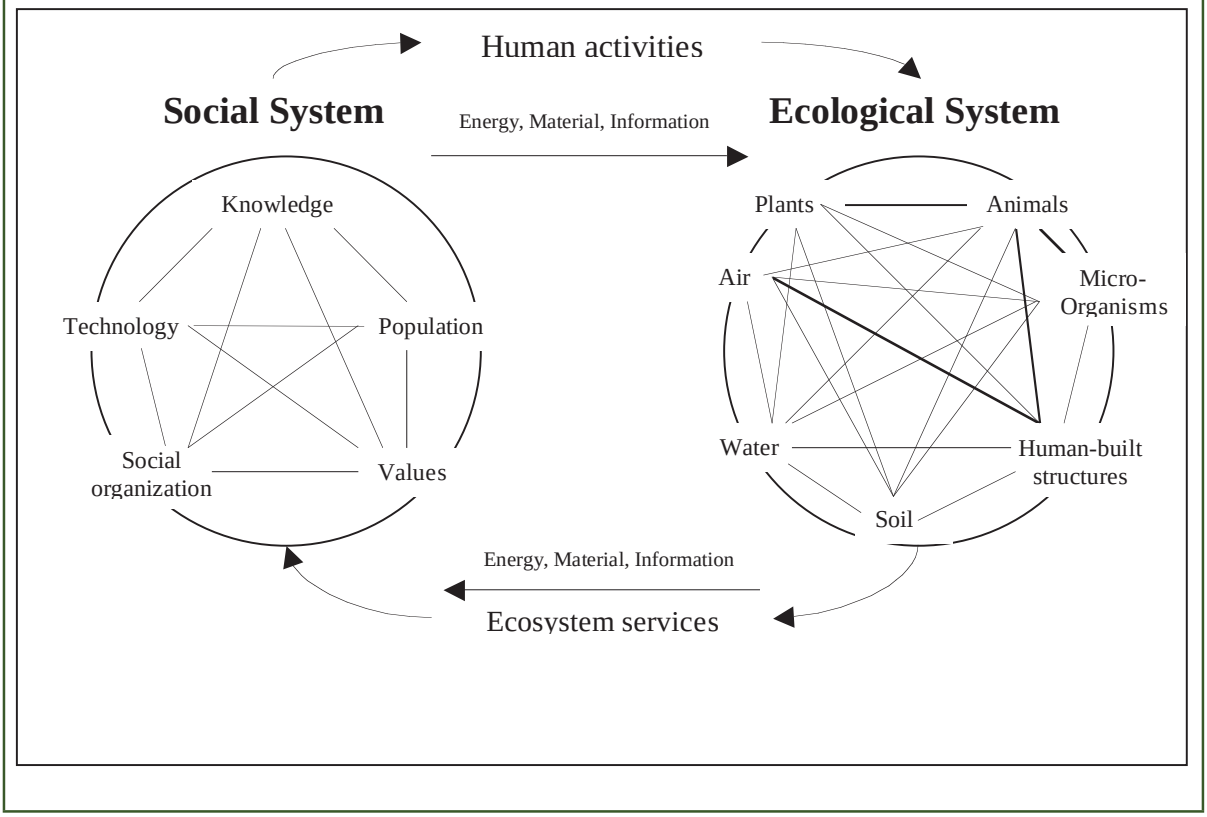
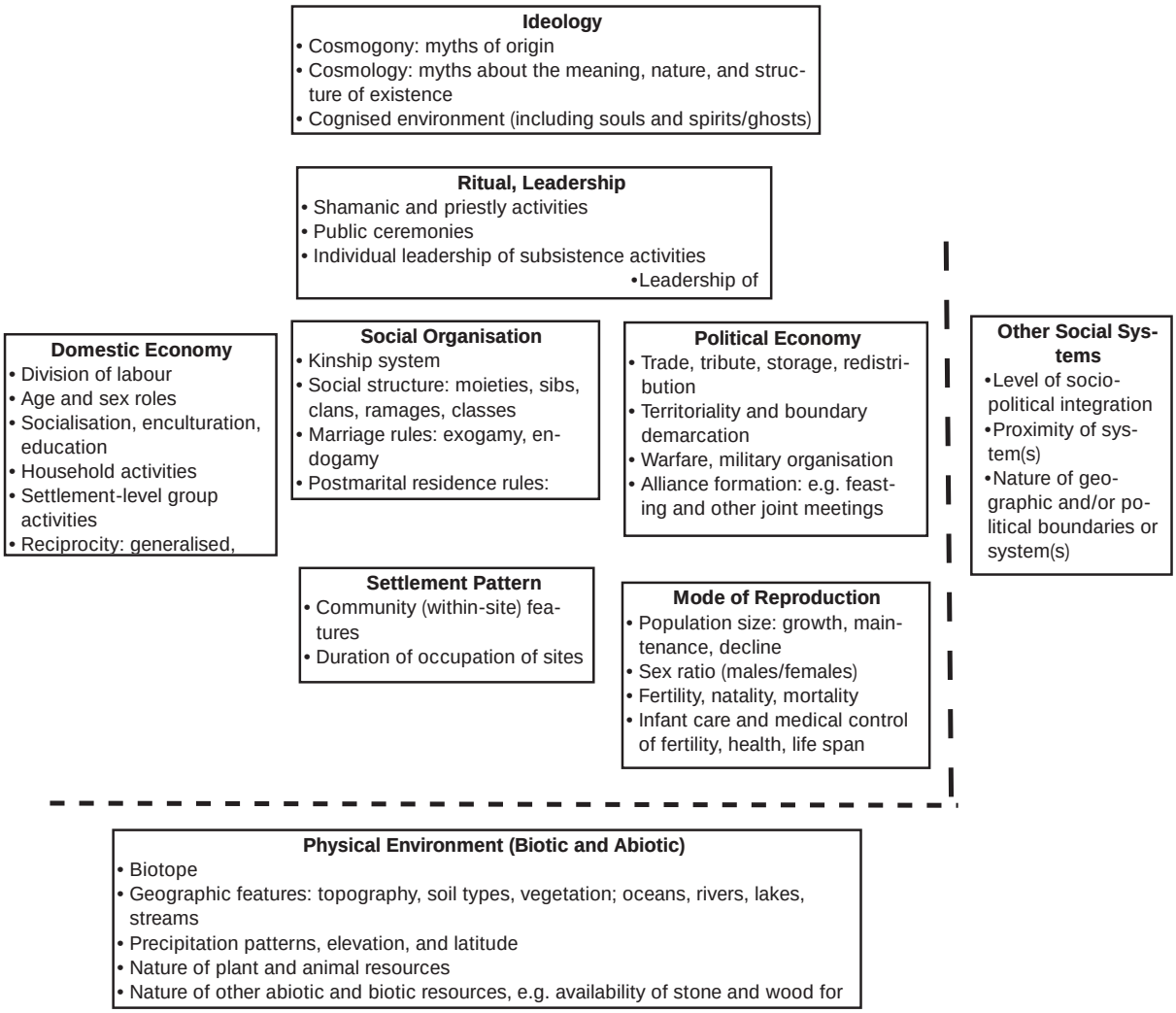


Figure 2.3 The Complete Systems-hierarchical Model of Human Adaptive Systems, with Ten



careful analysis of the complexities and interconnections of dynamic SES, and in particular, the empowerment of GIAHS communities. There are no standard interventions or recipes for achieving this goal since, although GIAHS are everywhere influenced by multiple external relations and drivers, their cultural, institutional, and environmental contexts and development paths are always unique.

There are hopeful cases where such an approach has been successful (Gladwell 2000): by finding the tipping points that can reverse the direction of change in a SES, 'vicious' feedback cycles can be changed into 'virtuous' ones.[4] Instead, a strategy is required that takes its lead from the stewards of these systems with regard to identifying needs, problems, priorities, drivers, and likely impacts of interventions and supporting their decisions as well as encouraging government policies that work toward achieving these priorities. However, given that even local communities may be unaware of emergent properties, of slow moving state variables, of scale effects, and of all the potential implications of introduced changes, and given that major drivers of local change are often external to GIAHS sites, GIAHS Programmes must address multiple scales and should include provision for monitoring SES following interventions, as unexpected consequences are expected.

2.3 Rural Subsistence Societies

As Box 1.1 stipulates, not all SES can be characterised as GIAHS. Rather, the majority of GIAHS are rural, predominantly subsistence societies, or communities within larger societies. There are theoretical as well as practical reasons for excluding from the current conceptual framework those SES that represent the agricultural heritage of fully market-based and highly developed economies. While a framework for such can emerge from many of the strategic principles laid out in this document, the contexts and conditions are very different and will certainly involve different political processes and forms. The essential dynamics of such SES are typically fundamentally determined by market forces and government policies, so that actors and agents within them must respond to the market and/or to transfer payments (e.g. subsidies). It is also clear that the majority of SES that will fulfil the selection

criteria stipulated in Box 1.1 are to be found in developing countries and countries in transition. The focus of this conceptual framework therefore is on those SES across the globe that are culturally and biologically diverse and that today continue to largely fulfil human needs and social reproduction through non-market and non-state mechanisms (i.e., that are subsistence-oriented or only partially integrated into markets and that are only marginally subsidised).

The majority of GIAHS candidates are agriculturally-based societies, but some are pastoralist, and most rely to a very substantial degree on wild and semi-domesticated biological resources (see Appendix) (Sutton & Anderson 2004, Moran 2000). No GIAHS site is isolated, although some may still be remote, so that trade and exchange with outsiders for materials, energy, and information is the norm. While many of these societies may be self-sufficient in terms of subsistence, they are increasingly engaged with wider market economies. Many could be considered as 'tribal' indigenous societies, having their own territories, languages, customs, and internal political and social means of control, but most are rural populations, often representing ethnic 'minorities', within nation-states. This implies that typical GIAHS systems are embedded in wider relations with other communities from other tribes and with encompassing political and economic systems at national, regional and international levels.

We now turn to a description of SES pertaining to small holder intensive agricultural societies with which the GIAHS programme is often likely to be concerned. These generalisations rarely apply to all of these societies as local conditions will differ even within the same biophysical environment or cultural milieu. Asian smallholder intensive agricultural systems provide an example. A range of subsistence techniques can be found in landscapes that appear to be dominated by terraces and rice paddies. These provide a diversity of sources of nutrition and the materials to satisfy other cultural needs. There is a built-in redundancy and overlap in production in both time and space, which increases the resilience of these systems by reducing the risk of food shortages due to natural and man-made disturbances. While these rice production systems are able to support the highest densities of people on the planet, it is well established that religious institutions, including beliefs and rituals, play an important role in organising the landscape and regulating the rice agricultural systems in Asia (see Chapter 3.5.2) (Lansing 2006, Rappaport 1984, Sutton & Anderson 2004). However, the degree of integration into wider political-economic systems varies dramatically, where the south China coastal area has been favoured by the Chinese government for two thousand years, whereas the Balinese managed to escape political control, and the Ifugao maintained their political control through warfare.

Box 2.1 provides a description of a SES that has been pervasive in coastal regions of south China. Similar descriptions of the complex interrelationships between beliefs, subsistence, knowledge, resources, and politics in SES could be given for the irrigated rice terrace systems of Bali (Lansing 2006), Java (Geertz 1963), Vietnam (Rambo 1973), Sri Lanka (Leach 1961) and for the Ifugao of the Philippines (Conklin 1980). Taken together, they demonstrate the limitations of an 'agro-centric' bias: that is, against focusing exclusively or even principally on field crop production or on crop diversity, while ignoring the great diversity of subsistence activities and agrobiodiversity found in agricultural societies, and the socio-cultural relations that organise and imbue them with meaning (Chapter 3). It also demands that their stewards be understood as the core conservers and adapters of such sys-

BOX 2.1 | A description of a pervasive social-ecological system in coastal regions of South China

In south China's coastal region, a complex and inter-related set of SES has developed over hundreds, or even thousands of years, that are based on 'exquisitely fine tuned choices of what to grow. The plant and animal production processes fit into each other neatly. They have come through the millennia to an accommodation' (Sutton & Anderson 2004). Towns and graveyards are situated above arable land, but are protected from typhoons by surrounding hillsides. Parts of the surrounding hillsides are burned (the ash washing downstream to replenish fields), but groves of trees are left above the village and provide shade, erosion control, fuelwood, fruit, and some timber. In some areas, nitrogen-fixing alder trees are planted in fallow fields to provide timber and rejuvenate soils. Rice paddies dominate the valley bottom, but around the villages are terraced vegetable gardens, in areas where soil is well-drained and near to homes so that they can be managed intensively and so that the effort to transport heavy fertilisers and harvest is reduced. Mulberry trees are grown on dikes between rice fields to stabilise the dikes and provide leaves to feed silkworms. Water buffalo and ducks are raised downstream of rice paddies in the lower valleys, along with crops that need more water. In the lakes and marshes close to the coast, wild and domesticated fish are intensively farmed, with a number of fish species that can occupy all aquatic niches. Fish ponds are fertilised with human waste and by products of the land economy. The rivers' alluvial fans are eventually drained and cultivated, and the brackish swamps are used for catching fish (Anderson 1988, Ruddle & Zhong 1988). Domestic animal breeds, often missed by researchers, are important for recycling of human and agricultural waste products into meat, and play a role in controlling weeds and pests. Wild flora and fauna serve a multitude of functions: insect-eating frogs keep pests under control, which other insects provide food for humans, herbs provide medicines, vines are used for tying, leaves are applied as fertiliser, and flowers are used for decoration and rituals. 'Cultural traditions have evolved to fit well with the overall system. Cooking, for example, has come to be based on processes that rely on very little fuel: stir fry and steaming, instead of baking and long boiling. Food preferences run to vegetables and fish, not the 'meat and potatoes' of western diets' (Ibid.).

Underlying this ingenious use of the landscape and its abiotic and biotic elements, is a cultural belief system known as feng shui, which regulates the placement of roads, towns, fields and forests, to ensure harmony. Good or evil fortune follows from one's choices in this regard, and mythical dragons are said to bring the good fortune. Feng shui includes land and crop management practices that seek to use wind and water efficiently and minimise damage to the landscape. 'Whatever mystical beliefs it may have accumulated over the years, feng shui is based on solid pragmatic observation. Its magical overtones make it more persuasive - persuasive enough to convince millions of peasants to sacrifice short term personal gain for long term community benefit. Without the magic, the ecosystems in south China will degrade or collapse' (Ibid.). Where recent changes have led to the loss of feng shui belief, groves have disappeared. The cutting of feng shui groves has led to predictable results: erosion, water shortages, droughts, and fertility loss. The undercutting of slopes by housing developers, which is said to 'cut the dragon's pulse', has led to landslides. Finally, all this did not develop in isolation from the wider political economic context of China. Going back two thousand years, the emperors of China have supported agricultural development and farming communities by keeping taxes low, providing extension manuals, conducting experiments, distributing superior seeds and cuttings, and sponsoring international missions to bring back useful plants (Anderson 1988).

tems; just as particular ecological systems and landscapes could not exist as such in the absence of a characteristic set of organisms and geographical features, particular SES could not exist without the specific beliefs, practices, technologies, and social relations that have shaped the landscapes and influenced other organisms.

The great majority of farmers in Latin America and Africa are also subsistence producers who farm small plots of land, often in marginal environments, utilising indigenous agricultural methods. One of the salient features of these traditional farming systems is their high degree of biodiversity. Polycultures are prevalent among subsistence farmers and cover at least 80 percent of the cultivated area of West Africa and Latin America, where more than 40 percent of the cassava, 60 percent of the maize, and 80 percent of the beans are inter-cropped with other crops (Francis l986). Using inventive self-reliance, experiential knowledge, and locally available resources, rural subsistence producers have developed farming systems that are adapted to local conditions enabling them to generate sustained yields that meet their subsistence needs, despite marginal land endowments and low use of external inputs (Denevan 1995, Wilken 1987). Part of this performance is linked to the high levels of agrobiodiversity in traditional SES which in turn positively influences SES function (Vandermeer 2001).

The persistence of millions of hectares under traditional agriculture in the form of raised fields, terraces, polycultures, agroforestry systems, etc., document a successful indigenous agricultural adaptation strategy to difficult environments and comprises a tribute to the creativity of rural subsistence producers throughout the developing world (Altieri 1999). A key challenge has involved the translation of such principles into practical strategies for natural resource management. While the ecological constraints on human adaptation in these systems are better understood and well documented in the anthropological, agroecological and ecological literature (e.g. Marten 2001, Moran 2000, Sutton & Anderson 2004), what is perhaps less understood and appreciated outside of the social sciences is the degree to which social and cultural institutions create demands for resources and thus impact the creation, management, and distribution of biodiversity and, in particular, agrobiodiversity and landscapes.

Kinship determines who is in the family and who is not, which has profound implications for the structure of a society and the way it interacts with its biophysical environment. Indeed, most 'landscapes' are, in part, the result of the enactment of rules pertaining to the kinship system, particularly rules of inheritance that affect land use and ownership. Inheritance systems are the most important way of moving property in systems that are kinship based, since there is no land market, use rights and material objects are passed from generation to generation.

In most tribal societies, the family, often synonymous with the household, is the key economic unit of production and consumption, where decisions are made about the flows of materials, energy, and information needed to sustain itself. Families determine who works with whom, which land can be used, who may share with whom, who inherits land and wealth after death, and who succeeds leaders.

While each SES can be said to have a generalised kinship system, in day-to-day reality some of these rules are often fluid and negotiable, but in ways that differ from society to society. Initial surveys may reveal a set of norms for inheritance of land, for instance, but in practice it is likely that these rules are malleable, context-dependent, and subject to overriding values, such as fairness, or to manipulation for political ends (see Chapter 3.5.6). Perhaps guidelines would more accurately describe the role of normative statements about human-land relations in many small-scale societies. With that caveat, we present some examples of the complex and varied way that kinship and other cultural variables interrelate with ecosystems in a variety of contexts, including swidden and small holder farming societies of the Asian tropics, East African pastoralists, and hunter-gatherers of arid grasslands and deserts of Australia and southern Africa.

Swidden societies in SE Asia often share communally owned land for cultivation of staple crops such as rice, with use rights being passed from generation to generation. A bilateral kinship system means that use rights are inherited from both sides of the family, so that everyone can claim a number of plots as potential swidden sites. Since everyone is closely related, borrowing or transferring rights to cousins, nephews, etc. is easily done. The actual location of swidden plots is negotiated every year, based on use rights, familial and community needs, and labour availability, in a way that accounts for fluctuations in family and community size over time. When stressed by population growth or limits to the incorporation of new land, intensification often leads to reduced fallow periods and declining fertility and yields (Puri 2005, Sutton & Anderson 2004).

In contrast, inheritance systems in peasant or small holder farming societies, which require that land and wealth be divided equally among all offspring, often lead to decreasing size of family farms. Where arable land is limited, this may lead to intensification of production, such as the development of multiple cropping, inter-

cropping, fertilisers, new tools and irrigation systems, or intensification of labour absorbing practices, or what Geertz (1963) called 'agricultural involution' in Java.[5] Land fragmentation in a limited or marginal environment may also force the development of a market for land, tenant farming, or the cultural means to reduce family size, either directly through increased birth spacing and infanticide, or indirectly through voluntary out-migration, or even forced expelling, of 'extra' sons to occupations such as the military or the church. In matrilineal Minangkabau society in Sumatra, for example, sons are forced to seek their wealth outside their farming communities in business and trade.

The Maasai pastoralists of East Africa organise their patrilineal society around age-grades, which are groups of people passing from one stage in the life cycle to another. Men tend livestock until age twenty, when they go through a rite of passage to become warriors and then get married. They can have as many wives as they can afford, but they must give cattle as gifts to the family of the bride, so Maasai men try and maximise their herd sizes. In terms of adaptation to the savannah grasslands, this strategy may risk overgrazing and thus be unsustainable, but it also serves to guard against imminent losses of cattle during frequent and cyclical droughts (Moran 2000). Cattle are also important status symbols and may be sacrificed to provide meat for feasts that gain prestige for their owners. The East-African Cattle complex[6] is an excellent example of the close interrelationships between humans and their ecosystems, demonstrating the adaptive importance of cultural values, attitudes, kin relations, and resource management to life in a grassland ecosystem, but also showing how variation in the habitats of neighbouring pastoralist tribes can generate differences in herding patterns, the practice of agriculture in relation to herding, seasonal migrations, and even inheritance patterns (Ibid.).

There is other evidence to suggest that kinship systems respond to environmental pressures. For example, bilateral systems (where one inherits from both their father's and their mother's lineages, which allows for a greater number of 'relatives' with which one can share or borrow from), are more likely to evolve in environments subject to repeated crises and disturbances that cause resource shortages, such as natural disasters and economic instability (Sutton & Anderson 2004). But all such ***social networks*** require maintenance in order to be useful for fulfilling immediate needs and as future insurance, which comes in the form of sharing and gift giving. Families don't just share food in order to survive: they reinforce their social ties through the reciprocal exchange of food and other materials, labour, and information (see e.g. Hawkes 1993 and the Appendix to this paper). With close relatives, these exchanges are ongoing and seldom immediately reciprocated, but with distant relatives, visiting is usually accompanied by formal or even ceremonial gift-giving, often of luxury goods. Hunter-gatherers around the world establish and maintain relations with distant

groups that they rely on to host them during prolonged periods of drought and increased resource scarcity in their own territories (Puri 2007). These relations are maintained through annual or biannual visits (e.g., going 'walkabout' in Australia) to give gifts, establish marriage alliances, share work, and exchange information. The undermining of institutions that support food sharing can make hunter-gatherers, and indeed all other societies, more vulnerable and less able to maintain their way of life (Moran 2000).

Even in egalitarian societies, where there is no political hierarchy, kinship plays an important role in establishing political leadership, but these positions are seldom ascribed and must be achieved with support from other members of the group.[7] Thus the status and political power of leaders, and their political alliances, also require that similar network-maintaining mechanisms be sustained. There are numerous examples from around the world that demonstrate how political leaders recruit their subjects to extract or produce natural resources to create the wealth necessary to establish and maintain their power. Those societies with access to abundant or valuable resources usually dominate their neighbours (see e.g. Diamond 1997). Where slavery, violent punishment or the threat of supernatural retribution are not employed to coerce subjects into paying taxes or providing labour for political leaders, ceremonial rites that redistribute or share wealth are often found, such as the potlatch ceremonies of the Pacific Northwest Indians (Suttles 1968), or the pig feasts held by New Guinea 'big men' (Rappaport 1984). Status is reaffirmed and prestige gained by leaders distributing their, or their subjects', wealth in these elaborate rituals. Meeting these needs can often drive populations to unsustainable resource use, rebellion, or warfare, as happened among Hawaiian

chiefdoms after the arrival of Captain Cook (Sahlins 1988).

An important issue illustrated here is that resource use and exchange in rural subsistence SES is often dictated by the need to maintain family ties, social networks and political power, rather than just to feed people or obtain cash. The fact that satisfying these cultural needs may prove to be uneconomical, and thus irrational from an economist's perspective, is irrelevant for the people in these systems. New introductions of resources, technologies, or markets will be seen and interpreted in terms of these social and cultural needs, which may or may not agree with the goals of those outside agents who introduce them. Economic anthropologists call this perspective cultural economics, emphasising that not everyone behaves like a capitalist (Haugerud et al. 2000, Wilk 1996) (see Chapters 3.5 and 4.4). Thus GIAHS sites are likely to be as concerned with cultural economics as they are with market economics.

2.4 Resilience and Adaptive Co-management Principles

This chapter has thus far introduced the concepts that are used as building blocks for a framework for Globally Important Agricultural Heritage Systems with the ultimate goal of developing guidelines and principles that can support their identification and management. The essential tasks of the GIAHS Programme are to a) identify key variables and processes that give rise to or undermine ecological and social resilience; and b) to develop and implement means to co-manage these variables and processes so as to ensure, to the greatest extent possible, social and ecological resilience of GIAHS SES.

The ***ecological resilience*** of SES depends generally on a few key state variables and processes, where resilience refers to the capacity of the ecological system to absorb changes and still persist. The desirability of such a stable state or stability regime, however, cannot be determined using ecological parameters alone, but must be defined socially, by the goods and services that it provides. An SES can only be considered to be ***socially resilient*** if it provides sufficient goods and services to generate cultural perceptions of well-being among the majority of its inhabitants, and if it is able to do so sustainably. 'Cultural perceptions of well-being' is used here instead of other more 'objective' measures of well-being since it is ultimately culture that defines needs, and it is highly unlikely that a SES that cannot meet the basic physiological needs of a population will be perceived by that population as providing sufficient well-being. Social resilience implies that the key social and economic variables and processes that characterise the system and that provide for culturally acceptable levels of well-being are able to absorb change and still persist. In this case, as in the case of key ecological variables and processes, we are tracking a moving target, since cultural values and perceptions of well-being are rapidly changing, e.g. with increasing commoditisation, participation in formal education systems, mass communications, etc. This change in values and attitudes is indeed one of the major drivers of change (Chapter 5).

Developing and implementing means to co-manage key variables and processes to ensure resilience is a major challenge. Although there is as yet little understanding of

the precise mechanisms of cultural adaptation and co-evolution discussed herein, there is much interest in emulating such processes while at the same time involving external agents, which is captured in the term ***adaptive co-management,*** defined as a combination of 'the dynamic learning characteristic of adaptive management with the linkage characteristic of co-operative management' (Berkes 2004, see also Armitage et al. 2007). Adaptive co-management focuses on social learning, the synthesis of different knowledge systems, collaboration and power-sharing among community, regional, and national levels, and management flexibility.[8] The approach has arisen in part as a result of continued failures to achieve conservation objectives in and around protected areas and their buffer zones, and the failure to integrate people and their needs into conservation and related development initiatives through programmes such as Integrated Conservation and Development (ICDPs), Community Based Natural Resource Management (CBNRM), Enterprise-based Conservation, and various forms of community forestry and Community-based Conservation (CBC), conservation pro-grammes around the world have been adopting Adaptive Co-management as their newest guiding conceptual framework (Olsson et al. 2003, Sheil et al. 2006, Turner 2004, Walters 1997, Wells & McShane 2004).

In the case of GIAHS SES, it is clear that it is traditional management, rather than external intervention, which is responsible for the existence and resilience of the systems, which gives rise to ***GIAHS Principle 4***. One of the greatest challenges that those involved with the Programme face is in fact to establish an environment condu-

GIAHS Principle 4

It is essential that GIAHS stewards be able to continue with their own inbuilt processes of adaptation. Traditional GIAHS institutions have generally served to manage and regulate social and material relations over long periods of time, and have been proven to be adaptive and resilient, so the Programme must reinforce such institutions or, where such institutions are deemed by their stewards to be inadequate, replicate, restore, or set in motion new processes that mimic the natural adaptive management strategies that have been developed by GIAHS stewards.

cive to exchange between GIAHS stewards and external actors that respects traditional management institutions and facilitates social learning.

Further, it is not only the stewards who must be involved in a social learning process: external actors must also be engaged at all appropriate scales, which is required in order to ensure appropriate action and sustainability over the long-term (***GIAHS Principle 5***).

> ***GIAHS Principle 5***
> *While respecting Principle 4, a fully inclusive and participatory social learning process is necessary that focuses on meeting local needs and longer-term priorities, including the heritage priorities, of GIAHS stewards and on eliminating or attenuating the impacts of negative change driers and mediating contextual factors, which requires that an environment be established that is conducive to fluid and mutually respectful exchange between indigenous inhabitants and external actors.*

A strategy is required that takes its lead from GIAHS stewards with regard to identifying needs, problems, priorities, drivers, likely impacts of interventions, and to support stewards' decision-making decisions as well to encourage external actors to work at multiple scales toward achieving these priorities.

In the 21st Century it is very likely to be the interaction between key social and ecological variables and processes that break down SES resilience and push them across thresholds, leading, in many areas of the world, to collapse, that is, to alternative stable states that cannot provide the goods and services required by a growing population. Many if not most of the drivers will be mainly exogenous and will include: climate change, demographic change, land use change, cultural change brought about by globalisation, energy shortages and carbon mitigation efforts, and conflict (see Chapter 5). Key factors in resilience given such drivers will be the degree of exposure of an SES to such drivers (e.g. of drylands to climate change), the degree to which the system will respond to them (sensitivity), vulnerability, and adaptive capacity.

The GIAHS selection criteria presented in Box 1.1 attempt to ensure that, at this particular moment in time, SES are largely resilient, that they currently provide all culturally necessary goods and services and well-being, they manifest adaptive capacity, and can conceivably do so in future if the drivers, thresholds, exposure, vulnerabilities and threats are identified and if GIAHS stewards provided at different scales with appropriate information, policy and technical support (***GIAHS Principle 6***).

> ***GIAHS Principle 6***
> *Collectively understanding the social-ecological system is essential to identifying potential strategies to enhance well-being, adaptive capacity and resilience. Given that even local communities may be unaware of emergent properties, of slow moving state variables, of scale effects, and of all the potential implications of introduced changes, and given that major drivers of local change are often external to GIAHS sites, the GIAHS Programme must include scientific research at multiple scales which is conducive to social learning, and it must include provisions for carefully monitoring GIAHS, as unexpected consequences are expected. Monitoring must be part of the social learning process and therefore should be participatory and involve decision-makers at all levels.*

In GIAHS, humans are keystone species that shape and organise the physical and biological environment and landscape. Culture provides the mechanism through which humans adapt and maladapt to changes, and includes knowledge and social learning, values and beliefs (including perceptions of well-being and vulnerability) and institutions (including those that determine entitlements and adaptive capacity) that are all crucial state variables and, at the same time, dynamic processes. On the other hand, rural subsistence-based SES that meet the GIAHS selection criteria are generally highly dependent on biodiversity and on ecological services. There is a very strong relationship as well between biodiversity and ecological resilience. The relationship between culture, biodiversity and resilience is therefore one of the most important to address, and is at the core of the following section.

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[1]Ecological anthropologists regularly use the concept of human ecosystems (Abel & Stepp 2003, Moran 1990), while some human ecologists refer to eco-social systems (Marten 2001). All of these concepts attempt to overcome the western dualist separation of Nature and Humans (or Culture and Nature).

[2]Personal communication, Martin Scheffer, ecologist and member of the Resilience Alliance, March 2007.

[3]See http://www.resalliance.org; Walker & Salt 2006. The terms 'resilience' and 'social-ecological systems' together resulted in 37,500 hits on google on 26-3-2007, whereas the term "social-ecological systems" resulted in 63,900, indicating that resilience appeared in more than half of the total hits.

[4]See the explanation and case studies on the EcoTipping Points Website: http://www.ecotippingpoints.org) (accessed 9-10-06).

[5]Geertz (1963) argued that increasing demands on decreasing lands were a result of the historical and cultural experience of colonialism, which alienated rice paddy land for export-oriented plantations. Involution allowed for greater amounts of labour to be expended to both support growing populations and the demands of a colonial power.

[6]This refers to dominant cultural values among East African pastoralist societies that are marked by a devotion to cattle, maximisation of herd sizes, and periodic burning of grasslands to clear brush, all of which were once seen as maladaptive, but have since been shown to be an adaptive set of responses to an environment that is marginal for agriculture, where pastures are widely distributed, wild animals carry diseases deadly for cattle, and the region is subject to cyclical drought (Moran 2000).

[7]In hunter-gatherer societies, conflict among potential leaders (such as among brothers trying to claim succession rights), usually leads to fission, with one of the leaders and his followers setting off to claim new territory. Over time and through deaths and marital alliances, these groups may again fuse (Moran 2000, Puri 2005).

[8]See http://www.resalliance.org/2448.php

Chapter 3

A Cuban conucu*, or homegarden*

Culture, Biodiversity, and Resilience in Subsistence Social-ecological Systems

3.1 Introduction

A useful social-ecological systems (SES) approach to traditional subsistence societies must broadly conceptualise the relations between people and their environments, why and how they have persisted for centuries in such environments, including how people are shaped by and are shaping these environments, the flows of information, goods and services within them, the value of these different goods and services to their stewards, and the forces that are altering these relationships in ways that tend to undermine human well-being, environmental integrity, and biocultural diversity.

GIAHS Principle 7

An emphasis on agrobiodiversity within GIAHS is necessary and strongly justified insofar as it represents three cornerstones of GIAHS-type SES: it both underpins and drives most ecosystems services, it is the principle source of livelihoods and hence determinant of human well-being, and it is the future provider of capacity of GIAHS communities to adapt to rapid change, particularly to the major change drivers of the 21st century.

An Oxford symposium on indigenous peoples and climate change recently reinforced the stress on the functions of biodiversity for GIAHS-type SES that is emphasised in ***GIAHS Principle 7***:

> *above all, [it is] in times of disaster and climate change that people depended on diversity – diversity of crops and their varieties, of wild plants, and of environments…Indigenous peoples universally use biodiversity as a buffer against variation, change, and catastrophe…over space and time, among species and varieties, in forests and agriculture, from landscape to genetic levels. Biodiversity is central to indigenous environmental management and livelihoods. Biodiversity is especially important among indigenous societies living on the margins of fragile and changing ecological, economic, and political systems* (Salick et al. 2007).

The concern for biodiversity in GIAHS-type SES, like the global concern with the rapid loss of biodiversity worldwide, is related to its cornerstone functions. ***Values of biodiversity*** include: (1) the direct use values (food, medicine, fibres, fuel, construction, etc.) and commodity values of species; (2) option values, where species diversity provides a type of insurance or as yet unknown option for future streams of goods and services; (3) existence values, where biodiversity, or particular species, have value in and of themselves, which may be part of a system of morals or religious or other beliefs; (4) value from providing process-based resilience of ecosystems and other ecological services.

While these values are conceptually equivalent at global and local levels, they do not necessarily translate into the same strategic objectives for global and local communities. GIAHS are likely to harbour globally valuable biodiversity since many are either found in 'hot spots' where a large number of species are concentrated or because they harbour unique endemic species, including domesticated or semi-domesticated crops and animals. In supporting GIAHS, the international community may be seeking to strategically support the conservation of globally valuable biodiversity. Further, biodiversity in GIAHS may provide important ecosystem services at a wider scale, such as serving as a carbon sink or protecting watersheds or coastal wetlands. However, within any given GIAHS, the local erosion of species diversity or change in species' range and composition may not threaten global values, but it may nevertheless have very negative repercussions for populations and ecosystems at local, sub-regional, national, or even regional scales. Species diversity may or may not regulate ecosystem processes and provide ecosystem services at a much wider scale, but they certainly do so on a local scale (***GIAHS Principle 8***).

To adequately conceptualise the relationships between biodiversity, human well-being, adaptive capacity and resilience, some of the most important co-evolved relations between ecosystems, culture, and biodiversity within traditional SES are discussed. Then, in Chapter 4, the relationships between markets, biodiversity conservation, well-being and SES resilience are addressed and, in Chapter 5, the major change drivers of the 21st century and their implications can be considered with respect to adaptive capacity and resilience, considering that selected GIAHS systems have stood the test of time. The remainder of this chapter is therefore devoted to describing and developing a means to conceptually understand these key functions and dynamics in traditional, subsistence-oriented rural societies. The implications of change drivers for adaptation of GIAHS-type SES can only be assessed within specific ecological and institutional contexts, and understanding these contexts and the dynamics of change within them provides the starting point for the GIAHS initiative both conceptually and within each GIAHS site. The chapter begins, then, with a review of the relation between biodiversity and ecosystem resilience and then moves to the conceptualisation of agrobiodiversity and agroecological systems within GIAHS-type SES. It turns to a framework for conceptualising rural livelihoods and the role of agrobiodiversity within them and, finally, the remainder of the chapter explores in-depth the relation between agrobiodiversity, livelihoods, human cultural institutions, and well-being, drawing out implications for adaptive capacity and resilience.

GIAHS Principle 8

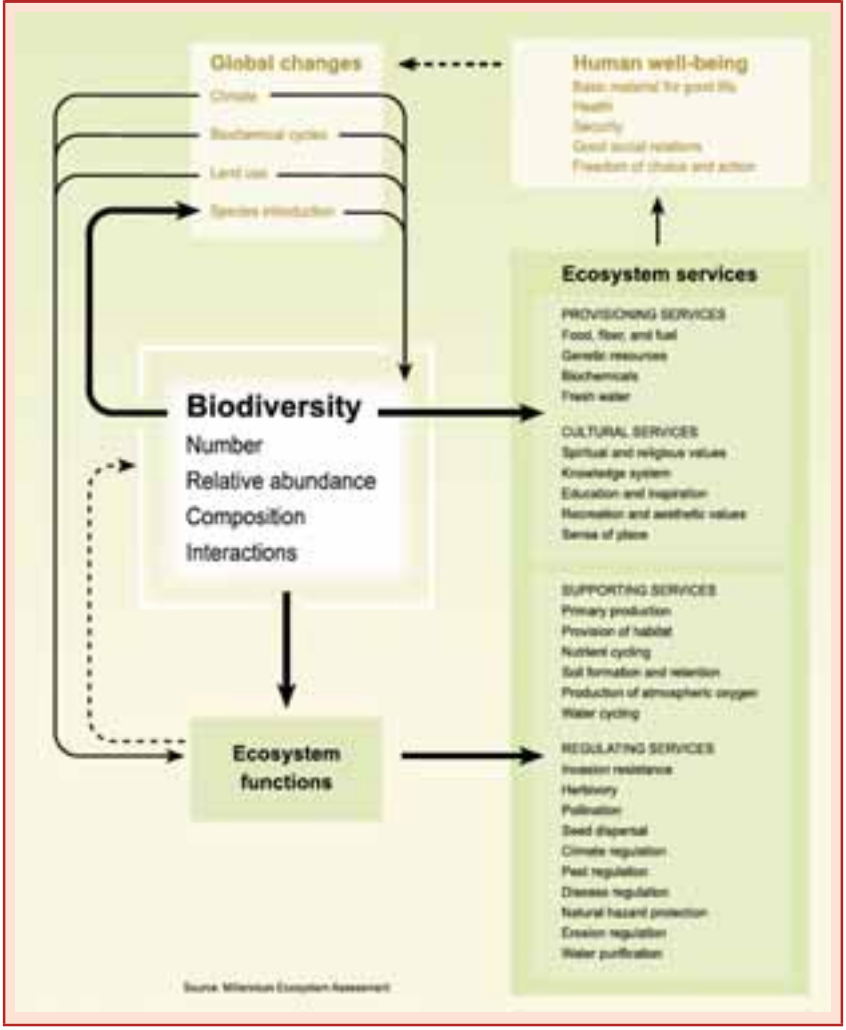
The most important values of agrobiodiversity for GIAHS are local values, since these are crucially related to well-being, SES resilience and adaptive capacity. It is also local values that provide incentives for GIAHS stewards to develop and maintain such biodiversity. It is therefore crucial to assess local values of agrobiodiversity, agrobiodiversity as livelihood assets, the increasing or decreasing values of its components given drivers of change, the flexibility with which people can substitute, complement, and transfer or procure these assets, the changing conditions of access (e.g. rights, terms of trade), and the influence of markets and non-market institutions on these incentives.

3.2 Biodiversity and Ecosystem Resilience

One set of values are those that biodiversity provides through ***ecosystem services*** that are crucial to ecosystem stability, and hence to the stability of GIAHS-type SES. The key ecological functions of biodiversity are presented in Figure 3.1, from the Millennium Ecosystem Assessment.

While it has been recognised since Darwin's time that species diversity is important to ecosystem stability and resilience, the precise nature of the relationship is still not well understood. A recent literature review attempted to synthesised the current scientific consensus. First, it is considered to be certain that species' functional characteristics strongly influence ecosystem properties, including the effects of dominant species, keystone species, ecological engineers, and interactions among species (e.g., competition, facilitations, mutualism, disease, and predation). Second, however, it is also certain that the relative abundance of a species does not always predict its ecosystem-

FIGURE 3.1 | Biodiversity, ecosystem functioning, and ecosystem services
(Mace et al. 2005, Figure 1.4)



level importance since even a rare species, such as a keystone predator, can play a dominant role. Third, it is certain that the loss of species and species invasions caused by humans have led to the loss of ecosystem goods and services in many well-documented cases, where 'many of these changes are difficult, expensive, or impossible to reverse or fix with technological solutions' (Peterson et al. 1998; see also Chapin et al. 2000). Fourth, ecologists agree that the effects of changes in biodiversity and the mechanisms by which the effects are manifest differ depending on ecosystem properties, types, and pathways of potential community change. Fifth, biodiversity loss may initially not lead to changes in ecosystem properties because there may be more species that have similar functional roles, some species may play only a minor role, or ecosystem properties might be controlled mainly by abiotic environmental conditions.

However, as spatial and temporal variability increase, ***greater species diversity,*** or a wide range of species that respond differently to disturbances and variations in biotic conditions, is required in order to provide a stable supply of ecosystem goods and services. Further, while ecologists are not absolutely certain, there is high confidence in the following propositions. Species diversity, manifest in certain combinations of species, can increase average productivity and nutrient retention in an ecosystem. Further, susceptibility to invasion by exotics is strongly influenced by species composition and typically decreases with increasing species richness, although other factors can override this effect. Finally, species diversity can stabilise ecosystem process rates so that 'Using practices that maintain a diversity of organisms of different functional effect and functional response types will help preserve a range of management options' (Ibid).

There are many other propositions about the relationship between biodiversity and ecosystem functioning that are currently the subject of much research and debate. The complexity and uncertainty entailed in this relationship, and the constancy of change in ecosystems, in species diversity, and in their relationships over time and space, will only increase during the foreseeable future due to continued land use change and climate change (see Chapter 5 on drivers). What is clear is that research at SES sites should be carried out regarding this relationship, particularly with respect to the existence and importance of dominant species, keystone species, ecological engineers and invasive species, taking into account as much as possible future likely scenarios, since these may have far-reaching unanticipated effects on the entire SES. It can also certainly be anticipated that general loss of species diversity and change in species' range that are very likely to occur can imperil ecosystem properties and stability, and negatively affect ecosystem services (see ***GIAHS Principle 7***).

3.3 Conceptualising Agrobiodiversity and Agroecological Systems

The GIAHS programme is specifically focused on 'agricultural' heritage, or 'Remarkable land use systems and landscapes which are rich in globally significant biological diversity…[where] traditional agricultural production commonly encompasses the multiple uses of both natural and artificial ecosystems, where crop production plots and adjacent habitats are often integrated into a single agroecosystem.'[1] The under-standing of the biodiversity and ecological dynamics pertaining to such systems often cannot be inferred directly from the sciences that focus primarily on natural ecosystems: rather, in agricultural systems, the concepts of agrobiodiversity and of agroecological systems are often the focus of attention.

Since the 1970s, ***agroecology*** has emerged as the scientific discipline that most clearly attempts to integrate a wider range of systems elements into agricultural re-

search, where it is explicitly concerned with the marriage of agronomy and ecology, 'ecological, economic and social dimensions', and 'ecological and social levels of co-evolution, structure and function' (Altieri 1995, Clement & Shrestha 2004, Francis et al. 2002). It seeks to apply ecological concepts and principles to the 'design and management of sustainable agroecosystems' (Gliessmann 1998), where agroecologists generally compare ecological processes occurring in natural ecosystems with those found in agroecological systems.

Such comparisons have given rise to specific characterisations of ecological processes within agroecosystems. Gliessmann (2004), for example, argued that, in comparison with natural ecosystems, human interference alters energy flows since much energy is directed out of the system during harvest. Therefore, 'renewable sources of energy must be maximised, and energy supplied to fuel the essential internal trophic interactions needed to maintain other ecosystem functions.' Nutrient cycling is also altered in cropping systems, where recycling is minimal and many nutrients are lost upon harvest and as a result of leaching and erosion due to the substantial reduction in biomass levels and exposure of bare soils. Population regulating mechanisms also change in cropping systems. Crops and animal populations are no longer self-reproducing or self-regulating and systems are simplified (lower niche diversity and biological diversity and reduced trophic interactions). This means that population sizes are determined by human inputs (seed, control agents), natural pest control systems are disrupted and microhabitats may be left unoccupied. With regard to dynamic equilibrium, whereas in natural ecosystems species richness or diversity permits resilience in the face of perturbations, the reduction of structural and functional diversity in cropping system leads to the loss of ecological equilibrium and a constant dependence on human-derived external inputs.

The global outcomes of such ecological changes have been summarised in the MEA:

> *Cultivated systems specialize in the provision of food, feed, and fibre, often at the expense of other ecosystem services; only four (crops, livestock, aquaculture, and carbon sequestration) of the 24 ecosystem services examined in the Millennium Ecosystem Assessment have been enhanced, while 15 (including soil cycling, pollination, and the capacity of agro-ecosystems to provide pest control) have been degraded. Cultivation has affected the provision of other services by conversion of biologically diverse natural grasslands, wetlands, and native forests into less diverse agroecosystems; by the choice of crop species grown and the pattern of cropping in time and space; and by the manner in which crops, soil, and water resources are managed at both plot and landscape levels* (Cassman et al. 2007).

However, it is also difficult to argue that such ecosystem transformations characterise GIAHS-type SES. Even agroecological approaches as they are currently conceived tend to reflect an ***agro-centric bias***, reproducing concepts of agriculture and rural livelihoods that are limited to a farming environment, emphasising, for example, the goal of using on-farm resources to provide nutrients and of managing on-farm biodiversity. It is unusual that these approaches, with all of their sophistication and clear conceptual and practical advances, consider the cultural or ecological complexity of GIAHS-type SES, which clearly depend upon and manage a much wider diversity of landscapes and plant and animal resources than those found in cropping systems. These resources and landscapes provide ecological services without which many cropping systems would not be ecologically viable or highly productive.

Ethnobiologists such as Ellen (1998) point out that traditional and indigenous peoples have over time used and manipulated a wide diversity of rural landscapes, forming a mosaic of spaces enriched by resources useful to them. Their concepts of such landscapes very often do not conform to the views of professionals: they are based less on uniform systems of vegetation (e.g. western concepts of 'forest' or 'agricultural fields'), but more on biotic patches of useful species wherever they are encountered, forming many different types of boundaries and a network of resources. In this view, simple distinctions between physical resource boundaries look 'pretty academic', with limited meaning to the local resource users themselves (Ibid.).

A factor that complicates analysis of biodiversity and ecosystems in GIAHS-type SES is the fact that off-farm resources found in so-called 'natural' ecosystems are also extensively managed. According to Ellen (Ibid.), 'There is now plenty of evidence for the manipulation and regulation of plant resources…in ways which maintain or increase yield…At which point management becomes cultivation is a major scientific puzzle.' He notes that , from an ecological point of view, many traditional and indigenous forest peoples are more like agriculturists in the way that they extract, protect, and ensure future supplies of plant resources. Management of an ecosystem upon which humans depend is not confined to 'agriculture', nor to farm borders. Much research has shown that plants and trees found in 'wild' or 'disturbed' environments are actively managed in situ. This is done by: altering environments (e.g., selective clearing, altering sunlight, humidity and competition); protection and maintenance (weeding, watering, starting controlled fires); stimulating production of desired products, such as pruning to increase fruit production; stimulating growth and regeneration (e.g. when harvesting, roots are cultivated to stimulate new growth); controlled utilisation (e.g., selective harvesting and partial cutting, so as not to destroy plants or trees, designating sacred groves, prohibiting harvesting at certain times of the year) (Andersen 1992, Shepherd 1992). The fact that management occurs along a continuum or 'network' of landscapes with different degrees of intensity, means that assertions commonly made by agroecologists, that agroecosystems tend to mimic 'local natural ecosystems', should also be questioned. Historical ecologists, whose research is focused on understanding the history of so-called 'natural' landscapes over time, argue convincingly that these 'local natural ecosystems' have also been co-produced by humans and nature (such as in the Amazon, see Box 3.1).

The problem of drawing boundaries around agroecological systems and agrobiodiversity are both technical (a question of relevant scale) and philosophical (a question of the relations between human society and the natural environment). The ***historical ecology approach*** advocated by Balée & Erickson (2006) negates the idea that humans simply adapt to a given environment and it also tends to negate the idea that traditional agroecological systems 'mimic' natural ecosystems. Both ideas presume a separation between humans and the natural environment that

BOX 3.1 | 'Natural' Amazonian ecosystems or co-evolved agroecosystems?

The Beni in Central Bolivia

Archaeologist Clark Erickson argues that this entire landscape—thirty thousand square miles or more of forest islands and mounds linked by causeways—was constructed by a technologically advanced, populous society more than a thousand years ago. In addition to building roads, causeways, canals, dikes, reservoirs, mounds, raised agricultural fields, and possibly ball courts, the Indians who lived there before Columbus trapped fish in the seasonally flooded grassland. The trapping was not a matter of a few isolated natives with nets, but a society-wide effort in which hundreds or thousands of people fashioned dense, zigzagging networks of earthen fish weirs (fish-corralling fences) among the causeways. Much of the savanna is natural, the result of seasonal flooding. But the Indians maintained and expanded the grasslands by regularly setting huge areas on fire. Over the centuries the burning created an intricate ecosystem of fire-adapted plant species dependent on indigenous pyrophilia' (Mann 2006).

Amazonian Terra Preta ('Dark Earth') Soils

Amazonian dark earth, both black terra preta and lighter or browner terra mulata which is lighter or brownish probably occupy at least 0.1-0.3 percent, or 6,300 to 18,900 square kilometers of forested lowland Amazonia, but others estimate 1.0 percent or more. They occur in a variety of climatic, geologic, and topographic situations, with depths of up to about 2.0 meters. The black terra preta is associated with long-enduring, Indian village sites, and is filled with ceramics, animal and fish bones, and other cultural debris. The brown terra mulata, on the other hand, is much more extensive, generally surrounds the black midden soils, contains few artifacts, and apparently is the result of semi-intensive cultivation over long periods. Both forms are much more fertile than the surrounding highly weathered reddish soil, mostly oxisol, and they have generally sustained this fertility to the present despite the tropical climate and despite frequent or periodic cultivation. This is probably because of high carbon content and an associated high microbial activity which is self perpetuating. The carbon in terra preta comes from kitchen fires and village refuse burning, and in terra mulata probably from in-field burning of organic debris (weeds, crop residues, thatch, branches from adjacent forest, etc.). Low intensity "cool" burning, what has been called "slash and char," resulting in incomplete combustion, can produce carbon in high quantity which can persist in soil for thousands of years. Dated carbon in terra preta is as old as 450 B.C. (Petersen et al. 2001). In contrast, slash and burn shifting cultivation fires today tend to be "hot" fires, set at the end of the dry season, which produce large releases of carbon dioxide to the atmosphere and more ash of brief persistence than charcoal…I have argued that in pre-Columbian times the use of stone axes made long-fallow shifting cultivation very inefficient, and as result probably uncommon until the European introduction of metal axes. Previously, soil fertility must have been maintained and improved by composting, mulching, and frequent in-field burning, making semi-permanent cultivation possible with only brief fallowing. Over time, these activities could have produced fertile, self sustaining dark earth soils' (Denevan & Woods 2004).

did not appear until very recently in human history and then only in certain parts of the globe. Highly intensively managed terraced rice fields in Asia do not 'mimic' natural ecosystems, but they have been demonstrated to be both ecologically sustainable and highly resilient. Obviously the humans who manage them have been able to transform their environments in ways that are conducive to stability.

This same concern with respect to the breadth of definition is also encountered in relation to the concept of ***agrobiodiversity***. FAO's definition has the virtue of corresponding to a broader definition of agroecosystems, and of being one of the most widely recognised, where agrobiodiversity refers to:[2]

> *the variety and variability of animals, plants, and micro-organisms on earth that are important to food and agriculture which result from the interaction between the environment, genetic resources and the management systems and practices used by people. It takes into account not only genetic species and agro-ecosystem diversity and the different ways land and water resources are used for production, but also cultural diversity, which influences human interactions at all levels. It has spatial, temporal and scale dimensions. It comprises the diversity of genetic resources (varieties, breeds, etc.) and species used directly or indirectly for food and agriculture (including, in the FAO definition, crops, livestock, forestry and fisheries) for the production of food, fodder, fibre, fuel and pharmaceuticals, the diversity of species that support production (soil biota, pollinators, predators, etc.) and those in the wider environment that support agro-ecosystems (agricultural, pastoral, forest and aquatic), as well as the diversity of the agro-ecosystems themselves* (FAO 1999).

An adequate conceptualisation of the relationship between agrobiodiversity and agroecological system resilience means rejecting suppositions about agrobiodiversity that are often held by plant breeders, agronomists, policy makers and others involved with farming systems, as summarised in Box 3.2. Such suppositions are strongly linked to the concerns of scientists and policy makers in certain disciplines with staple crops, and with the drastic decline in staple crop diversity worldwide.

There is an growing awareness, based upon a vast amount of evidence, of the fact that agricultural communities rely for direct use value upon a vast range of 'wild' biological resources for food security, pharmaceuticals for humans and animals, materials for construction, storage, clothing, spiritual and ritualistic needs, etc. Further option

BOX 3.2 | Agrobiodiversity: surpassed suppositions

- Agricultural fields constitute the most important habitat for agrobiodiversity.
- The primary motivation that farmers have to develop agrobiodiversity is related to environmental constraints (e.g. insect and diseases, climatic variability, soil conditions).
- Non-cultivated agrobiodiversity is not generally subject to human management (e.g., managed in secondary vegetation, fallows, forests, etc.), and therefore activities related to 'wild' resources are sharply separated from 'agriculture'.
- Farmers maintain agrobiodiversity (as opposed to foragers, hunters, fisherfolk, forest dwellers, etc.

values are represented by crop wild relatives, which are crucial to breeding success, not successfully conserved ex situ, found in 'disturbed' environments rather than in cultivated fields, and which are subject to genetic erosion, as well as by 'underutilised and neglected crops' which are cultivated only on a small scale and locally (such as in homegardens), and that nevertheless have potential for production as new raw materials for food, energy, and industry, for their nutritional qualities (i.e. as weaning foods, and as sources of micro-nutrients), and as culturally and environmentally well-adapted crops (Hammer 2003, Heywood 1999, Meilleur & Hodgkin 2004, National Research Council 1996).

The FAO definition reflects a much broader set of concerns that have arisen with regard to 1) agroecosystems functions and the importance of agrobiodiversity to these (see below), 2) the concern with food security and the dependence of subsistence producers on a much broader range of biological resources for food and agriculture, where many of these resources are also under threat; 3) the 'option value' of a wide range of biological resources, both wild and domesticated, for supplying future needs; 4) the ecological services provided by micro-organisms, pollinators, pests and organisms involved in nutrient cycling; and 5) the importance of cultural diversity, that is, of a diversity of socially shared institutions, values, beliefs and motivations for utilising agrobiodiversity that give rise to greater amounts of agrobiodiversity, and specific types of agrobiodiversity that would otherwise not exist.

This definition of agrobiodiversity leads to the identification of a far greater number of plant species that are considered to have direct use value for humans: more than 6000 species of plants 'are known to have been cultivated at some time or another, and many thousand that are grown locally are scarcely or only partially domesticated, while as many if not more are gathered from the wild' (Heywood 1999), and with respect to food uses alone, more than 12000 plant species worldwide are today considered to be edible (Kunkel 1984). There is no global inventory of all plant species that have direct use values for humans, but PROSEA (Plant Resources of Southeast Asia)[3] recorded nearly 6000 species that are used in that region and, 'assuming similar levels in other tropical regions, we can extrapolate to a figure of 18-25 thousand species for the tropics as a whole. These figures exclude most of the 25 thousand species that are estimated to have been used or are still in use as herbal medicines (Heywood 1999).'[4] As of January 2006, the FAO Global Databank on Animal Genetic Resources (covering 182 countries) contains a total of 7616 breeds (FAO 2006). An estimated 1200 insect species are consumed.[5]

Thus, agrobiodiversity and corresponding agroecological systems extend far beyond agricultural fields, including, for example, 'the tens of thousands of species that are grown in a pre- or semi-domesticated state on home gardens or similar polycultures…many thousands more are harvested wild to supplement farm household incomes' (Heywood 1999). Traditional subsistence systems are based on a wide range of subsistence techniques (see e.g. Ellen 1982, Moran 2000), as well as a wide range of agroecosystems that are managed not only by farmers but as well by pastoralists, farmer-foragers, fisherfolk, homegardeners, hunters, etc. Traditional agroecological systems in the tropics (such as swidden gardens and homegardens) often contain more than 100 plant species with direct use value and varietal diversity can also be very high (Altierri 1999). Heywood (1999) provided a schema (Table 3.1) that demonstrates the complexity of agrobiodiversity,[6] and brings into the equation the 'diversity of agro-ecosystems themselves' (the column 'Agroecological diversity').

There are several criteria within the FAO / CBD definition that are therefore important to highlight when adopting an SES approach to GIAHS: 1) it includes all biological resources that are indirectly and directly useful in SES, ranging in scope from wild to domesticated, above to below ground; 2) it embraces the full range of environments in which 'agriculture' is practised, including habitats (farmers' fields, homegardens, grazing lands, forests, etc.) that are not normally considered as part of agrobiodiversity (Heywood Ibid.); 3) it results from intentional human efforts and their intended and unintended consequences, which have resulted in major modifications or transformations of landscapes, organisms, and ecological relationships and, as such, 4) it differs according to motivations, management systems and institutions, and local environments; where intentional human efforts are in-

TABLE 3.1 | The composition and levels of agrobiodiversity (Heywood 1999)

Agroecological diversity	Organismal diversity	Genetic diversity
Biomes Agroecological zones Agroecosystems Polycultures Monocultures Mixed systems Rangelands Pastures Fallows Agroforestry systems Silvicultural Silvopastoral Agrosylvopastoral Homegardens Forest ecosystems Managed forests Plantation forests Seed forests Fisheries Fresh water systems Marine systems Habitats Field Crop Plot	Kingdoms Phyla Families Genera Species Subspecies Varieties Cultivar groups Cultivars Landraces Breeds Strains Pure lines	Gene pools Populations Individuals Genotypes Genes Nucleotides

formed by environmental, social, cultural, spiritual, and economic relations, values and needs.

There is now broad consensus about the need for **in situ *conservation*** of agrobiodiversity. In order to achieve this, scientists also widely agree that (a) local people are managers of the agrobiodiversity; (b) agrobiodiversity maintenance depends on the extent to which it continues to meet the needs of local people, so the approach taken needs to be embedded in local communities and it needs to reflect these communities' values and concerns; (c) agrobiodiversity is based upon not only ecological and economic, but also social, cultural, ethical, and spiritual variables that are culture and context-specific (see e.g. Heywood 1999, Hodgkin and Ramanatha Rao 2002, Sastrapradja & Balakhrisha 2002, Wolff 2004). There is also a growing realisation that drivers that erode cultural diversity, local values, institutions and languages are also responsible for much erosion of agrobiodiversity, and conversely, those that tend to maintain such values also maintain agrobiodiversity. This corresponds to the mounting body of evidence that, in many traditional SES, principle reasons for maintaining most agrobiodiversity are related not to environmental selection pressures or to markets, but rather to non-monetary, culturally-specific use values.

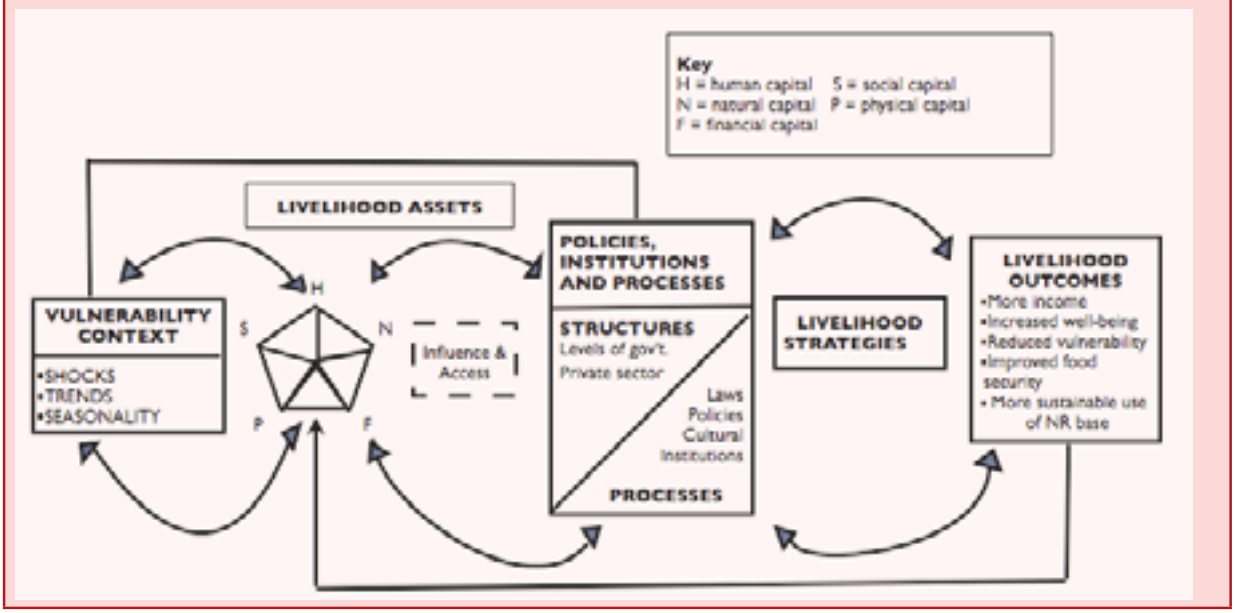
3.4 Agrobiodiversity, Livelihoods and Resilience

A means to understand some of the direct use values of agrobiodiversity in GIAHS-SES is provided in part by the ***sustainable rural livelihoods*** framework (Figure 3.2). First, livelihoods, or the living gained by the individual or household, are comprised of assets (natural, physical, human, financial, and social capital) and activities, and different combinations of these are often considered as ***livelihood strategies***. Different strategies correspond to different cultural histories, resource endowments, relations with other communities and larger economies, and exposure to risks and shocks; strategies also differ within communities that correspond to divisions of assets and labour. In rural subsistence-type SES, livelihoods are natural resource-based (both primary activities such as gathering, food cultivation and livestock rearing, and secondary activities like weaving, thatching, construction, etc.) and hence are strongly related to ecosystems, and non-natural resources based (rural trade, wage labour, remittances, etc.) which may be dependent on economic ties between communities and with larger regions. Second, livelihoods are determined by social relations of access to assets and activities, which are mediated by institutions (see the following sections). Third, the process of gaining a livelihood is dynamic and adaptive both over time (seasonally or from year-to-year), as well as in relation to shocks, adverse trends, and risks. A 'successful rural livelihood strategy is one in which the quantity, quality, and mix of assets are such that adverse events can be withstood without compromising future survival,' which requires flexibility and substitutability between assets (Ellis 2000). ***Livelihood diversification*** (e.g. the use of a range of assets and a range of activities) often contributes to a successful livelihood strategy due to its capacity to ameliorate the effects of risk and seasonality, unpredictable events and adverse trends (Ibid).

The concept of sustainability in this context refers both to resilience of livelihoods themselves and of the natural resource base: 'A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base' (Chamber and Conway 1992, cited in Scoones 1998). Livelihoods should provide for 'well-being', which extends beyond the material to encompass dimensions such as 'self-esteem, security, happiness, stress, vulnerability, power, exclusion', allowing people to define the criteria that are important to them. Natural resource base sustainability is defined as 'the ability of a system to maintain productivity when subject to disturbing forces…[which] implies avoiding depleting stocks of natural resources' (Scoones 1998).

The emphasis on livelihood strategies means that livelihoods should be conceived of as processes rather than

FIGURE 3.2 | A process-oriented sustainable livelihoods approach (Knutsson & Ostwald 2006, Figure 1)



static states, and the emphasis in sustainable livelihoods analysis is not only on current well-being and resource use but as well on vulnerability, adaptive capacity, and resilience. Livelihood strategies and adaptive capacity involve sequencing (what assets are required for start-up), the substitutability and complementarity of assets (whether one type of capital can be substituted for, or must be combined with, others), dynamics related to access to assets, and trade-offs (the relative costs and benefits of different livelihood strategies). Three major types of rural livelihood strategies have been identified, including agricultural intensification or extensification (either capital-led or labour-led), livelihood diversification (developing a wide income portfolio either oriented toward accumulation and reinvestment, or to cope with temporary adversity or to permanently adapt when other options are failing), and migration, either voluntary or involuntary (Scoones Ibid). The scale of analysis (individual, household, community, region) is crucial to understanding livelihood effects of change or shocks. Within this context, livelihood vulnerability may be defined as 'the inability of an individual or group to mobilise and transfer assets in the face of changing conditions' (Knutsson & Ostwald 2006). Certain assets may allow for greater flexibility (e.g. financial capital, education, livestock) which, because they permit greater adaptability in a short timeframe are gaining in value (and hence are not accessible to all), whereas others have lower flexibility (e.g. land, landraces) but may be more equitably distributed and gain in value over a longer timeframe, while others may cease to have value (e.g. labour-intensive technologies as overall labour demands increase). All assets must be seen in the context of the overall livelihood system:

> *Assets that do not have a value for the system as a whole will eventually stop being an asset. If the ability to transfer the decreasing value of a capital asset is limited, or if people are blocked from doing investments in capital assets with an expected increasing value, the supporting function of their livelihood system is weakened and the vulnerability of the system is increased. Therefore, in order to understand vulnerability, we should…start focusing on understanding and accounting for the processes between capitals in times of rapid change* (Knutsson & Oswald 2006).

With such a framework in mind, it is important here to emphasise the high degree of consensus that ***biodiversity provides the main source of livelihood sustenance for rural, subsistence populations across the globe***. Most human labour is dedicated to procuring, producing, processing, transforming, storing, and consuming biological materials. Plant resources, besides being the ultimate origin of all food, provide the material basis for livelihoods as the principle raw materials for food, medicine, construction, textiles, fuels, utensils, crafts, cosmetics, chemicals, religious and ritualistic artefacts, and other products that fulfil most human needs. Rural subsistence populations not only produce or procure the majority of food that they consume through plant materials or livestock (for a discussion of agrobiodiversity and food security in subsistence SES, see the appendix). They lack access to pharmaceuticals and so depend on botanical medicinals for human and animal health. Rather than purchasing chemicals for combating crop pests and diseases, they utilise natural predators (e.g. ants) and plant-based products (e.g. neem). Construction materials, and materials for making storage containers, are also locally procured or procured. Fuel is nearly exclusively provided by local biomass, and fertilisers are also locally derived from plant and animal sources. Until recently, most fibres, soaps, and cosmetics used were also based on local plant and animal resources. Between all of these applications, a single community often purposefully exploits many hundreds of plant species.

The degree to which rural subsistence societies depend on agrobiodiversity for livelihoods is generally greatly under-estimated. One of the first initiatives to address a bias toward field crop production in assessing the importance of agrobiodiversity is found in Scoones et al. (1992), who compiled a bibliography on the 'hidden harvest' provided by off-farm landscapes containing hundred of citations detailing use, management and value derived from wild plant resources. Such evidence of the direct use values of a wide range of environmental resources for rural people has only continued to mount. Research on the importance of non-timber forest products (NTFPs), homegardens, and medicinal plants has added tremendously to this knowledge. For example, the World Bank recently published a report on income generated through forest environmental resources where 54 case studies from across the globe were analysed, and found that these contributed an average of 22% of household incomes, especially through the collection of wild foods, fodder, and fuelwood (Vedeld et al. 2004). This is very likely an underestimation since, as the authors indicate, many studies undercounted certain types of resources, and the studies were also confined to 'a subset of environmental income', which was forest-related income, when rural people use and manage many other types of landscape and agrobiodiversity. Agrobiodiversity in the form of both domesticated and wild resources is also a major source of cash income for rural subsistence producers.

Given the fact that biodiversity in all GIAHS sites is very likely to erode as well as to change in composition and structure due to climate and land use change, among other stressors (see Chapter 5), it is also certain that livelihood vulnerability and hence the need for adaptive capacity and flexible assets will increase if GIAHS-type SES are to maintain resilience. Therefore it is crucial to emphasise the importance of assessing biodiversity as livelihood assets, the increasing or decreasing value of its components given change processes, the flexibility with which people can substitute, complement, and transfer or procure these assets, and the changing conditions of access (rights, terms of trade (see ***GIAHS Principle 9***).

Adaptation and resilience are clearly related to the livelihood options value of biodiversity. Ecological economists have confirmed what it is possible to understand intuitively: although there are costs associated with conserving biodiversity, the option value that it represents means that the net benefits of conservation are positive. Consider a situation where a pool of species are perfectly substitutable in terms of some direct use value or ecological service. The value of the species diversity differs depending on whether the user is confronting certainty or uncertainty:

> *Under uncertainty, since the species are perfect substitutes, only one species, the most convenient one, is needed at any time; all other species in the pool are left unused. This is the situation under which the…literature claims that diversity in the pool is valueless. The*

same value is produced if only one species exist as if many do. If conservation is costly, all species will be allowed to disappear except for the most convenient one. Under risk of extinction the conclusion may be diluted somewhat, but not altered in any significant way; close substitutes, often sensitive to similar risks, are not good as insurance policies. Under uncertainty about the relative abilities of the species in the pool to produce the good or service of interest in the future, the situation is quite different. The species best able to produce the good or service may change over time. If, furthermore, diversity losses are irreversible, then there is a justification for keeping an otherwise useless species alive because it may become the species of choice in the future (Kassar & Lasserre 2002).

Human adaptation to biodiversity change (extinctions and changes in species range) is discussed further in Chapter 5.

While the ecological economics literature (discussed more extensively in Chapter 4) and conceptual frameworks that relate natural resources to livelihoods offer very important conceptual frameworks and insights into the direct and options values of biodiversity for traditional SES, there is another vast body of scientific knowledge dealing with the cultural importance of plants and animals, their values and management and associated institutions in traditional SES, found in the disciplines of anthropology, human ecology, and the ethnosciences (Table 3.2). Virtues of this literature are that it seeks not only to understand the relationships between social institutions, ecosystems and agrobiodiversity, but it often at the same time reveals the complex relationships between food security and livelihoods, health, social status, social relations, and other aspects of human well-being and agrobiodiversity, and as well discusses the drivers that lead to erosion and maintenance of agrobiodiversity within SES. It is to this research that we turn to highlight the most important concepts and relations.

3.5 How Cultural Institutions and Agrobiodiversity are Interrelated

Throughout human history, people have manipulated and exploited biodiversity to achieve their aims. It is well established that much biodiversity is the outcome of human intervention: human have intentionally and unintentionally exercised selective pressures that have given rise to much species richness, and also to species loss, over time. It is also well-established that most agrobiodiversity is concentrated in societies that, for various reasons, are still largely subsistence-oriented, or where traditional institutions such as kinship play a very significant role.[7] The need to maintain these institutions affects traditional resource use and landscapes (see Chapter 2.3). Much research explores the motivations that individuals (e.g. individual preferences) in traditional SES have to develop and conserve agrobiodiversity in all of its forms. But beyond this, individual actions and decisions, however rational or self-seeking these may be, are made in the context of ***cultural institutions*** that have co-evolved often over a long period of time within specific ecosystems. Such institutions define for individuals what are legitimate goals, values, behaviours, and practices, or ways in which people should interact with the natural world and with each other (e.g. if it is a legitimate goal to have a mink coat, and to raise and kill minks exclusively for this purpose; if it is a legitimate goal to increase pig production for sale for individual gain, or if this can be done only for ceremonies where the surplus meat will be shared within the community). It is therefore imperative to examine how institutions are involved in biodiversity management and conservation.

Cultural institutions influence individual motivations and decisions in numerous ways and are necessarily entailed in conservation of agrobiodiversity and SES. They regulate access to and management of natural resources including agrobiodiversity; they conserve and transmit information (knowledge) about ecosystems and agrobiodiversity; they determine who does what with respect to agrobiodiversity development and mainte-nance, and also who receives the benefits. In traditional SES, the market is very often an important, but not the most important, institution and people's behaviour is regulated more by cultural institutions than by market signals. Therefore, while it is important to understand how markets influence traditional social and cultural institutions and motives to develop and conserve agrobiodiversity, it is even more important to understand how non-market institutions accomplish these goals. It is not only institutions and individual decisions that determine motivations and behaviour. Uncertainty, unintentional effects, and unconscious human behaviour also lead to changes in agrobiodiversity and SES functioning, with positive, negative or neutral effects for resilience. But humans generally have the capacity to learn from, and adapt to, changes that occur for whatever reasons. Because it is not possible to discuss all aspects of SES, the discussion here particularly emphasises those factors that have apparently led to high levels of agrobiodiversity and / or to high levels of endemism in particular social-ecosystems, much of which is related to ecosystem interactions, but much of which is even more strongly related to cultural institutions.

Culture as defined herein comprises a world view and related knowledge, beliefs, values, norms, symbols and ways of doing things that vary by locality or social group. Culture also refers to the cumulative body of knowledge and practices that have to a large extent generated much agrobiodiversity itself, and that have permitted people to manage and use agrobiodiversity sustainably over long time periods. Culture is embedded in and expressed through cultural institutions such as religion, language, education, governance, law, and kinship. Understanding cultural institutions is important to understanding how people define, value, and use natural resources, how they divide or distribute resources and the products of resource use among themselves (as groups and as individuals), how they manage such resources over time and space, how they learn about and transmit knowledge about resources and ecosystems and the practices and skills needed to use and manage these, and about who is involved in which aspects at what times. Within this, there are ***five central dimensions of culture*** that have been demonstrated to be very important to agrobiodiversity and social-ecosystem management: ***cultural identity***, ***cosmology and religious beliefs***, ***traditional knowledge***, ***social position and status***, and ***natural resource tenure regimes***. These may be seen by traditional peoples or outsiders as different '***institutions***' or they may be largely undifferentiated: for example, law and

TABLE 3.2 | Some of the recognised ethnosciences with societies, journals, books, and other resources in academia and on the World Wide Web

Designation	Definition
ETHNOECOLOGY	The study of the way different groups of people in different locations understand their environment and their relationship within it. It seeks to understand how we as humans have interacted with the environment and how these intricate relationships have been sustained over time.
ETHNOMETEOROLOGY	The study of the ways in which people understand climate, weather, predict and manipulate weather, and ways in which weather, climate and humans interact.
ETHNOBIOLOGY	The study of the past and present interrelationships between human cultures and the plants, animals, and other organisms in their environment, including relationships with ecosystems as a whole. It draws on knowledge from many different fields of knowledge, such as linguistics, anthropology, biology, and chemistry. Ethnobiology can be divided into several sub-disciplines, some of which are represented in this table.
ETHNOBOTANY	The study of the complex relations between (uses of) plants and cultures. The focus is on how plants have been or are used, managed and perceived in human societies.
ETHNOENTOMOLOGY	The study of the relationship between insects and people. The focus is on how insects have been or are being used in human societies around the world. This includes insects used for food, rituals, music and medicine.
ETHNOZOOLOGY	The study of relations between people and animals
ETHNOPEDOLOGY	The study of local knowledge of soils and land management
ETHNOMEDICINE	A sub-field of medical anthropology that deals with the studies of traditional medicines: not only those that have relevant written sources (e.g. Traditional Chinese Medicine, Ayurveda), but especially those, whose knowledge and practices have been over centuries only orally transmitted. The focus of these studies is than the perception and context of use of traditional medicines, and not their bio-evaluation.
ETHNOVETERINARY MEDICINE	The study of people's knowledge, skills, methods, practices and beliefs about the care of their animals
ETHNOPHARMACOLOGY	The study of the effects of traditional drugs (plant, animal- or mineral-based) traditionally used by humans and also with how their usage and effects vary between cultures and ethnicities. It is associated with ethnopharmacy, but while the aim of ethnopharmacology is the bio-evaluation of the effectiveness of traditional medicines, the former deals instead trans-disciplinary aspects related to the study of the perception, use, and management of pharmaceuticals.
ETHNOASTRONOMY	The study of the astronomical systems of non-Western people.
ETHNOPSYCHOLOGY	The study of native theories and understandings of emotions, of illness and curing, and of self and personality.
ETHNOSEMANTICS	The description of semantic characteristics that are culturally revealing. In anthropology it has come to include a number of different types of analysis which have so far been used mostly in studies of kinship and folk science.
ETHNOMATHEMATICS	The study of mathematics that considers the culture in which mathematics arises. It especially focuses on the mathematics that is part of general culture, rather than formal, academic mathematics, though some ethnomathematicians study formal mathematics as an artefact of a particular culture or cultures. The goal of is to contribute both to the understanding of culture and the understanding of mathematics, but mainly to the relationship between the two.

religion may be seen as inseparable as they are in many Western cultures, or they may be expressed in a single institution such as is found in some Islamic cultures. Below each is discussed in turn and the interrelationships between these dimensions are highlighted.

3.5.1 Cultural Identity and Agrobiodiversity

The sense of belonging to a specific culture, or cultural identity, knits people together in shared language groups, territorial collectivities, collective action groups, communities and households. Forms of worship, dress, architectural styles, culinary traditions, art forms and status symbols form part of one's sense of identity. Agrobiodiversity constitutes an important part of people's of human attachment and belonging), shared sense of identity and sense of place (of belonging to a unique place which fosters a sense that which distinguishes them from others, or 'outsiders'. Identity and difference are expressed in manifold ways, many of which affect the type of agrobiodiversity that is managed. For example, styles of dress are traditionally based on local climatic conditions, needs for protection and comfort, religious considerations, social status, aesthetics and culturally important botanical and animal resources (Box 3.3). Architecture and the design

BOX 3.3 | The cultural significance of bark cloth among the Baganda clan in Uganda (Nabanoga 2005)

Culturally, the fig tree (Omutuba - *Ficus natalensis*) forms one of the principle pillars of the Baganda clans. A principle use of fig trees is for bark cloth. Every Muganda, from the poorest peasant up to the King, uses bark cloth in many different ways, for special occasions such as royal coronation ceremonies as well as in day-to-day rural life. Bark cloth is a traditional fabric that provided the main textile for clothing, but now it is only widely used for traditional ceremonies. One such ceremony is burial: in Buganda, except among Islamic groups, almost all corpses are covered with bark cloth. Relatives and friends of the deceased should pay their last respects by making a gift of bark cloth. Bark cloth is also used for the installation of the new heir and for all other traditional clan ceremonies. It is used to cleanse twins after birth and it is in bark cloth that the 'false twins' are wrapped and stored to protect the lives of the live twins. The fabric was also commonly used for bedding. Women still use bark cloth to make various handicrafts such as place mats, wall hangings, floor mats, handbags, hats, etc. Yet another use of bark cloth was for paying both the taxes to the Chief and the dowry to the clan for a prospective bride, which still occurs in traditional marriage ceremonies.

and engineering of homes and other structures for animals, storage, transport, irrigation, and religious observances, are likewise ingeniously adapted to local environments, based on local building materials (often botanicals), aesthetics, social and religious principles, and specific technical requirements. Concepts of mental and physical health and illness are often inseparable from religious beliefs; a vast amount of scientific research has not only demonstrated the cultural and agroecological specificity of traditional ethnomedical systems and pharmacopoeias, but as well their great efficacy. There are many other examples of ways in which people's 'way of life' are linked to local agrobiodiversity and SES.

Zimmerer (1991) summarised the relation between agrobiodiversity, cultural identity and sense of place eloquently when referring to the Quechua in the Peruvian Andes, who have developed and maintained much of the world's potato diversity:

> *A locally shared sense of the good and the beautiful in farm nature guided the Quechua cultivators in deciding the sums of diversity. This desire of cultivators to handle crops the right way in accord with a cultural or moral aesthetics was broadly similar to widespread sentiments among farmers and others about the proper character of farm nature…Paucartambo farmers voiced customary expectations not just of cuisine but also more generally of cultural self-identity, social justice, and environmental health. Cultivators used diversity to share their ideas of being able to belong and to farm in the place they lived…By farming certain diverse crops and expressing particular styles of production and consumption, the Quechua people…were actively creating their sense of place* (1991).

*Traditional maize storage house (*espiguero*) in Portugal.*

The importance of agrobiodiversity to the maintenance of cultural identity in new places is very obvious when people migrate. Numerous studies show that agrobiodiversity is diffused across communities, regions and even the globe together with its curators. Greenberg's research (2003) on Mayan migrants who moved from a subsistence-based agricultural economy in the Yucatan Peninsula to a wage-labour, cash economy in Quintana Roo, Mexico, is illustrative. Immigrant homegardens are sites of *in situ* conservation not only of traditional Yucatec crops, and also of elements of traditional Yucatec cuisine (some 140 plant species were found in 33 gardens, the majority of which were used in traditional cuisine), which helps to preserve the cultural identity of immigrants in their new environment (for other studies, see e.g. Airriess & Clawson 1994, Corlett et al. 2002, Gladis 2001, Niñez 1987, Vogl et al. 2002).

3.5.2 Traditional Belief Systems and Ecological Knowledge in Agrobiodiversity Management

The importance of traditional religions to GIAHS resides in the fact that ***traditional ecological knowledge (TEK)*** (what some call 'folk science'), and conservation ethics, are not easily separated from traditional belief systems, or religions. Both TEK and traditional conservation ethics are considered by many scientists and local people alike to be essential to the management of natural resources and maintenance of ecosystem resilience in SES. Anderson (2005)[8] highlighted the difficulties encountered when attempting to sort out what is 'science' and what is 'religion': 'Science is not a mess of facts; it's a system that is meant to represent the world accurately and empirically. It necessarily includes a lot of black-box variables [consisting of theories, rather than empirical certainties] that are hypothesised but are generally under examination, and that often turn out to be wrong.' He noted that, before Western societies had laboratories and other technical means to test their theories, they had many theories that

Illustration by Felipe Guaman Poma de Ayala (c. 1550 – after 1616) of an Andean planting ritual

were similar to those found in traditional societies today which they used to explain 'black box' variables. Even within science today, there are many 'black boxes' where theories, rather than facts, are set up to explain the world and the cosmos. Humans seek to explain things and, when they can't, they come up with theories. Many anthropologists today would agree that belief in supernatural beings is probably due to human's tendency to look for causes of things in someone's will to make things happen (agency). 'People naturally assume human-like agency as a default, whenever explaining anything…It makes evolutionary sense for people to look for someone causing things that happen in the world…When traditional peoples infer similar 'black box' mechanisms, we label those 'supernatural' (Ibid).

Anderson continues to explain that religion is 'not just a bunch of supernatural beliefs; it too is a system, in which emotionally compelling beliefs collectively represent social contracts and social ethics' (Ibid). Most anthropologists agree that supernatural beliefs are used to promote ethics, and that religion is an emotional force that can be mobilised to ensure adherence to ethics. In traditional societies, knowledge, the belief in supernatural beings, and ethics are integrated in a single system, whereas in the West it is usually considered that they are separate.

Many would argue that culture itself is a ***cognitive system***, or a 'system of meaning' of which traditional belief systems are a part, which is organised in human minds and shared within a society, containing theories (for example, about time, the movement of the planets, the place of humans in the natural world, the ways in which spirits interact with humans, the effects of fire on grassland regeneration). This system of meaning includes language (for naming things, classifying them, interrelating them) and symbols whose meanings have much emotional and practical significance. Words and symbols exist for things in one culture that do not exist in another: for example, bats are symbols of evil in much of Western Europe; in China they are symbols of good fortune and happiness and the written symbol for bat is 'fu' , which is also good fortune. Ethics are part and parcel of such a cognitive system, 'synthetic digests of information partially and intermittently shared among the causally linked population of human minds that constitutes a 'culture' (Atran 2002). Ethics and norms of behaviour (such as how people should behave toward their elders, or how they should behave at a funeral) are embedded in religious and practical knowledge, rituals and everyday practices. ***Traditional belief systems (cosmologies, religions)*** provide theories as well as normative frameworks, not only for how humans should relate to the spirit world, but as well for how they should relate to other humans, to other organisms, and to their environments. It is still a subject of debate to what extent, and under what conditions, religious beliefs provide a stimulus for the conservation of agrobiodiversity and ecosystems, but there is a very substantial amount of evidence that, in many traditional SES, religion conveys strong theories about ecological relationships, including notions that lead to conservation.

Many traditional belief systems are characterised as 'animist' or 'pantheist', where personalised (for example, ancestral), supernatural beings (or souls) that are endowed with reason, intelligence and will inhabit ordinary

Woman making an offering to a shrine of the rice goddess, Bali, Indonesia

objects (such as landscapes, food items) as well as animate beings (such as animals and trees), and govern their existence: everything has a soul. Within such belief systems, it is common, for example, that such beings must be respected. A multitude of studies demonstrates the ***strong linkages between cosmological beliefs, cultural identity and the maintenance of SES and the agrobiodiversity*** contained in them (see e.g. Alexiades 1999, Anderson 1993, Condominas 1986, Patterson 1992, Piper 1992, Rimantha Ginting 1994, Steinberg 1999, Trankell 1995). To illustrate the relationship between spiritual beliefs, agrobiodiversity and management of SES, we describe how spiritual beliefs give symbolic meaning as well as organisation (of agroecological landscapes, of human labour, of seed selection) to the entire process of rice production, post-harvest processing and consumption over much of Asia.

Asian farmers have developed some 120,000 varieties of rice, each of which was adapted intentionally or unintentionally to specific agroecological conditions, and much of which was brought into being as an expression of spiritual beliefs of local peoples (Hamilton 2003a). The beliefs underlying the development of enormous diversity across much of Asia, but particularly in Southeast Asia, are summarised in Box 3.4. In this belief system, human bodies are made of rice, which is a sacred grain, and the rice plant itself 'lives from year to year in the form of the rice spirits' (Hamilton 2003b). Much ritual around rice production, storage and consumption is related to attracting, appeasing, and honouring rice spirits. Many rituals are associated with the agricultural cycle and take place at sacred sites within or near the fields where the rice spirits may be harboured, and such rituals may involve a special rice type or other sacred plants:

> *Special rituals are often held for the cutting of the first grain….In Bali, the female head of household pays a special visit to the rice fields shortly before the harvest is to get underway. Beginning at the most sacred corner of the plot, where the irrigation water enters, she cuts the first stalk of grain. She forms these into two bundles, which are bound side by side and decorated with fresh flowers and palm leaf ornaments. This construction is called the Nine Pantun, or Rice Mother… the two component bundles are also widely held to represent the Rice Goddess and her consort. The symbolism of the Nine Pantun therefore has to do with the fertile union of male and female elements…Another important task that takes place at the beginning of the harvest is the selection of the seed rice that will be saved for the following crop cycle. This is very often a task for skilled senior women. Senior Ifugao women, for exam-*

BOX 3.4 | Twenty tenets of rice cultures (Hamilton 2003d)

Each rice-growing society has its own unique set of values and beliefs associated with rice. Listed below are 20 of the most common tenets that are widespread in many parts of South, Southeast, and East Asia. The list is a composite. No single society holds to every tenet, and the wording below is generalised rather than specific to any particular group of people. Many societies, however, do follow a large number of the tenets, and taken together, they can be said posit a creed of rice culture.

1. Rice is a special sacred food, divinely given to humans.
2. A rice plant has a living spirit or soul comparable to that of humans, and the life cycle of the rice plant is equated with the human life cycle. The rice spirits must be honoured and nurtured through rituals in order to assure a bountiful harvest.
3. The stages of rice agriculture determine the annual cycle of human activity, including the conducting of the proper rituals at each phase of the rice crop's growth process.
4. The work involved in growing rice is the ideal form of human labour, reflecting a well-ordered, moral society.
5. The mythological origin of rice is attributed to a Rice Mother or Rice Goddess; in many versions of the story the goddess is killed and the first rice grows from her body.
6. The fertility of the rice crop is metaphorically equated with the fertility of the Rice Goddess and with the fertility of human females; therefore rice is often regarded as female and in exchange systems it functions as a categorically female good.
7. Rice must always be treated with respect in order to avoid offending the rice spirits or Rice Goddess; at harvest time rice may be cut with a special type of knife to avoid harming them.
8. The granary is the home of the rice spirits and is often built to resemble a small human house. After the harvest, the grain is ritually installed in its home.
9. Special objects may be placed in the granary to accompany the rice; these include anthropomorphic figures made of rice stalks symbolising the rice goddess, or in other cases carved wooden figures or even copies of religious texts.
10. The spirit of the rice remains alive at least until the rice is milled; thus the rice that is set aside before milling to serve as seed rice perpetuates the rice spirit, keeping it alive until the rice is planted again in the following agricultural cycle.
11. The maintenance of special ancestral genetic strains of rice is a primary link between living humans and their ancestors.
12. The daily milling of rice by pounding it in a mortar is traditionally one of the most characteristic activities of village life. Only after it is milled can the rice be brought into the house.
13. The daily milling, cooking, and eating of rice determine the daily schedule of human activity.
14. Language reflects the special nature of rice as the primary food of humans; often there is no general word for 'food' other than the word for rice and an invitation to 'eat' implies the eating of rice.
15. The household or family unit is defined as those who eat rice together, especially the rice that is produced through the joint efforts of the family members.
16. Cooked rice is the ultimate human food and only rice is capable of properly nourishing humans; other foods are regarded as condiments to accompany the rice or as snacks and do not constitute a meal if rice is not served.
17. Because humans live by eating rice, their bodies and souls are made from rice.
18. Rice and rice alcohol are quintessential offerings made to spirits, deities, and ancestors.
19. The offering of a portion of the daily cooked rice to spirits, deities, or ancestors sanctifies the remainder of the rice, which becomes the sacred daily food to be eaten by humans. The living humans, the ancestors, and the deities are united through the daily sharing of this sacred food.
20. Because rice ties humans to their ancestors, defines the family unit, and provides the ultimate human nourishment, the growing and eating of rice define what it means to be human.

'The single most important adaptive feature of culture is that it allows the gradual, cumulative assembly of adaptations over many generations, adaptations that no single individual could evoke on his or her own' (Richerson & Boyd 2005).

If we added together all of the world's scientific knowledge about how to live in and with the natural world, both past and present, would it begin to approach the enormity of human knowledge and experience that these landscapes and these lives still contain today? These landscapes and lives, and their deep reservoirs of knowledge and natural and cultural diversity, are rapidly being lost. Who holds this knowledge? What do these landscapes and lifestyles mean to them? What scope is there to retain them for all generations to come? (Howard 2006).

> *ple, make their way through the fields at dawn on the day selected for the first harvest, carefully selecting the best heads of rice to be kept for seed. The women who perform this task must be familiar with the desired characteristics of perhaps several dozen different varieties of rice. The genetic heritage of the community's rice varieties is literally in the hands of these women, and this weighty responsibility speaks eloquently of the association of women, rice, and fertility* (Hamilton 2003c).

Hand knives are used for harvesting to avoid scaring away or injuring the rice spirit. Winnowing, threshing, and transporting, as well as storage, are no less infused with ritualistic and religious meaning, and rice storage areas within or outside of human dwellings are considered to be sacred. Post-harvest handling of rice is followed by the largest ritual festivities, 'giving of thanks to the spirits or deities for the success of the harvest' (Ibid).

Much of the rice diversity that is produced is also destined for ritual and religious use. Among the Pahang Malay, for example, specific varieties of glutinous rice are bred for their colour, each of which 'has specific ritual uses, or is required for making special confections or cakes' (Lambert 1985). Rice wine (the 'perfect drink') is also very important in ritual, ceremonies and festivities. For example, in the central Cordillera of northern Luzon, Philippines, 'Ibaloi religious life requires the availability of tapuy, rice wine, made best from glutinous and semi glutinous varieties. Virtually no ritual would be proper without it. Propitiation of the ancestral spirits, so important to the well-being of the community and the individuals who compose it, would be seriously incomplete without the offering of tapuy to the dead. Fully one-fourth of the total land area devoted to rice is given over to the production of glutinous varieties, even though they are low-yielding' (Barnett 1969). Aside from providing a rationale for increasing rice diversity, Iskandar and Ellen (1999) showed how religious beliefs are entailed in the rejection of modern varieties among the Baduy peoples in the Javanese uplands: the Baduy have maintained their swidden (forest fallow) farming and traditional rice landraces in spite of the mass introduction of modern varieties largely because their form of agriculture has great religious significance, rice landraces are essential to the performance of rituals and feasts related to the agricultural production cycle and consumption. The Baduy resist cultural assimilation in part through their religious beliefs.

It is misleading to simply equate religious beliefs and conservation ethics with SES resilience, or to argue that traditional peoples are 'environmental stewards' because of these beliefs. Religion and rituals may or may not provide the rationale or the values that tend to develop and maintain agrobiodiversity or ecosystem resilience. There are also many cases where certain religious beliefs lead to unsustainable practices, both because they are not consciously developed to guide practical action and because religious beliefs and rituals do not change in tandem with ecological, economic and social change, but may lag behind. Nevertheless, religious beliefs clearly do change with changing conditions. In any case, religion represents only one set of many different variables that guide human action (Moran 2000, Sutton and Anderson 2004, Wilk 1996). Nevertheless, there is a substantial body of evidence that spiritual beliefs and 'conservation ethics' are closely interrelated in SESs that have proven to be resilient (see e.g. Berkes 2004, Turner 2004). Many spiritual beliefs are inseparable from ways in which traditional people value and understand agrobiodiversity and ecosystems, and form one of the axes of ***Traditional Ecological Knowledge***, which is dealt with below.

3.5.3 Traditional Knowledge: Its Transmission, Distribution, and Erosion

'Traditional' knowledge, 'local' knowledge, or 'indigenous' knowledge are all similar but contentious concepts, essentially because each adjective has something wrong with it. 'Traditional' is wrong because it 'implies timelessness, whereas knowledge is ever changing and dynamic'. 'Local' is wrong for much the same reason that 'indigenous' is wrong: knowledge has many sources and is continually exchanged; new knowledge is adopted, adapted, tested, rejected, tested, and 'hybridised' (two ideas are fused and become, in the process, a new idea). Mass media, extension services, in- and out-migration, travel, trade, social visits, formal education, and now even the Internet all move ideas around not only SES but as well around the globe (Sillitoe 2002). What each of these concepts does try to capture, however, is the fact that most of the knowledge in SES is not derived from books or through formal education: it is culturally and ecologically contextualised (embedded in 'systems of meaning' and specific ecological contexts); encoded in language and symbols rather than in texts (although some is also written, the interpretation of such texts is often very localised); and transmission occurs through a multitude of means, particularly oral (e.g. stories, songs, myths, conversation) and also through demonstration and learning-by-doing (Richerson & Boyd 2005).

To be consistent with the scientific literature on SES, we prefer the term traditional ecological knowledge (TEK) to refer to the nexus of knowledge, practices and beliefs that are related to the ecological components and processes that emerges from the complex interactions within SES (Berkes 1999). Scientists who are concerned with cultural evolution consider that ***humans accumulate TEK*** in much the same way as scientists accumulate knowledge: through trial and error, experimentation, learning-by-doing, imitation and instruction, except without the same theories and without lab equipment. TEK is seldom the product of individual inventors, just as tech-

nologies are likewise seldom the product of single inventors: small, incremental steps in knowledge lead to major 'discoveries'. Knowledge at times also needs to adapt quickly to shocks or rapidly changing circumstances. However, scientists also recognise that, 'despite the attention directed towards documentation of these [knowledge] systems and approaches to conservation…we still have a limited understanding about their development, evolution and transmission over time and space' (Turner 2004).

Turner (2003) described the breadth of indigenous women's TEK in the Pacific Northwest of the US and Canada (Box 3.5). This work is unusual because there is no research that thoroughly and explicitly documents the breadth or depth of TEK for any society. This is because it is impossible to accomplish, not only because of the multiple domains of knowledge that are evident (see also Table 3.3), but as well because knowledge is not distributed evenly within communities (see below). Further, ***knowledge transmission depends on the continuity of social relations over time,*** and transmission often depends upon specific groups and individuals and their social networks, rather than on 'the community' as a whole. Considering that knowledge is essential to human survival and cultural continuity, it is not surprising that knowledge transmission does not occur randomly: social mechanisms (which can be considered as another cultural institution equivalent to an educational infrastructure) ensure not only that knowledge is transmitted from generation to generation, but as well as that innovation and creativity can arise and can be fed back into the 'cognitive system,' or 'system of meaning' (see Table 3.3) (Berkes 2004, Davidson-Hunt 2003, Puri 2005, Turner 2004). For example, elders (as individuals or as a group) are often invested with the responsibility and authority, to 'pass on' knowledge to younger members of a tribe or clan; these are seen as the 'wise ones' and it is to them that people turn for guidance when things go awry; it is also these people who can encourage, admit, or reject innovations.

Whether or not such individuals or groups exist in a particular society, ***knowledge is distributed unevenly*** within communities. It is by now well established that factors such as sex and age differences, subsistence or livelihood strategies, positions of power and authority, specialisations, individual competency, geographical origin, residence, ethnicity, religion, occupation, educational level, and wealth status all may influence who has what type of TEK, and by whom and how knowledge is transmitted (see e.g. Alexiades 1999, Boster 1985a, Howard 2003, Pfeiffer & Butz 2005). Until recently, in much scientific research, there was a strong tendency to overlook the fact that knowledge is distributed unevenly. One common assumption was that all people from a particular community had the same knowledge, or that 'farmers' or 'forest users' all had the same knowledge, which was based on the idea that they were all using the same resources in the same way. Another assumption that was often made is that 'experts' hold the most knowledge, so that, for example, if one wants to know about medicinal plants and healing, specialist healers (such as shamans) should be the key informants. However, many studies show that lay persons (e.g. mothers) have an extensive amount of medicinal plant knowledge, and that this knowledge is different from that of specialists because mothers treat different illness which do not require specialist treatment, or because they do not have direct access to spirits and therefore must use more plants in comparison with shamans, who may use magic in healing even more than they may use plants. The failure to recognise and understand intra-community knowledge distribution leads to many errors in science and in practice (Howard 2003, Pfeiffer & Butz 2005).

Boster (1985a, b) demonstrated unequivocally that knowledge distribution and social structure are interrelated, as have a growing number of more recent studies that have been focused on this issue. While at societal level a corpus of knowledge can be said to exist that could be likened metaphorically to a body of Western scientific knowledge around a discipline, just as in Western society, not everyone has equal access to this corpus: variation in knowledge 'can be explained by factors that reflect differential knowledge: age, sex roles, and opportunities to learn', which depends on one's position in the social structure:

> *An individual can be considered as having a number of identities: a member of a society, an actor in a sex role in that society, a member of a household, and an indi-*

BOX 3.5 | North-western North American aboriginal women's base of knowledge and practical skills
(Turner 2003)

- Familiarity with ecosystems, geographic features, climate, moon cycles, tides, winds, currents, and weather;
- Understanding of ecological succession, habitats and lifecycles of resource species, and of ecological indicators of these phenomena;
- In-depth knowledge of names and categories of culturally important plants and animals, and vocabulary relating to working with various resources;
- All manner of survival skills, including knowledge of wilderness survival, navigating in stormy or foggy weather, or tracking routes through rough terrain; recognition of poisonous plants and how to treat poisoning, and general first aid, midwifery, and childcare;
- Techniques required for harvesting and processing foods, materials and medicines, including dehydrating, smoking, cooking, storage, and weaving baskets, mats, bags, and clothing using a variety of techniques, materials, and designs, dyes, and tanning agents;
- Knowledge of all kinds of plants, their habitat requirements, distributions, growth cycles, means of reproduction, variants, and associated plant and animal species.
- Knowledge of wildlife foods and habits, including predatory animal behaviour and where to search for root and seed caches of small mammals;
- Knowledge of various types of tinder and fuel and where to find it, and of how to kindle and maintain a fire;
- Knowledge of nutrition, foods, and famine foods, including quantities required for preservation, food safety, and potential toxicity of foods;
- Knowledge of the preparation, safety, and effectiveness of medicinal herbs; and
- Cultural knowledge and understanding of social protocols, including rules relating to use and proprietorship of resources, privately held and confidential knowledge, family and clan crests, basket designs, songs, names, and dances, and means of teaching, sharing, and acquiring knowledge in culturally appropriate ways.

TABLE 3.3 | Pathways by which TEK may have been accrued using examples from North American indigenous people (Turner 2000)

Lessons from the past	Stories of positive and negative experiences remembered by individuals, recounted within families and communities, or embedded in art, place names and ceremonies
Language	Terms that embody conservation concepts, understandings and teachings, e.g. the Heiltsuk word 'mnaquels,' which refers to 'selectively collecting things outside,' and 'miaisila', which refers to someone whose responsibility it is to be a guardian of certain fish-bearing rivers, or the Nuu-chah-nulth word 'uh-mowa-shitl', to keep some and not take all
Metaphorical sayings and narratives	Symbolic and metaphorical stories also teach lessons about conservation (e.g. Nlaka'pamux story of Old One and the Creation of the Earth)
Lessons from other places	Technologies, products, names, and ideas relating to conservation for environmental stewardship (e.g. the use of fire for clearing; digging and propagation techniques) passed from one community to another through intermarriage, potlatches, trade
Learning from animals	Observations of animal foraging strategies, populations, browsing and predation, behaviours that might engender understandings of kinship and reciprocity (e.g. grizzly bears foraging for edible roots; birds' egg-laying habits; pack and leadership relationships in wolves; bears 'pruning' berry bushes)
Monitoring - building on experience and expectations	Routine observation of seasonal changes, animal migrations, plant life cycles, and berry production brings recognition of expected patterns and ability to detect variation from the norm
Observing ecosystem cycles and disturbance events	Relative abundance and productivity of plants and animals in particular circumstances, both temporal and spatial, can guide people's land and resource management strategies (e.g. successional stages following fire; effects of flooding on salmon migration patterns; relation between moisture and berry productivity)
Trial and error experimentation and incremental modification	Observing the results – positive and negative, intentional or incidental, short term and long term – of people's own activities, such as selective harvesting, or of emulating natural disturbance (e.g. harvesting cedar bark and planks)
Learning by association, extension, and extrapolation	If a practice works in one place at one time, it might work in another place at another time; conversely, if a practice or activity results in negative consequences in one circumstance, it might be avoided at another time or place (e.g. knowledge about harvesting or conserving one type of shellfish, berry or root might be extended to other, similar types)
Elaborating and building sophistication	Gained from all of these pathways, and building up knowledge, practices and beliefs into complex systems of land and resource management (e.g. Heiltsuk berry gardens; Saanich reefnet fishery)

> *vidual. Different amounts of knowledge are shared at each of these layers. A certain amount can be presumed of any adult member of the society. That and more can be assumed as an actor in a sex role. Still more is shared between closely related people. Finally, certain knowledge is unique to the individual. As the difficulty or specialization of [a]…task increases, agreement at all of the layers decreases but not at equal rates. Sharing at the most general layers falls off most quickly. Thus there is an apparent succession in the importance of these layers of identity depending on the difficulty of the task* (1985a).

It is clear that some knowledge is shared, but not all knowledge; the more important a set of knowledge is to everyone in their daily lives, the more likely that it will be shared. For more specialised knowledge, social identity clearly affects personal experience and motivation to learn, as well as opportunities for learning from others.

The distribution of knowledge is in part a reflection of the division of labour and specialisation: among the Aguaruna manioc cultivators whom Boster studied in northern Peru, women are responsible for manioc cultivation and hold the lion's share of knowledge about manioc diversity (1985b). This is so because manioc is culturally defined as a 'women's crop'. Women are expected not only to cultivate manioc, but to maintain manioc diversity and transmit knowledge about manioc to other women through their kinship networks. Chiefs' wives are those who are expected to have the greatest knowledge and hold the most manioc varieties that can be used to replenish lost planting stock or to share, so chiefs marry women who have great expertise. Underlying this division of labour are values and belief systems that prescribe the type of activities and responsibilities that are appropriate for different groups of people, as well as with whom people of different social positions can appropriately interact. Zimmerer (1991), for example, found in the Peruvian Andes that Quechua women hold the greatest knowledge about potato and maize diversity. The explanation for women's superior knowledge can be found in their role as the managers of seed (men are not permitted to manage seed or to enter seed storage areas), which has its roots in Andean cosmology:

> *the feminine and divine element represents the fertile mother: in Quechua…all of the plants that are useful to humans are venerated under the names of Mother: Mama sara (maize), Mama acxo (potato), Mama oca (Mama cocoa), etc…The belief in this relation between women and seeds is coherent with the tradition of Andean thinking in terms of a dual concept of reality: the duality defined by the principles of masculine and feminine…'seed' also refers to…semen…[providing a metaphor] between the 'seed' that the male deposits in the womb and the seed that is sewn in the field, collected, and later deposited in the home* (Tapia & de la Torre 1993).

Descola (1994) also found that, among the Achuar in Ecuador, religious and practical knowledge is 'a closely guarded secret' which is 'probably the most precious possession a mother can transmit to her daughter' (Ibid). It has very often been found certain types of knowledge are purposefully not shared, kept secret, or shared only with very specific groups (Howard 2003). Just as in post-industrial societies, knowledge in traditional societies is used to confer status, manipulate social relations, gain material advantage, and maintain control over certain aspects of one's life. Knowledge is an integral part of power, authority and social status. If someone's knowledge is taken away, or lost, their status in their society is also lost, as is their ability to function. The distribution of TEK within societies cannot be understood without reference to belief systems that legitimise and mediate relations of prestige, power and authority. These social relations and the ways in which they are manifest may be relatively transparent and clearly demarcated by exclusive occupation of prestigious social positions, or they may be much more subtle, embedded in language and in rules about the production and exchange of goods, such as medicinal plants and medicines or planting stock. We return to this below when discussing traditional rights to agrobiodiversity.

If people of different sexes, ages, caste groups, or clans relate differently to different groups of people, that is, they have different social networks, then their 'knowledge networks' also differ, which affects the type and quality of knowledge and knowledge transmission. Different people also have different access to formal and exogenous knowledge. In many societies, for example, women, members of lower castes, and ethnic minorities often have less access to exogenous knowledge sources since they receive less formal education, have less contact with extensionists and other government agents, may be physically isolated or less able to leave their communities, and may be less able to speak languages or dialects other than their own. They may, for these reasons, also hold the majority of traditional knowledge.

Homegardening and swidden gardening knowledge and knowledge transmission provides one example of specific types of TEK associated with social relations and land use forms. Homegardening knowledge may incorporate more TEK in comparison with agricultural production, since homegardens are far less likely to be the subject of extension programmes, are more likely to contain higher amounts of local agrobiodiversity and to be ecologically-specific, and are more oriented toward subsistence and cultural uses. The greater species diversity in homegardens implies greater breadth of knowledge about plant requirements and uses, plant associations, and the creation of micro-climates through plant communities. Cultivation is very often continual, where dozens of species grow and mature at different rates, whereas some species are cultivated in continuous cycles. The scale of homegardens and intensity of management imply that different cultural techniques are used for soil, water and plant management in comparison with agricultural fields (Howard 2006, Lok 2001). As a human-designed landscape, homegarden planning is as strongly related to the outputs desired as any factory system, except that these are 'factories' that may produce hundreds of different items intended to fulfil a large number of household needs in a diverse range of areas: for food, fibres, medicinals, fodder, fuels, ornamentals, rituals, etc. Planning must combine an understanding of vegetative cycles, of perishability and processing and storage characteristics, and of timing and quantity of demand, including the needs for ingredients for specific dishes and / or medicines and substitutability of those ingredients, and of the need to meet nutritional and medicinal needs of households whose composition (and therefore nutritional needs of its members) also changes over time (Finerman & Sackett 2003).

The complex knowledge that is entailed in homegardening is gained experientially as well as through lifelong interactions between homegardeners and their protégées that begin at a young age. Several studies show that this knowledge is transmitted largely among women and then principally among closely related kin (Boster 1985a, Descola 1994, Greenberg 2003, Hays 1974, Ireson 1992, Keys 1999). Keys (1999), who researched agricultural knowledge among the Guatemalan Kaqchikel, showed that 'Women educate children through the chores of the garden. They teach how to use farm tools, what plants need to thrive, and how to manage crops, especially through weeding and harvesting... Education in the garden takes place regardless of the father's input,' and boys have already learned the basic concepts of cultivation before they accompany their fathers to work in agricultural fields. Hoffman (2003) also found that not only was gardening knowledge transmitted between mothers and daughters, but plant material as well: knowledge, materiel, skills and practices are often part of a 'package' of cultural and physical capital that flows among women and between women and their offspring.

It is well established that the loss of such knowledge is occurring rapidly, is part and parcel of the loss of cultures and languages, and it coincides with the loss of motivations and capacities to maintain traditional SES. This is a process that the GIAHS Programme must pay particular attention to, both in order to promote dynamic conservation of such TEK, and because certain GIAHS interventions may create conditions for knowledge loss (see ***GIAHS Principle 9***). Turner mentioned some of the reasons that cultures and their TEK are being lost across generations among indigenous peoples of Northwest North America:

> *Many have become marginalized within nation states, although most have remained distinct linguistically and culturally, and continue to define themselves in relation to their home environment…the survival of many indigenous cultures is severely threatened by insensitive economic development, by coercive education systems, by assimilation into the modes of production and inexorable movement toward the market economies of the dominant society, and by the escalat-*

ing ecological destruction of peoples' homelands and resources…traditional knowledge among younger generations, in most indigenous groups, has inevitably diminished as assimilation and environmental change have escalated (Turner 2000).

Research on homegardening TEK provides context-specific reasons for TEK loss. One that is frequently mentioned is assimilation into a dominant culture through education and migration, so that younger generations learn less about plants and homegardening (Angel Peréz & Mendoza 2004, Benjamin 2000). Keys (1999) point outs that particularly young Guatemalan women are affected by off-farm employment in textile factories which leaves them with no time for homegardening, and Hoffman (2003) stresses not only off-farm employment, but as well migration and participation in formal educational systems that denigrate women's traditional gardening knowledge, which leads to loss of TEK. While formal education can bring many benefits, it is very often not oriented toward the realities of ethnic minorities, traditional or indigenous peoples, not presented in their own languages, and is denigrating of traditional peoples' ways of life, modes of production, knowledge or beliefs (Turner 2000, Hoffman 2003). GIAHS activities that support increased attendance of children in formal schooling must be aware of the potentially damaging consequences for TEK and the knock-on consequences for maintaining GIAHS (***GIAHS Principle 9***).

GIAHS Principle 9
There must be a concerted effort to counter the loss of traditional ecological knowledge, which nearly everywhere is occurring rapidly, and which coincides with the loss of motivations and capacities to maintain GIAHS. Formal education and training must be oriented toward the realities of GIAHS stewards, presented in their own languages, and respect their ways of life, modes of production, knowledge and beliefs.

3.5.4 Language, Aesthetics and Agrobiodiversity

As discussed earlier, linguistic diversity and biodiversity are directly interrelated, although the precise mechanisms and relations are still a subject of much investigation and debate (Maffi 2005). Irrespective of the conclusions of such debates for global biological and cultural diversity, there is considerable evidence that language, knowledge, and management of agrobiodiversity are interrelated within specific SES. It is only necessary to imagine Western medical science without any specific vocabulary for anatomy, physiology, biochemistry, etc. to realise that language is the principle vehicle through which knowledge is accumulated and transmitted. In traditional societies, 'systems of meaning' are manifest in language and transmitted orally; TEK is 'written' only in the dictionaries and thesauri of native language terminology. Kokwaro (1995), for example, pointed out that, even though Ethiopians have had their own written language for more than 2000 years, 'Knowledge of traditional medicines is handed down orally by medical practitioners, parents, elders, or priests and priestesses..' This oral tradition has all the advantages of a living culture, being continually enriched' but, because it is orally transmitted, it is also vulnerable, and can be easily lost or distorted. The erosion or disappearance of language may mean, among many other things, the loss of capacity to classify, understand and talk about important agrobiological resources and practices. Traditional societies have managed to preserve extremely detailed knowledge of biological resources and relationships despite rule by what are often foreign-language speaking elites, and one means of assessing knowledge loss is 'by analyzing patterns and rates of change or loss of such terminologies by native speakers…Relevant measures include total numbers of terms for plants and animals in native vocabularies, ratios of over- and under-differentiation of ethnobiological nomenclature, and patterns of borrowings from intrusive languages employed by colonial, state, or commercial powers' (Hunn 2001).

Language, however, is not simply an encyclopaedia or dictionary of TEK, or a conveyor of utility. It is a vehicle to convey cultural identity, history, social relations, spirituality, humour, and aesthetics. Sadiki et al. (2007), who recently reviewed the literature, noted that 'The names farmers give to their traditional varieties or landraces are fundamental to their very essence and use'. It is unsurprising that traditional societies do not have much vocabulary, or ways of talking about agrobiodiversity, that is purely technical. Studies that investigate in-depth the development and maintenance of landrace diversity have found that, while agroecological adaptation and utility (such as culinary and storage characteristics) are important in landrace selection and classification, linguistic and aesthetic qualities are often more important in determining the amazingly large amount of diversity present in agricultural fields (Box 3.6).

Aesthetics are also very important in the management of agrobiodiversity. In a seminal study, Boster (1985b) found among the Aguaruna Jivaro of northern Peru, who have developed an astonishing diversity of manioc (*Manihot esculenta*) landraces, women cultivators identify cultivars on the basis of leaf shape, petiole colour, and stem colour. The capacity to distinguish cultivars on the basis of the senses - sight, taste, and smell - is necessary for selection to occur based on utility. 'The number of cultivars that can be maintained by a cultivator is constrained by the ability to observe and remember perceptible differences among the cultivars …It is more likely that women accept a cultivar that 'fills a gap' in the continuum of existing cultivars rather than selecting one that is extremely similar. Women have thus bred cultivars until there is one continuum of just barely perceptible differences, e.g. the entire 'rainbow' of leaf colours. Women breed to fill this continuum because they can, and because in so doing they fulfil their social duties and achieve status in their communities.

Shigeta (1996) provided another case study that confirms how the creation of landrace diversity in ensete (Ensete ventricosum) in Ethiopia is related to both language and aesthetics. The Ari have more than 100 vernacular names for ensete landraces, 78 of which refer to distinguishable types (excluding synonyms, as well as dialectal and geographical variants). Only 18 of 78 names seem to have meanings: five are derived from wild plant names and six refer to kinds or tastes of food. At times the names refer to locations, ways of propagating the types, or personal names (such as of people who are considered to have developed or introduced the landrace). As is the case in the Andes and among the Aguaruna, 'People recognize variation in the ensete population according to

BOX 3.6 | The language and aesthetics of cultivar diversity in the Peruvian Andes (Zimmerer 1996)

Zimmerer (1996) found in the villages in the Peruvian Andes that he studies that 'Classification, identification, and naming, processes filtered through the medium of language, comprise cornerstones of the vast "local agricultural knowledge" on which the production of diverse native potato cultivars rests'. 'Farmers tagged a unique name to each landrace – all seventy-nine of the potato types, all 180-odd subtypes, and so on in each of the diverse crops. Pervasive naming of every tuber and grain clashed with the lack of a name for the term crop in general, a rubric that was missing from their Quechua vocabulary. The complete christening of landraces by farmers, however, helped communicate the know-how for working their mountains of diverse crops…Naming kindled a lively interest in the character of landraces. Careful deliberation, unwavering curiosity, and jocular competitiveness inevitably enriched the simple acts of landrace identification and naming'. For example, naming of hybrid seed incorporated references to human racial mixing in the Andes; naming of wild crop relatives referred to wild animals such as the fox. Seed anatomy is discussed in terms of analogies with the human body, such as 'eyes, ears, nose, face, skin, head, heart, veins, and other body parts…Choice seed typically showed a beautiful face…or flowerlike eyes,' where one farmer 'coined precise terms for liplike eyes and eyes about to sprout that pinpointed the exact traits that left a tuber unsuited for seed'. Farmers 'discussed their farming with language drawn from an immense agricultural vocabulary and a rich array of metaphorical and other figurative expressions. The cultivators' artful use of farm language created the expressive verbal medium for knowing diverse crops. Their large lexicon of metaphorical references granted an impressive range of referents for the cornucopia of agricultural objects and processes that established a world center of crop diversity…The farmers could refer to the familiar terrain of the body to express nuanced observations of their diverse crops. Less intimate or less plentiful linguistic devices would not have so fully accommodated the specialized farm knowledge of the Quechua people'. Cultural and moral aesthetics define the majority of cultivar diversity in the communities that Zimmerer studied. Potato landraces are classified into use categories, where most fall under a single use category, 'of which the largest were the boiling potatoes', each of which fit into a specific farm space (i.e., boiling potatoes fit into lower hill areas, freeze drying potatoes into upper hill areas). However, most varieties fall under the 'boiling potato' category (71 or more landraces, more than 90% of the regional total). Why, then, are so many varieties produced? 'Farmers decided the number of landrace numbers in a boiling potato field after the harvest when they chose the seed for sowing the next year…Size rather than the sort of landrace was…the main desideratum at first…They also seized the extra large…for the purposes of gift-giving as well as proud display and special eating', but the remaining landraces were selected in mixtures. Scientists had believed 'that nothing less than precise landrace-by-landrace selection was needed to fit each unit to a matching series of specific environments both between and within fields. Farmers were thought to handpick the sums of diversity', but this was not the case. 'On the contrary, farmers…governed the selection of boiling potatoes with general desiderata…[one farmer] voiced it this way: "The good seed tubers are the ones that appear in the harvest", that is, they left the selection to the agroecological outcome of the harvest. Hand selection did occur, however: 'Farmers were especially keen to finger a few of the most choice sorts…because these landraces promised an unmatched culinary aspect, such as extra flakiness, sweetness, or fast cooking', although surprisingly, 'the most preferred variants of boiling potatoes were actually the rarest…in reality, indirect selection and general criteria of production' accounted for most landrace diversity. ' A subtle process of selection did in fact steer the diversity and the composition of boiling potato fields…Following local aesthetic canons, they especially judged the conspicuous contrasts within the striking potpourri of colors and shapes in their tuber piles. They then judged whether they had garnered the right diversity for the next planting'. This did not lead, however, to random levels of diversity. 'Indeed the farmers shared a remarkably common vision about the amount of landrace diversity that was fit for an individual field. It was their culturally shared vision that inspired the uncanny similarity of diversity levels across the boiling potato fields of the region…[which is] part of being a Quechua farmer'.

their classificatory rules and judge or select the necessary observable (perceptual) variations from overall variation.' Landraces are classified by pigmentation of the plant body, and then by grouping secondary characteristics: a) morphological characteristics in outer appearance; b) life cycle characteristics (only observable over the long-term) and means of propagation; and c) use and taste. Wild ensetes are also often given names and are protected ritually, are prefaced with the term 'wild' and then are given names of cultivated landraces. The Ari do not have a concept of selecting 'the best' cultivars because they 'place primary significance on the characteristics which are not directly related to practical use. These characteristics are mainly morphological'. If only their practical uses were considered, Shigeta observes, 'these landraces would be reduced to a few superior ones'; in fact, people preserve even minor landraces that have no apparent practical use, which also ensures the introduction of wild populations. The main driving force of landrace diversification is 'human observation of morphological differences and naming. The Ari say that they maintain great diversity of ensete landraces because it is 'custom' or 'good'; they do not say they do this for utilitarian reasons, although there are many criteria that they do employ, such as cooking styles, tastes, and the strength of leaves. Again, formal schooling or training in non-local languages and linkage to broader political and economic institutions may directly or indirectly lead to erosion or loss of local language and, with it, the loss of TEK, and will have inevitable consequences for culture and identity.

3.5.5 Social Status, Social-ecological Systems, and Agrobiodiversity

No objective definition of 'status' is possible: ***social status*** is culturally, historically, and contextually defined, and therefore must be understood within the societies in question. Social status is derived in part from one's position in the social structure (one's 'social identity'), which determines the importance of particular resources and institutions to particular people within it. Social status determines one's place in a SES: access to resources, capacity for decision-making, and motivations. The social status of individuals is very generally determined by culture and social structure, and also by individual capacities and motivations. People are constrained in their abilities to make decisions and to act in accordance with their social status. It is not possible in this context to go into an in-depth discussion of social status, social relations, power and political processes in traditional subsistence oriented societies, in large part because political processes and power are deeply embedded not only in local history, but as well in regional and even global history. What needs to be said is that ***power, influence, and social status are interrelated, that they are embedded in SES, and that they also are determinants of SES resilience***. Political instabil-

ity, conflicts, great inequalities, social exclusion, and increasing processes of social differentiation (into classes, sub-cultures, dispossessed groups) are all features of many traditional SES throughout the world. Indeed, the processes of forming cultural groups and identities have often been traced to the need that people have to unite against other groups. Seen through the lens of cultural evolution, 'Without feuds and conflicts, social groupings would be much more atomistic and isolated from one another than they are' (Keesing 1998).

Social differentiation and political instability within traditional SES are generally increasing because of all of the driving forces mentioned in the quotation of Turner (2000) above, and due to the negative drivers discussed in Chapter 5. With increasing social differentiation, social relations of reciprocity and support for disadvantaged (e.g. handicapped, the ill, the elderly, women heads of household, minorities, etc.) are also breaking down. Some traditional SES are highly unequal and generate high levels of poverty and depravation among specific groups, as can be seen, for example, in caste systems. Such SES can be seen therefore as highly unstable, since the struggle for human rights, and against all forms of discrimination, has been taken on not only by oppressed peoples themselves, but as well by nation-states and by a very large number of regional and world-level organisations and institutions. People who live in traditional SES are themselves most often the subjects of discrimination and disempowerment vis a vis outsiders, so that if there are people within such SES who are disadvantaged vis a vis others in such systems, their positions are very poor indeed.

The 'poor', or the 'poorest of the poor' are often accused of degrading the environment. Much research shows that the poorest people, who are often landless or have insufficient access to land or other resources to sustain a livelihood, are more reliant on 'wild' natural resources and common land areas for fuel, food and other basic needs, and for income generation. However, many other studies have shown that it is better-off groups who have sufficient resources (e.g. labour) to use such resources on a large-scale: the relationship between poverty and dependence on such resources is indeterminate, and locally specific. Box 3.7 shows some of the dynamics that generate poverty especially among landless and female headed households in one region in the highlands of Ethiopia that, until about three decades ago, was part of one of the most resilient SES known, having a history of at least 1000 years. Understanding such social relations and divisions is essential if communities are to be able to sustainably manage their resources; without resolving the factors that underlie the generation of poverty, including social inequality within such systems, system resilience is severely compromised.

Further, it is clear from the example in the box that not everyone's interests within a community always coincide. The interests of livestock and land owners may be to strongly support the status quo in communal resource management: in the case of highland Ethiopia, they also make up the lion's share of members of communal organisations that manage resource use and set rules (Howard and Smith 2006). However, women, and especially female headed and landless households, use communal resources in other ways, especially for fuelwood, medicinal plants, fibres, aromatics, and wild foods, and many of their needs are not being met because their access to such resources is severely restricted by these community institutions where they have little influence. Serious conflicts may emerge and may be resolved or simply suppressed by institutions, whether endogenous or exogenous. Means to resolve conflicts, and to ensure representation of less powerful, poor or vulnerable groups, is essential to adaptive management, and the support of more powerful groups as well as of poor or vulnerable groups, must be enlisted in this process. It may also be that conflicts cannot be resolved by recurring only to resources within the community: this is when outside support may be crucial.

In subsistence-oriented SES, land ownership is a means to produce and control agrobiodiversity, but it is certainly not the only means (see the following section). It stands to reason, then, that ***well-being and social status are strongly related to access to agrobiodiversity***, knowledge about it, its management, and the contributions that different groups of people within particular societies make to subsistence and to the perpetuation of such knowledge. Social relations determine the distribution of knowledge about agrobiodiversity, the distribution of the costs and benefits of agrobiodiversity maintenance and use, and the pursuit of social status has been found to be a factor motivating individual behaviour in relation to willingness to engage in collective action (Froemming 1999). The relationship between agrobiodiversity management and social status has been little addressed in the literature on agrobiodiversity, but it has been addressed in other research.

Status can be related to agrobiodiversity in subtle ways that are not readily observed by outsiders. Descola's (1994) work highlighted how researchers often mistakenly assume that the agrobiodiversity that swidden gardeners create or maintain is due to ecological or economic motivations. He found, rather, that it is related to the ways in which people gain social status in their communities. For the Achuar, it is a 'point of honour' for women to cultivate large swidden gardens. The garden diversity evident, particularly in tubers, cannot be attributed to nutritional or culinary needs since 'Men - whose attitude openly encourages their wives' agronomic capacities - recognise by taste alone only a very low proportion of the varieties of manioc, yams, or sweet potatoes.' Nor can it be attributed to the need to reduce species-specific diseases, since only one serious manioc disease is recognised, and only a few plants are usually affected. Rather, 'A woman who successfully grows a rich pallet of plants thereby demonstrates her competence as a gardener and fully assumes the main social role ascribed to women by proving her agronomic virtuosity.' Among the Aguaruna, Boster (1985b) reported that women select such variation partly to demonstrate their agronomic virtuosity. Indeed, among Amazonia Amerindians in general, male prestige is often related to ceremonial exchange of food products such as manioc beer, and women gain prestige as producers of the crops that men exchange (Descola Ibid, Heckler 2004). In the Ecuadorian Andes, people observe each others' homegardens and from these infer information about the owners' wealth status, occupation, and market orientation, as well as health status. The abundance and diversity of a garden, which are virtual 'indigenous medicine cabinets' containing hundreds of species, is an important source of status for women who develop reputations as skilled gardeners whom people continually approach for planting materials and advice, and to exchange produce. Agrobiodiversity management is linked to the roles that women

BOX 3.7 | Social-ecological dynamics and the generation of poor and destitute female headed households in the highlands of Ethiopia (Howard & Smith 2006)

People in the highlands of Ethiopia have cultural traditions and a livelihood system derived from plough-based cereal production, communal grazing lands and forests and wild plant use that have been in place for more than a thousand years. Over the past few decades, this system has been subjected to repeated external shocks such as drought and civil war. These shocks, combined with the breakdown of traditional natural resource management systems which occurred as Governments imposed top-down conservation measures and land reforms, have led to very high levels of poverty and food insecurity, deforestation and devegetation. Further, the poorest of the poor are female headed households, which represent up to 40% of all rural households. Recent research in one highland community showed that many factors are involved in the generation of high numbers of very poor female headed households. Under the traditional, lineage based tenure system, called the 'rist system', new households gained land to farm both from their parents and from the community, by clearing communal land. Land could not be sold because it belonged to the lineage; land rights were basically usufruct rights. Both men and women were expected to bring land and livestock into the marriage and, in case of divorce, assets were supposed to be divided equally. Population growth, together with the increase in livestock populations, put increasing pressure on this system since it led to farm fragmentation and decrease in communal land resources. Land reforms essentially perpetuated such a system, except it was now the State, rather than parents or traditional community institutions, that allocated land to households, and periodically such usufruct rights to land were reallocated. Land markets were prohibited, although land could be rented or sharecropped. Over time, average agricultural holdings decreased to .5 ha, which is insufficient to sustain a family, until the point where land reallocations had to end. Communal land was in the first instance declared to be State property. Traditional local management institutions, which had previously regulated grazing land and local forest use and management, were largely disbanded. Communal land was either enclosed by the State for conservation purposes (woodlots and restricted grazing), or became open access – effectively without regulation. State enclosures were not respected by local populations, and it took another government, which came into power only after a long civil war, to implement a regime that returned some of the power for local resource management to the communities, although much regulatory power is still retained by the State.

There is now a large and growing number of landless households, and many people are starved for land. Families do not have enough land to allocate it to their children (total fertility is around 6.8 children per woman). Men must strategise to obtain access to land when they marry, and to increase their holdings over time. One of the principle ways to do this is to sharecrop land in from people who have land but cannot farm it themselves. Women are generally not able to farm their own land, in part because they are culturally proscribed from ploughing land with oxen, and in part because they do not have access to oxen or to enough labour. The main source of land that men can sharecrop in is land pertaining to female headed households. Many men have found that they can gain access to additional land by marrying women who have some land (from parents, or from the State), and then divorcing them. Upon divorce, men keep the lion's share of their ex-wives' land and livestock, and all of the household's oxen. Their ex-wives, who are usually unable to farm the land that they receive after divorce, often have no option other than to sharecrop it out to their ex-husbands. The ex-husbands then remarry other women who have land. Through this process, and also by having children out-of-wedlock (since they also sharecrop the land of women with whom they have children, but haven't married), men are able to obtain enough land and livestock to support their current households; other than sharecropping in their ex-wives' land, they generally don't support them in other ways. Divorce is very frequent, and gender relations are such that women who are not married are very disadvantaged. The number of female headed households may be rising. Female household heads are often so destitute that they have no option other than to become commercial sex workers. HIV/AIDs is spreading rapidly throughout the region. These women are socially stigmatised, excluded, and the poorest of the poor. Development aid barely reaches them and is more oriented toward landed male heads. Female headed households make much greater use of common land resources for food, fuel, fibres and other basic needs. But female household heads cannot use grazing land and timber resources, which are the major common land resources, because they have neither the livestock, nor the labour that is required, and they also don't have access to cash with which to purchase raw materials sold in markets or from communal woodlots.

are expected to perform as family caretakers and household representatives. Homegardens reveal:

> *the extent of the owner's commitment to family well-being…The presence of a garden rich in…[medicinal plants] epitomizes her exertions on behalf of kin, and her proficiency as primary health provider; a spacious and productive garden filled with medicinal plants suggests that the family, too, is prosperous and fit… Gardens themselves [are] a manifestation of the community's most deeply held values: autonomy, status, religious piety, and personal investment in family…A*

garden demonstrates a woman's freedom from dependence on products from neighbors and commercial vendors; her fiscal standing evidenced by her ability to expend valuable land on a garden; her faith displayed by a sacrifice of resources to adorn the church; and her industriousness and devotion to family exhibited by her investment in plant cultivation (Finerman & Sackett 2003).

It is clear that the status provided through agrobiodiversity management is not confined to visible characteristics of agricultural fields or gardens or the skills of their owners. Many studies show, for example, that ***much produce that is not consumed is much more commonly given as gifts or exchanged with others rather than sold in markets***, and most studies also report that the vast majority of planting materials that are present in traditional SES that are not self-provisioned are acquired through non-monetary gifts and exchange, which also applies to field crop production (see e.g. Nuiten 2005, Shrestha 1998, Wright & Turner 1998, Zimmerer 1996). Such exchanges are not only important in terms of the products or planting materials that people access: they are just as important as a means to create and maintain social networks. Gift giving and exchange of planting materials often help people to maintain kinship and neighbourly ties with people both within their communities and in distant places, and provide opportunities to accumulate knowledge or seek help when crises strike.

The implications for the GIAHS Programme should be obvious: as discussed in Chapter 2.3, production of agrobiodiversity for status reasons may sometimes not make much economic sense, and it may lead to over-production which can have degrading effects on the ecosystems in question. Introductions of new agrobiodiversity, or agricultural and other commodities, may be fuelled by status-driven motivations rather than economic gain, and may involve trade-offs for traditional social relations (see Chapter 4.3).

3.5.6 Property Rights and Management of Agrobiodiversity

Another cultural institution that is of great importance to SES resilience and agrobiodiversity conservation is that which Western science refers to as 'law', or systems of ***property rights***. Economists, conservationists and anthropologists all tend to agree that ***property rights institutions are among the most important in determining whether resources can be managed sustainably and conservation goals can be met.*** One of the most important negative drivers that has been repeatedly shown to undermine SES resilience is the disruption or breakdown of customary property rights systems through the imposition of colonial legal regimes, State-led land reform programmes, forestry regimes, water management systems, conservation initiatives, force privatisation or collectivisation of resources, and other interventions that impose new sets of rules about who can use and manage resources, which have largely ignored local rights regimes or set up conflicting or contradictory sets of rules enforced at different levels and by different institutions. Property rights must also be linked to the ability of people to meet their livelihood needs; if they are not, they are not likely to be upheld in the longer term. Like all cultural institutions, property rights institutions vary from culture to culture, context to context, and over time. Indeed, they are so often changing that some have argued that property rights need to be seen not as things, but as processes.

Property rights systems structure the way in which wealth (in whatever form) can be acquired, used, managed, and transferred. Biological resources are an important form of wealth. As is the case with all other property rights, claims to use, manage, control, and transfer germplasm, plants, animals, insects, etc. that are considered to be valuable resources are best conceived as a 'bundle' of rights and obligations. Property relations, as a basic organising constituent of social relations, are highly complex, multi-layered, context specific, and are continually contested and changing:

to focus on property immediately entangles one in a long history of deeply intertwined conceptual discussions, social philosophies and ideological justifications of past, present and future property regimes. This is not surprising as property concerns the organization and legitimation of rights and obligations with respect to goods that are regarded as valuable…Property is of central importance in all economies, but it cannot be reduced to 'the economic'. Property is always multifunctional. It is a major factor in constituting the identity of individuals and groups. Through inheritance, it also structures the continuity of such groups. It can have important religious connotations. And it is a vital element in the political organization of society, the legitimate command over wealth being an important source of political power over people and their labour, no matter whether we think of domestic or kinship modes of production, capitalism or communism. Property regimes, in short, cannot easily be captured in one-dimensional political, economic or legal modes (Benda-Beckmann et al. 2007).

What is considered to be a 'good regarded as valuable', or a resource, of course varies from society to society, from place to place, and over time. Oil was not considered to be an important resource (rather, where it appeared it was considered to be a nuisance) until the advent of the internal combustion engine; a particular species or landscape may be considered as a resource or not; a resource may be tangible or intangible (an idea, a song); a tangible resource may be a resource for intangible reasons (spiritual, aesthetic); and what one person or group sees as a resource may not be a resource to another person or group. Property relations are not only a way to regulate access to and use of resources, as pointed out above. ***Struggles and conflicts over property and the benefits to be derived from property are one of the major driving forces of social and ecological change*** (see Chapter 5 on conflict). Further, there is not one uniform set of property rules or relations: ***legal pluralism*** prevails because not only do formal (e.g. state) and customary tenure systems often exist side-by-side; regulations and reforms in both create many layers of often times contradictory sets of rules, where such rules are interpreted and applied in different ways by different people in different contexts. Even in Western Europe, where property rights are completely codified and where land owners are considered to be 'autonomous' actors with respect to their property, private property rights have been limited and overlain with many different public legal regulations in relation to environmental protection, land use planning, historic conservation, etc. The myriad, overlapping, and at times contradictory set of

regulations governing private land are so complex and multiple that private land owners and States alike are unable to untangle and implement these, and yet there is still an insistence that property is in the private domain and regulated by markets (Ibid).

Because natural resources (land, but also trees, water, air, etc.) often fall into what many Western scientists call ***'common property'*** or 'common pool resources', such property relations are the subject of much scholarly discussion and debate. Economic theory tells us that, when access to natural resources is 'open' (where anyone can use a resource without limit), such resources will be exploited as long as there is immediate benefit to be derived. Open access to common property resources leads to overexploitation and resource degradation, or the 'Tragedy of the Commons' (Hardin 1968). Open access conditions may exist because there are no owners (e.g. as is the case of most of the world's oceans) but, even with formal ownership, *de facto* open access may prevail because owners are unwilling or unable to control access to the resource. Economists generally considered that the only way to effectively regulate resource use was through individualisation of private property rights, or through State control. Because 'common property' was thought to be 'open access', it was considered to be inefficient and ineffective.

This conceptualisation has been largely overturned, since it has been found that ***many traditional common property resource management regimes have been largely effective and sustainable over the long term.*** In fact, certain principles explain why it is (or is not) that common property regimes succeed or fail (see Table 3.4). These principles are based on theories of ***collective action***, which is a 'well-developed branch of political science and decision theory dealing with social choice' that uses game theoretical approaches (Smith & Wishnie 2000). The assumptions are based on rational self-interest, where individuals choose actions that are efficient means to achieve desired ends. People engage in collective action 'when more than one individual is required to contribute to an effort in order to achieve an outcome' and it is in people's self-interest to collaborate (Ostrom 2004). Collective action (or 'public choice') theory is concerned with the ways in which public goods are provided and managed through the collaboration of two or more individuals, and the impact of externalities (such as free ridership) on group behaviour. Such theories attempt to explain individual and collective behaviour irrespective of cultural differences or the type of collective good in question. Indeed, there is a great deal of empirical evidence that the principles laid out in Table 3.4 explain why some traditional common property regimes have been successful in sustainably managing natural resources.

There is, however, recognition that collective action and property rights 'institutions' are more complex than this. Rational choice itself '…is associated with action that is instrumental, self-interested, based on empirically-informed beliefs, and limited to material and social incentives. This rules out actions solely motivated by emotions, adherence to norms, altruistic urges, the pleasure of doing, and expressions of self' (Froemming 1999). Further, rationality is dependent upon knowledge, information, and cognition, or the relation between beliefs and evidence: 'rationality is relative to the evidence available for a decision and its optimal collection. In that sense, it is both a panhuman mechanism and culturally specific' (Ibid). What this means is that behaviour that is not based on 'rational' self-interest, but rather on emotional or psychological need or cultural norms (such as status seeking behaviour, altruism, or collectivist ideals) is in general not considered by such theory, nor does it take into consideration the fact that beliefs, rather than 'evidence', may determine actions (e.g. the belief that a determinate action incurs the wrath of God or spirits). Atran (2002) also argued that 'institutional mechanisms are not the exclusive or primary means for preserving common resources', and provides the example of the Itza Maya in Guatemala, who

TABLE 3.4 | Design principles from studies of long-enduring institutions for governing sustainable resources (Anderies et al. 2003, based on Ostrom 1990)

Principles	Definitions
1. Clearly defined boundaries	The boundaries of the resource system (e.g. irrigation system or fishery) and the individuals or households with rights to harvest resource units are clearly defined.
2. Proportional Equivalence between Benefits and Costs	Rules specifying the amount of resource products that a user is allocated are related to local conditions and to rules requiring labour, materials and/or money inputs.
3. Collective-Choice Arrangements	Most individuals affected by harvesting and protection rules are included in the group who can modify these rules.
4. Monitoring	Monitors, who actively audit bio-physical conditions and user behaviour, are at least partially accountable to the users and/or are the users themselves.
5. Graduated Sanctions	Users who violate rules-in-use are likely to receive graduated sanctions (depending on the seriousness and context of the offence) from other users, from officials accountable to these users, or from both.
6. Conflict-Resolution Mechanisms	Users and their officials have rapid access to low-cost, local arenas to resolve conflict among users or between officials and users
7. Minimal Recognition of Rights to Organise	The rights of users to devise their own institutions are not challenged by external governmental authorities, and users have long-term tenure rights to the resource.
For resources that are parts of larger systems: **8. Nested Enterprises**	Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organised in multiple layers of nested enterprises.

have few co-operative institutions, and yet manage scarce resources sustainably. Von Benda-Beckmann and colleagues call into question the concept of 'common property' per se:

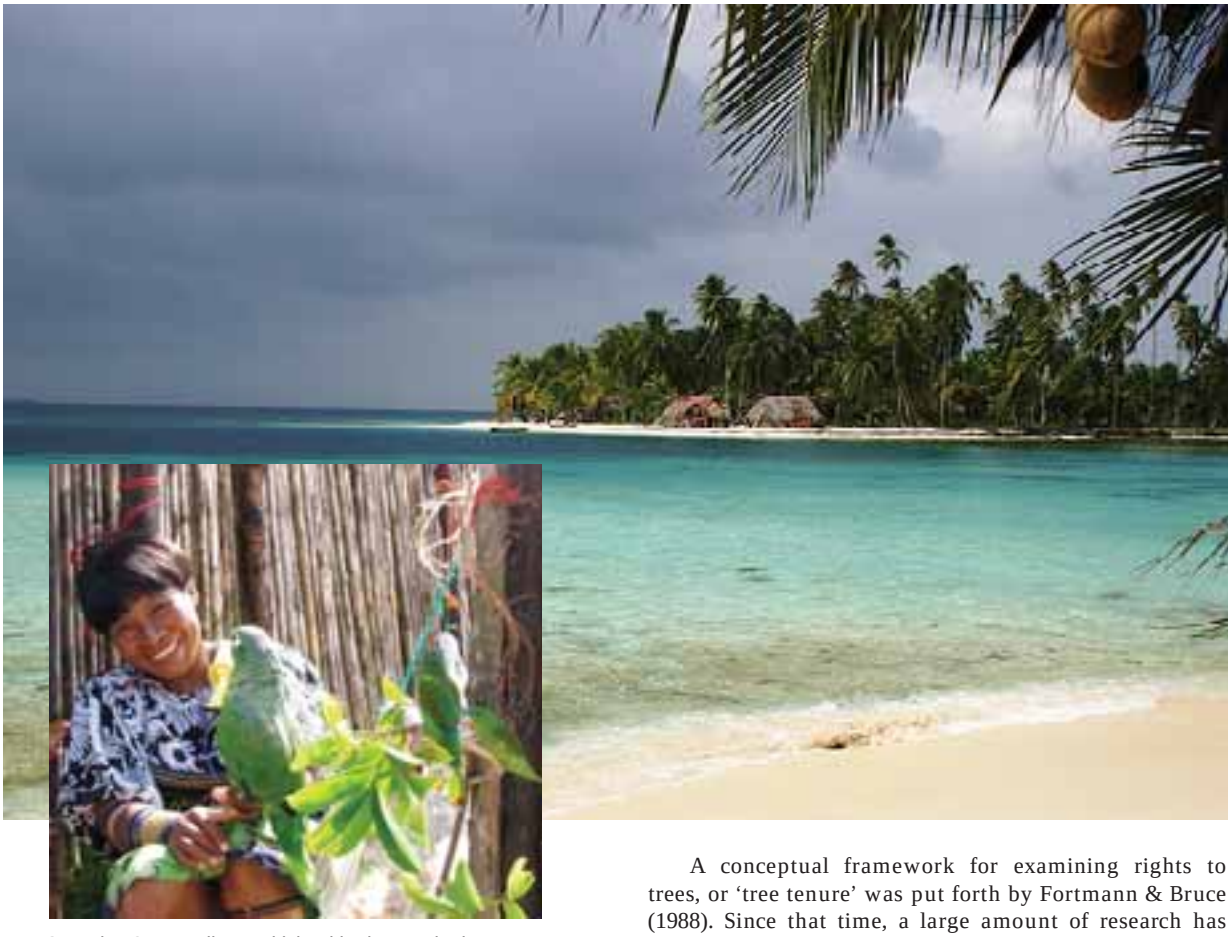
> *the category [of common property] is not well suited as a descriptive device or as a basis for theories or policies. For example, communal property may comprise different kinds of rights…Furthermore, it comprises a wide variety of collectives, ranging from a few individuals, to larger groups, entire villages, the state, and even 'mankind.' And the rights of the members of such collectives, and the resultant complex combinations of possible groups vary considerably. Moreover, communal or common property was mainly theorized at the level of categorical property rights, that is abstract categories and general rule sets that define generalized types of property objects, holders and the relationship between them. Little attention was given to the nature and distribution of concrete property relations that connect actual property objects and holders. Moreover, other functions of property, such as its significance for social security, the continuity of social groups and as the source of political power were not considered* (Benda-Beckmann et al. 2007).

Today, much attention is being directed toward conceptualising the complexity and interrelationships between legal pluralism, the multiple functions of property, individual and collective action, externalities, change drivers (e.g. shifting tenure regimes, commoditisation, etc.), and resource management, including management of agrobiodiversity, as exemplified for example by the CGIAR System-wide Programme on Collective Action and Property Rights (CAPRi) initiative.[9] More researchers are attempting to explore the interrelationships between community values, norms, religious beliefs, rational self-interest, and collective action both through in-depth empirical research (e.g. Froemming 1999) and modelling (e.g. Janssen 2002). Such research is very important to scientific knowledge of SES and policy making, but it does not promise to reduce complexity or the need for in-depth, context-specific research or adaptive decision making.

When considering property institutions that regulate access to, use, management and distribution of natural resources (***natural resource tenure***), we are confronted with yet another set of complexities which is related to the physical and biological characteristics of the resources themselves, and their multiplicity of uses. It is well understood that water presents different properties compared with land (for example, water is generally indivisible), which means that property institutions around water are different from those around land ('water rights'); the same can be said for minerals, and fish or game ('fishing' or 'hunting' rights). Here we illustrate the complexity of rights to agrobiodiversity using the example of rights to plant resources (without considering rights to planting material which, due to its specific characteristics, is an important sub-topic). An assumption has usually been made that 'ownership' of agrobiodiversity is automatically derived from land tenure: those who own land ipso facto hold exclusive rights to biological resources growing on or associated with that land, and biological resources found on land that is 'commonly' held are also 'common' property. These assumptions derive from notions of property embedded in many Western legal systems, and they obscure the fact that ***rights to agrobiodiversity are often quite different from rights to land, and so-called 'common property' in agrobiological resources is in fact often not 'common'*** (Cleveland and Murray 1997, Howard and Nabanoga 2007, King & Eyzaguirre 1999). Rights to plants are no different in this sense from rights to other important natural resources such as trees and water, where for some decades it has been recognised that traditional rights regimes around these resources are highly complex and dynamic; that they exist apart from, although interrelated with, rights to land; and that they establish '***bundles of powers***' for heterogeneous groups of users and knowledge holders within cultures, which also create differential entitlements to the benefits of their use (see e.g. Acharya 1990, Benda-Beckmann et al. 2007, Bruce & Fortmann 1988, Conklin 1954, IWMI et al. 2005, King & Eyzaguirre 2005, Kundhlande & Luckert 1998, Meinzen-Dick & di Gregorio 2004, Nugent 1993, Robbins 1996, Sheridan 2001). Rights to biological resources of all kinds are ubiquitous, are an integral part of power relations, are embedded within cultural systems and regulated by customary institutions and norms, are both consciously and unconsciously respected, and yet are generally uncodified (informal). Simple notions of 'private' or of 'common' property in relation to agrobiodiversity simply do not reflect reality.

Over the past decade or so, nearly across the globe, there has been a strong resurgence of policy and academic debates around customary resource tenure. Two major causes are involved. The first is the concern with environmental degradation and sustainable resource use that leads to a focus on so-called common property resources (CPR) and especially on the question of whether CPR regimes are more or less effective for sustainably managing natural resources while alleviating poverty. But CPR debates and research have generally not addressed traditional people's rights to many types of agrobiodiversity (e.g., plants or seed, animals, insects), so that these institutional dimensions of plant biodiversity conservation and loss have been largely unexplored, although anthropologists, geographers and others have investigated all sorts of social and ecological relations in traditional societies and often discuss social relations of access, use, and management so that there is an extensive literature about specific societies or resources.

How are traditional rights to biological resources expressed, and what does this have to do with social organisation and resource management within SES? An illustrative case is presented by Howe & Sherzer (1975), who showed how such a system of rights to plants is culturally, rather than formally encoded in the way one population classifies the plant world. They studied the San Blas Cuna Indians, a population of about 25000 agriculturalists inhabiting the North-east coastal area of Panama, where each household cultivates numerous swidden fields dispersed throughout the landscape. People are unable at all times to monitor their holdings, so that theft, or the threat of theft, is an intrinsic feature of their life-world. On the other hand, as is the case with many subsistence-oriented societies, the San Blas Cuna also 'have a strong and very self-conscious ethic of generosity, one in which food-sharing plays a central role.' The authors posited that, given these conditions, there must be 'a set of shared understandings concerning access to things growing on farms' and interviewed informants to unearth such patterns. They discovered 'more or less identical set of criteria that characterise and differentiate into access-sets the



San Blas Cuna Indian and island in the arquipelago

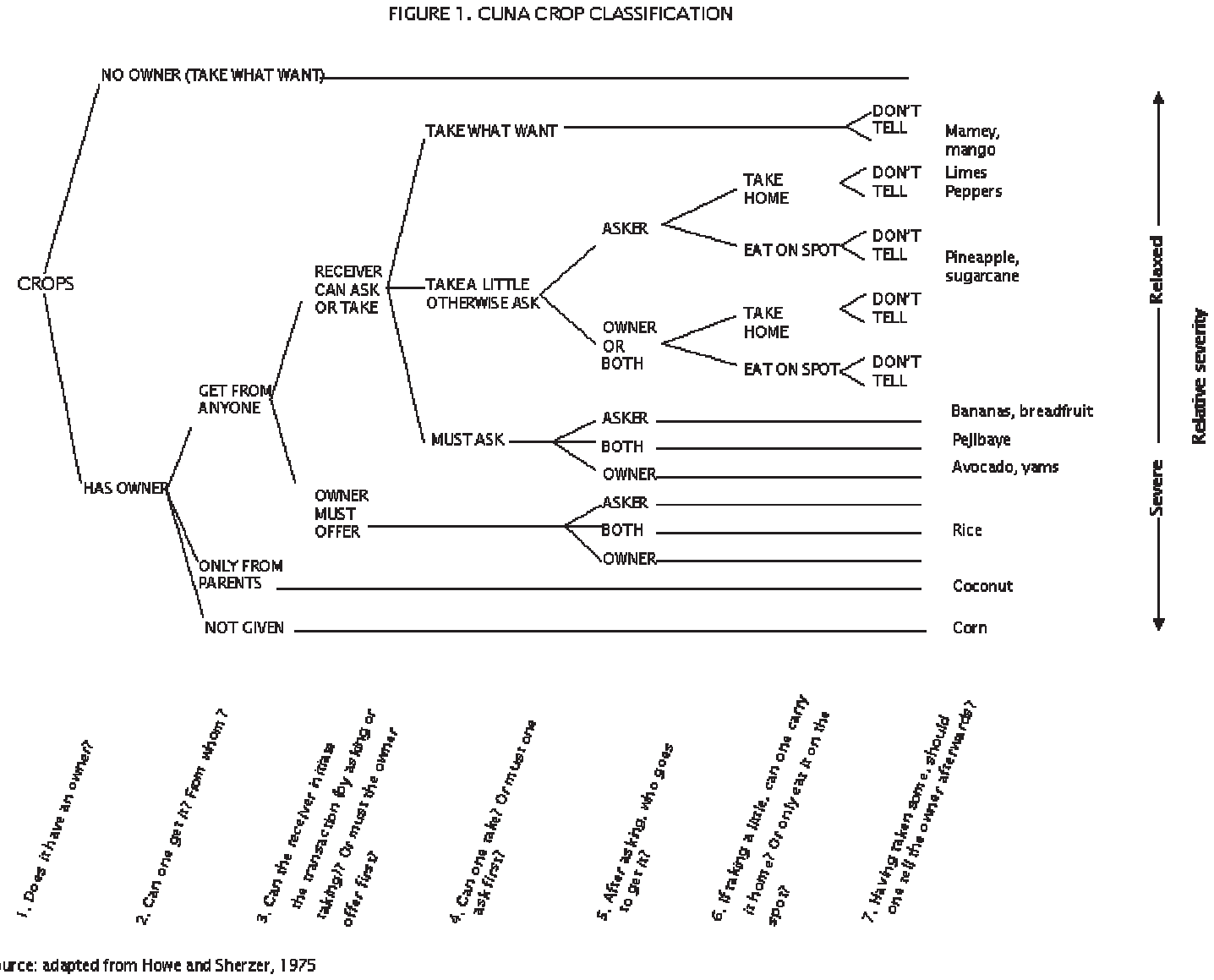
products of every kind of plant or tree in the forest, wild or cultivated' (Ibid). One semantic term first classifies plants into the categories 'have an owner' (ipet nikka) or 'belong to God' (tios kati); a sub-category distinguishes products that can be obtained as a gift from the owner and those that cannot (where coconuts can only be obtained from a parent); and another distinguishes what must be asked for 'in advance' versus what can be taken without prior permission, and so forth. It is worthwhile reproducing the authors' summary of the San Blas Cuna classification system in Figure 3.3. The general principle that they put forth is an essential requisite for understanding social relations and agrobiodiversity: shared sets of understandings about access to important biological resources must exist and must be socially encoded.

Such 'shared understandings' or property rights regimes are embedded in 'bundles of powers' (Ghani 1995; cited in Ribot & Peluso 2003). Rights or powers are associated with duties or '***bundles of obligations***' which are embedded in social, behavioural and spiritual norms about social roles that form the basis for and legitimate ***customary rights regimes*** around biological resources, as much research has shown (e.g., men may be vested with the obligation to be generous and to exchange resources such as food within the community, whereas women, but not men, may have the obligation to produce the crops that men exchange; herbalists may have the obligations to provide medicinals free of charge to the community and they may have exclusive rights to their knowledge and to harvest certain plant species).

A conceptual framework for examining rights to trees, or 'tree tenure' was put forth by Fortmann & Bruce (1988). Since that time, a large amount of research has made use of this frame work and has documented its complexity and variability among different cultural groups and regions. In the framework, tree tenure is conceived of as the rights to own, bequeath, plant, use, and dispose of a tree or tree part, where an individual's rights to trees may depend on their rights to the land upon which the tree is growing, or where land rights may be established by planting trees. Tree tenure consists of a distinguishable bundle of rights and obligations that may be held by different people at different times, where rights are dependent on factors such as tree species, ownership, location, land ownership in that location, whether the tree was planted or grew naturally, and the division of labour in tree management and use, or in the management and use of tree parts (Ibid). In turn, these may be related to cultural or spiritual beliefs that prescribe or proscribe activities and resources to certain groups. The multiple uses to which a tree or tree product may be put and the degree to which different uses are in conflict (e.g. for timber versus fuelwood) also influence rights.

A more general framework for understanding rights to plant resources (Howard & Nabanoga 2007) attempts to capture how the sets of rights and obligations may correspond to social structures, that is, how access to 'bundles of powers and obligations' are distributed among groups and even among individuals. They argue that the allocation of ***rights to plants*** bears a relation to the distribution of plant knowledge within traditional and indigenous communities, where both are determined by the importance of particular plants to particular people within them. In traditional communities, the most commonly used plant resources are likely also to be those

FIGURE 3.3 Cuna crop classification as a system of rights to plants



Source: adapted from Howe and Sherzer, 1975

where access rights and obligations extend to all members of a community, or where the obligation to produce such plants is pervasive. Gender is one of the major factors influencing rights to plants: being a woman implies sharing certain rights and obligations with other women, but not necessarily with men. Then, women in a particular household or kin network will be more likely to share rights to particular plants. However, unlike knowledge, plants are physically tied to land, and different plant resources have different biological characteristics that create quite different sets of conditions around access and use. For example, certain uses of plants will destroy them whereas others won't, and right regimes may proscribe uses that destroy plants, or stipulate that plants be managed in such a way as to stimulate reproduction or production of particular parts, such as fruit (see also Peluso 1996, Pfeiffer & Butz 2005). The occurrence of particular species only in a particular biotope may lead to the creation of rules applicable only to that species that may be quite different from rights regimes that apply to this biotope more generally. They put forth the hypothesis that plant rights regimes will tend to reflect the following parameters:

> *Part Z of species A in resource area X can be used by person Y if the use is for B and Y abides by rule M, during season C*
>
> *Within this complexity, patterns emerge in relation to:*

- *Resource areas (variable X) since this is also governed by land tenure (*de facto *and* de jure*; customary and formal); Particular uses (variable B – e.g. for medicine, for consumption on the spot, for household subsistence, for sale);*
- *Trees (a subset of variable A - tree tenure),*
- *Groups of persons (variable Y – e.g. children, herbalists, poor women, cattle owners)*
- *Particular periods or seasons (variable C – e.g. when species become available; when competition with livestock does not occur; during religious holidays)*
- *Harvesting limits or management practices (variable M) e.g. the requirement to use a digging stick to cultivate roots at the same time that a wild species is being harvested; to not uproot plantlets), which are also associated with the species, the resource area, the uses and the persons involved* (Howard & Nabanoga 2007).

The formula incorporates the relation between rights and social identities insofar as it requires the specification of 'person Y', and one way in which the so-called 'bundles of powers and obligations' become visible is by analysing patterns that emerge from the application of the formula across persons, resource areas, species, variable time periods and uses, revealing which sets of interactions are related to which social identities (Box 3.8).

A final essential caveat with regard to the patterns that are likely to emerge from the application of such a formula is that, like power relations, customary property rights are far from static. As a social institution, property consists of 'constellations of social interactions, in which people move, acquire and exchange ideas and resources, and negotiate or contest the terms of production, authority and obligation' (Berry 1997). Therefore, as Berry further argued, property is best viewed as a process rather than 'sets of fixed rules' (processes that economists like to explore as 'games' or 'social bargaining'). Again, the case of the San Blas Cuna is illustrative. As cash crops were incorporated into their subsistence economy, thus contradicting traditional ethics and mechanisms that ensured reciprocity, plant rights were adapted, so now the Cuna

> *differentiate crops according to whether and to what extent the compulsion to give applies, thus leaving people free to be generous with some things, and ungenerous with others, especially cash crops… [the system is] neither static nor timeless. It relates to history not merely as a worn-out residue, a combination of bits and pieces from the past. Rather, it reflects both the situation in which the Cuna now find themselves and the dominant social and economic changes they have undergone in the last century, and we cannot fully understand the classification without taking these processes into account* (Howe & Sherzer 1975).

If such systems were not dynamic, they would rapidly become dysfunctional, out of sync with environmental and economic realities and with shifting power configurations internal and external to communities. Rules are also inherently flexible. First, at any given moment, differences exist between rules and what people actually do: some rules are enforced more severely than others, and some people 'get away' with things while others do not. Secondly, customary rights systems are ambiguous, as Howe & Sherzer (Ibid.) also noted when analysing the San Blas Cuna system: 'each person's versions of the rules is not only idiosyncratic in some respects but also variable. Ambiguity may be a basic facet of the system, even on the individual level': such ambiguity may lead to resilience since it implies flexibility and individual room for manoeuvre.

Even in cases where formal systems have prohibited or seriously constrained communities' rights to agrobiodiversity, customary rules or norms regarding access continue to apply. In the Ethiopian highlands (see Box 3.7), where deforestation and devegetation have been severe, the State and local, democratically-elected councils have created restrictions on the use of locally endangered species and it has also created a series of area enclosures for conservation purposes. However, a series of informal rules, morals and modes of behaviour affect how formal rules of access are understood and implemented. Both residents and officials who are supposed to implement restrictions have their own concepts of morality that affect their willingness to report or punish violators. Violations are generally not reported or enforced where people who violate them are 'the poorest of the poor' and depend upon sales (e.g. of fuelwood or aromatic plants) for income or only small amounts are taken (usually by women) for subsistence use, or the use is for medicinal purposes. Further, anyone can take any species (even restricted species, or species found in restricted areas) at any time from any place (private, enclosed, or open access) if the use is for medicine; children can also take anything at any time from any place for own consumption ('snack food'). Such concepts tacitly acknowledge that formal access rules discriminate against disadvantaged community members and uphold the precept that everyone has a right to meet their subsistence needs, which has often been found to underlie customary resource tenure regimes. Ultimately, residents and officials responsible for enforcing restrictions all struggle to negotiate a 'fragile balance' between the need to use and conserve agrobiodiversity, and this struggle and its tensions are embedded in

BOX 3.8 | Customary rights to plants

Uganda - Customary rights to plants are very often separate from rights to land. Rights are nearly universally differentiated according to sex and age, and rights systems relating to plants present no exception. Among the Baganda, in Uganda, women's homegardens are regarded as their private property and anyone wanting to harvest for any use from what is not their property is expected to obtain permission. But there are important exceptions. For instance, elderly women can harvest vegetables for own consumption from any homegarden in the village. When asked why there are no restrictions on these women's rights, Mrs. Katumba said, 'We get all our vegetable seed from the elderly women, therefore all vegetables belong to them. They even have the power to curse vegetable yields if you don't let them harvest.' Closely-related kin are allowed to harvest enough vegetables to consume at one meal without permission as long as this does not become routine. Also, if a request for a vegetable is made by others than kin, the woman gardener would have to harvest the vegetable for the requesting person. Anyone can harvest a handful of the vegetable from another's garden without permission as long as the vegetable is meant to feed a sick person, since it is then seen as a medication and not a food. No one can sell what is harvested from others' gardens. It is disgraceful for men to be seen harvesting vegetables. Although men can harvest from any tree found in their wives' gardens, they do not have the right to harvest vegetables for any use other than for medicine. Single men must rely on their female relatives to harvest vegetables. The right to harvest plants depends not only on the ownership and control of the resource area, but also on one's relationship to the plants' owners, the use to which the product is put, and the resource area in which the product is located (Howard and Nabanoga 2007).

Thailand - Price (2003) found a complex system of rights to gather wild plant foods, many of which are actively managed through protection, selective harvesting, and transplanting. Access to these foods for domestic consumption and market sale carries different restrictions at the species level, which are linked to perceptions of market value, taste, and species rarity. She examined in detail how rights to collect these plant foods on what is acknowledged as private property are linked to the system of residence, female kinship networks and inheritance of farm land. The system of rights serves a vital social function that further underlines the reasons that plants are subject to the same kind of social regulation as other productive resources. Rare wild species of cultural value were protected from over-exploitation for commercial purposes. A woman's right to gather wild plant foods from agricultural land depends both upon land tenure and the specie status. The most forbidden species were those that women identified as having better taste, greater marketability, and the greatest rarity. Such 'most forbidden' plants could not be gathered from land belonging to others if the intent was to sell, although these could be gathered if it was for own consumption. Ultimately, the system of gathering rights that involves protection and partial privatisation of wild plant foods as a resource can be understood in relation to the occurrence of these plants on privately-owned agricultural land and the existing associated exclusive rights to domesticated plants that accompanies this ownership. Farm women's privatisation rationale, however, holds for only those wild species of cultural value that women farmers perceive as rare. Perceived rarity leads to increased restrictions on gathering of selected species for market sale, and to certain prohibitions on gathering for domestic consumption.

dynamic and multi-layered access rules (Chisholm 2000, Howard & Smith 2006).

As discussed above, customary rights regimes have helped to ensure sustainable management of both resources and landscapes over the long term, as well as a distribution of resources that permits all members of a society to meet subsistence needs. Such rights are threatened by changing formal tenure regimes, establishment of restricted areas for purposes of conservation, commoditization and expropriation of resources and land, development interventions, racism, increased social differentiation, migration, and population growth (Howard & Nabanoga 2005). Most traditional SES have already experienced erosion of such rights as well as conflicts over access, and such threats are likely to accelerate in future due to numerous interacting stressors discussed here and in Chapter 5, giving rise to ***GIAHS Principle 10***.

GIAHS Principle 10

GIAHS communities must be empowered to regulate and control property rights in ways that enhance resilience and maintain agrobiodiversity, in accordance with their norms, values and beliefs; to negotiate for changes in rules to enable this to happen, and to recur to mechanisms where absolutely necessary to resolve conflicts within communities, and between communities and other instances and agents that have opposing claims.

3.6 Agrobiodiversity, Adaptation and Resilience Considering Change

This chapter has highlighted the importance of agrobiodiversity for managed ecosystems, explored its importance in traditional SES livelihoods, and identified the cultural institutions that have co-evolved over time to bring this diversity to life, to manage it, and to give it meaning. As is discussed in Chapter 5, there are multiple global change drivers that are very seriously threatening both the biodiversity and the cultures that constitute the basis of traditional SES. These are and will continue to interact in synergy with direct endogenous (national or sub-national and local) drivers, some of which have been discussed in this chapter, such as change in indigenous knowledge, property rights and social status, and with market forces (discussed in Chapter 4), where it is the synergies that will largely determine the outcomes within these systems.

As an example, pastoralist societies are likely to have to adapt as plant species begin to shift location, or to disappear as a result of climate change (see Chapter 5.2). Adaptive capacity could then depend in part on natural resource tenure and people's ability to change location in order to find adequate grazing resources and water. Should pastoralists be unable to access shifting resources due to national borders or to the fact that such resources occur on land that is owned by farmers, conflicts will almost inevitably arise since both societies may be threatened. People's ability to manipulate their existing environments may be severely limited by a lack of access to alternative livelihood resources that could partially offset the reduction in grazing area, or it may be facilitated by access to technologies and knowledge for storing water, or for introducing palatable species that are adapted to the changing conditions that can provide alternate feed sources. Indigenous knowledge pertaining to other subsistence societies and scientific botanical knowledge may both have to be mobilised.

The discussion in this chapter also clearly shows that humans have a tremendous capacity to understand, learn, manage, and to innovate - to affect their environments as well as their cultures to both induce change and to respond to it (see also Chapter 5.X). These capacities are the mainspring of human resilience, and they need to be har-

nessed and empowered in order to permit these societies to confront the enormous challenges that the future holds.

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[1]See http://www.fao.org/sd/giahs/

[2]In spite of a growing consensus about agrobiodiversity's values for humans and for agroecosystems, different agencies and international agreements define agrobiodiversity differently.

[3]See http://www.prosea.nl/. PROSEA documents information on plant resources of South-East Asia covering the fields of agriculture, forestry, horticulture and botany.

[4]Heywood (1999) noted that 'Most of the wild plant species that are used in local farm households have not been the subject of attention'. When referring to underutilised crops, he referred to the Andres Bello Convention (involving Bolivia, Colombia, Chile, Ecuador, Spain, Panama, Peru, and Venezuela), which has identified over 1000 species that are native but which have 'not been extensively domesticated, are underutilised, or little known but with economic potential.' 'Another major source of agrobiodiversity is the tens of thousands of species that are grown in a pre- or semi-domesticated state on home gardens or similar polycultures…many thousands more are harvested wild to supplement farm household incomes…[but] our knowledge of their most basic biology and agronomy is virtually non-existent and we must depend on knowledge developed over long periods by local farming societies' (Ibid).

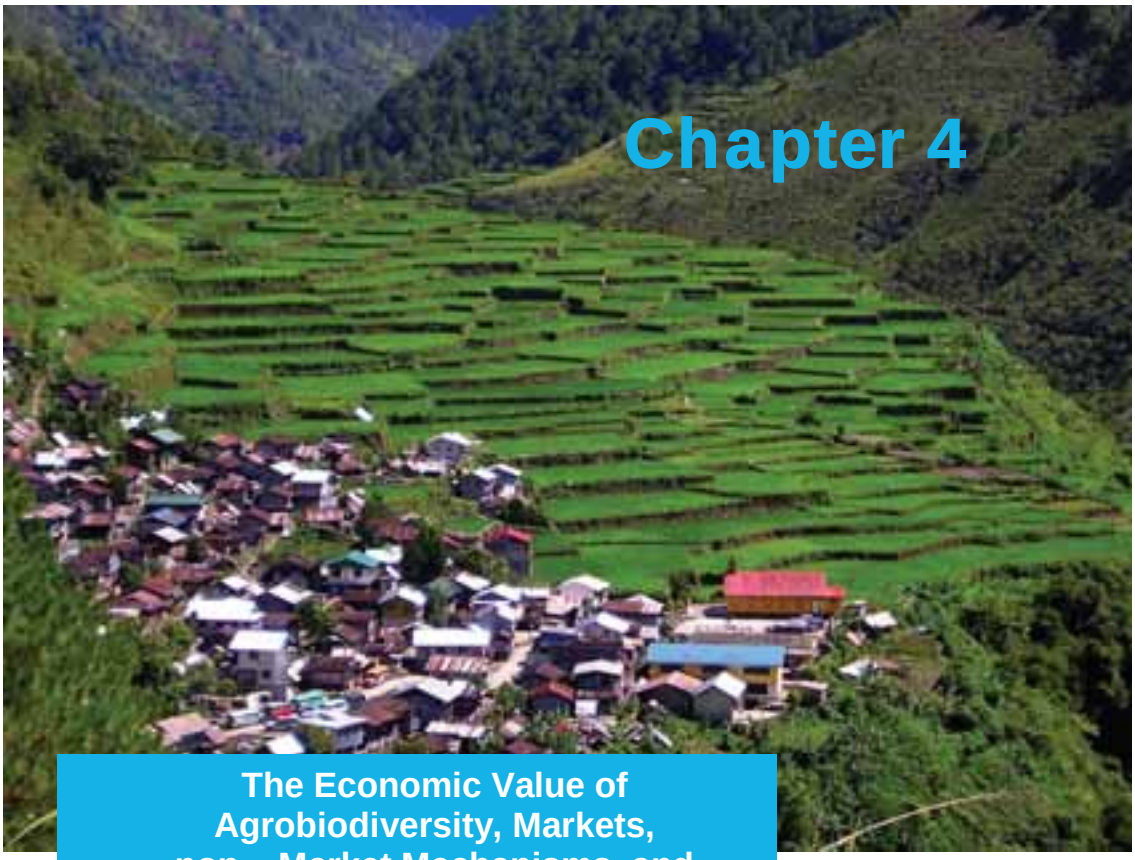
[5]See Foliart, G. de. 2002. The Human Use of Insects as a Food Resource: A Bibliographic Account in Progress. Dept. of Entomology, University of Wisconsin-Madison. Online at: http://www.food-insects.com/

[6]The Biodiversity Convention of the UN Conference on Environment and Development in Rio de Janeiro in 1992 indicated that biodiversity 'encompasses the whole range of the genetic diversity within species, the diversity of species and higher taxa, up to ecosystem diversity, and even the diversity of ecological interactions' (reported in Duelli 1997). Biodiversity is characterised by species richness, species diversity, taxonomic diversity, functional diversity, autecological diversity, synecological diversity, habitat diversity, systems diversity, and ecological diversity, depending upon the scale, and is evaluated at three levels: genetic, species and ecosystem levels (Benckiser & Schnell 2006). Duelli & Obrist (2003) provided an overview of the 'domain tree' of biodiversity based on a review of 125 texts in English, which reflects the conceptual complexity of that concept. Such a review has not yet been done for the concept of agrobiodiversity, but its complexity is at least as great, if not greater, due to the explicit inclusion of additional phenomena, including landscapes and habitats, as well as human intentionality and cultural diversity.

[7]In part this is because '"species diversity is generally by disturbances that occur at intermediate levels of frequency and intensity"' which include anthropomorphic disturbances…at low population densities' (Smith & Wishnie 2000, citing Perry & Amaranthus 1997), implying that there are either geographical, technical or social reasons for intermediate intensities of disturbance.

[8]Anderson, E.N. 2005. Magic, science and religion. Online at: http://www.krazykioti.com/index.php?option=com_content&task=blogcategory&id=68&Itemid=45 (accessed 10-10-06)

[9]See http://www.capri.cgiar.org/



Chapter 4

The Economic Value of Agrobiodiversity, Markets, non – Market Mechanisms, and Social-ecological System Resilience

4.1 Introduction

The conceptual framework contained in these pages concerns traditional rural subsistence societies. By definition, such societies have not been completely integrated into modern markets - that is, their essential logic of production and reproduction is only partially influenced by, and oriented toward, commodities and monetary circulation. However, there are several key issues relating to markets and monetary values that must be addressed. One is whether and how economic valuation approaches used in much environmental decision making are useful for decision making in the GIAHS Programme, that is, whether economic valuation is objectively possible, rational, and useful as a policy instrument to dynamically conserve agrobiodiversity in GIAHS-type SES. A second crucial issue is whether and how greater integration into national or global markets might represent a viable means to enhance GIAHS communities' well-being, adaptiveness and resilience, or might represent increasing risk and uncertainty given global change drivers. New modes of market integration based on payments for ecosystem services also need to be considered as means to support traditional subsistence SES. Finally, the question must be posed as to whether there are alternatives to modern market integration that can potentially enhance human well-being and whether these can represent better or complementary paths toward enhancing SES adaptive capacity and resilience.

4.2 Economic Valuation Approaches and Their Applicability

One approach to dynamic conservation of biodiversity and agrobiodiversity that has been widely advocated although, to date, less widely applied, is the economic valuation approach. Developed by the disciplines of environmental and ecological economics, it addresses the problem of resource degradation (in this case, biodiversity or agrobiodiversity loss) as a problem of externalities, which are the side-effects of an activity that are not taken into account in its price, and which can be positive (or beneficial) or negative (imposing costs that are not compensated). Biodiversity and ecosystem services are both often negatively affected by market activities, and we discuss some of the reasons for such negative externalities below. Economists attempt to 'internalise' externalities in many ways so that they can either be reflected in market prices or in policy decisions, to correct the 'imperfections' of the market and thus reduce negative externalities. Another reason for economic valuation is that it permits decision makers to have a better basis for making decisions that are economically efficient, that is, to be able to allocate resources in a way that maximises the net benefit attained through their use. For example, if policy makers (or farmers) have a limited budget for conservation, valuation of different types of biodiversity can help them to decide where it is most efficient to invest scarce resources. Much scientific effort has been directed toward the economic valuation of biological diversity in general, but to date much less has been addressed toward valuation of agrobiological diversity. Virtually no research has been addressed toward the economic valuation of cultural diversity or phenomena such as traditional ecological knowledge,[i] probably because it is perceived that the latter poses untoward ethical dilemmas (e.g. is one culture or set of knowledge economically more valuable than another?). Here we address the issue of whether biodiversity, and specifically agrobiodiversity, can be economically valued and whether current valuation approaches are adequate for the adaptive management of agroecological systems, setting aside the issue of social systems and their interrelations with ecosystems. We discuss a series of problems that scientific reviews have indicated present serious barriers to this type of economic valuation.

The first issue to address is the perceived need for economic valuation approaches in agrobiodiversity conservation: that is, what are they meant to achieve? According to Drucker et al. (2005), in their review of applied economics literature on valuation of crop and livestock biodiversity,

> *scientific research about agrobiodiversity could be advanced by a holistic approach to valuing its components…The hypothesis is that the costs, benefits, and policy recommendations differ when interactions among biodiversity components are taken into account…[this is crucial to] demonstrating the benefits, as well as the costs of conservation; identifying cost-efficient, diversity maximizing, or optimal conservation strategies…A full assessment of these values…is key to encouraging decision makers to invest in programs for the active protection and maintenance of agrobiodiversity.*

Ceroni et al. (2007) also argue that valuation of non-market benefits of agrobiodiversity are needed 'to identify incentives for farmers to adopt innovative cultivation methods that might be beneficial for agrobiodiversity but might not be economically viable.' Essentially, economic valuation methods, they posit, are necessary because (a) most agrobiodiversity is not traded in markets and related prices cannot be observed, and (b) many services (e.g. ecosystem services) provided by agrobiodiversity are also non-market. These are also reasons why, they argue, the discipline of economics 'has in fact contributed relatively little to the debate about the value of crop or livestock genetic resources and their diversity…most of the value associated with the diversity of these resources in agriculture probably stems from their use values' (Drucker et al. 2005).

The second issue that must be addressed is what should be valued and how it should be valued. Ceroni et al. (2007) argue that most studies value only a few components of agrobiodiversity (e.g. particular crops or animal genetic resources, or specific uses of specific species), whereas the 'nonmarket values of genetic resources have been assessed in a very few cases...Almost no information exists on the economic value of most components of biological diversity to human societies and, particularly, their indirect value' as providers of ecosystem services. Drucker et al. (2005) found that economic studies to date have focused on single components of agrobiodiversity, treating the other goods and services provided by other components as exogenous. Such an approach can even have negative consequences for agrobiodiversity, since 'programs designed to encourage infra-specific diversity in one crop might have the opposite effect on another.' This recalls the resilience approach, which argues that approaches that seek to optimise a single component of a system should be abandoned in favour of approaches that seek to enhance systems' overall resilience (see Chapter 2.1). Due to agroecological complexity, holistic approaches to valuation are clearly needed, but such an integrated approach will need to be very complex since it will have to deal with interactions among different components of agrobiodiversity, which also means much greater investment in research that of necessity will be location-specific. Gatzweiler & Volkmann (2006) argue that economic valuation studies tends to focus on only one of a variety of possible scales (e.g. genetic resources; domesticated spe-

cies), which leads to different conclusions and different recommendations. However, because of linkages between levels of scale, the whole system should analysed simultaneously, paying particular attention to 'overall system behaviour', or what we have earlier referred to as emergent properties (see Chapter 2.1). They conclude that, 'the closer look one takes at the diversity of life and the more detailed analysis is pursued, the less we know about biodiversity as part of the entire socio-ecological system or "web of life,"' which requires new approaches to valuation (see Vatn 2004 and below). This is hardly surprising given that there is still a great deal of uncertainty about the relationships between biodiversity change and ecosystem functioning (see following section and chapters 3.2 and 5.3).

A third problem discussed by Drucker et al. (2005) is related to the concept of economic efficiency and its relation to decision making. Efficiency requires that individuals assign values to biodiversity components in order to decide whether to conserve them or not, and such values are often multiple, wide ranging, and based on shifting preferences. There are two associated assumptions that cannot be supported when attempting to apply this to traditional subsistence SES. One is that, as pointed out in Chapter 2.3 and throughout Chapter 3, traditional societies are not composed of autonomous individuals making rational choice based on individual preferences as is presumed by neo-classical economic theory: indeed, such an understanding of human behaviour is questionable in any part of the world because, as critics contend, preferences are shaped by social learning, social position, and multiple goals that are dynamic over time (see e.g. Vatn 2004, Gatzweiler 2005). Both A second assumption is that of perfect knowledge, which does not hold given that humans have imperfect, socially and culturally contextualised knowledge about complex SES, where uncertainty prevails.

It is also questionable whether, even if such conceptual and methodological difficulties could be resolved, economic valuation would in practice achieve what it is intended to achieve. Economic valuation approaches presume that it is individual human behaviour and choices that determine outcomes. However, in the case of agrobiodiversity conservation, it is well established that 'the institutional arrangements within which people act and make choices, rather than human behaviour itself, are the drivers of biodiversity loss' (Drucker et al. 2005). Institutions (such as markets, legal systems, etc.) define the logic or rationality of individual choices. They conclude that, 'there are obvious limitations to what can be accomplished solely through valuation exercises, since management of genetic resources involves crucial institutional and organisational decisions. Institutional analysis is generally lacking' in applied economics valuation literature. Further, Gatzweiler & Volkmann (Ibid) also question whether policy makers even use economic efficiency criteria as a major instrument in decision making, pointing out that decisions are more likely to be an outcome of '"power-oriented political processes rather than of efficiency-oriented institutional choice"' (citing Birner & Wittmer 2000). If they did use a calculus of economic efficiency, this might not favour in situ conservation initiatives since, as Drucker et al. (2005) point out, 'The marginal commercial value expected from an individual plant genetic resource in agricultural use will not be high enough, in general, to fund national innovation or conservation efforts at levels desirable for society'. It is also very possible that even the aggregate economic value of conserving agrobiodiversity does not provide sufficient justification for conservation, since diversity is site specific and 'the impacts, if successful, are felt only locally rather than nationally' (Sastrapradja & Balakhrishna 2002).

Nor is Freese (1998) optimistic about the capacity to develop adequate economic valuation measures for wild species: 'to the extent that we can define biodiversity benchmarks, current levels of research and monitoring are wholly inadequate to enable us to measure and understand changes caused by harvesting and management regimes, whether at the genetic, species, or ecosystem level.' Economic valuation is also very difficult 'because many of the goods and services provided by natural ecosystems and biodiversity are impossible to reasonably quantify. Thus, there is widespread aversion to attempting such calculations and to incorporating them into decision making'. Hence it is suggested that a paradigm shift is required away from an efficiency stance and toward a complexity stance, 'in the perception of rationality from individual to social, a shift in the type of human interactions from instrumental to communicative and deliberative processes, and a shift towards dealing with complex rather than simple systems' (Gatzweiler & Volkmann 2006).

This does not imply that economic valuation cannot occur at all, but what it does imply is that economic valuation should be carefully interpreted, and complemented by other forms of assessment, including culturally appropriate valuation in non-monetary terms. An example of a very recent effort to integrate economic valuation of ecosystem services and natural resources with policy making using a multifaceted approach can be found in Box 4.1, but it is nevertheless as yet not clear whether these new initiatives overcome some of the many problems mentioned above.

On the other hand, cultural valuation methods, which are used by some conservation programmes, use the currency of relative use value as local people define them, which can be applied to the range of agrobiological resources that communities use in order to understand their own priorities for conservation and adaptive management. Cultural valuation approaches use local people's own value categories (e.g. for food, medicine, ritual use, tools, basketry, construction, fuelwood, water, heritage, etc.) and permits outsiders as well as locals to understand differences and similarities in the ways that different

groups within communities (e.g. castes, sexes, age classes), or types of users (e.g. commercial, non-commercial, livestock owners, non-owners) perceive value and distribute it across species, land cover types, land use types, etc. Multidisciplinary methods, both qualitative and quantitative, have been developed with regard to forest and plant resources that are being adapted and applied (Sheil et al. 2003, Kristensen & Lykke 2003). This type of valuation exercise allows local communities to better understand their own values and to communicate their needs and values to outsiders; thus, their priorities for development and conservation can be incorporated into conservation initiatives (Sheil et al. 2006)[ii] and therefore should be considered strongly for application in GIAHS sites.

4.3 Markets and Agrobiodiversity

The most obvious means to increase human well-being in subsistence SES from nearly everyone's perspective (policy makers, development agents, scientists, and local communities) is to increase income through greater market participation. Improving market access and access to credit and information, stimulating demand for goods and services, and increasing production of particular crops or other species (fish, wild plants, etc.) that are in demand are all seen as means to facilitate income generation for traditional subsistence communities and conserve biodiversity. There is, however, a very serious question as to whether increasing cash income through greater market participation, and adaptively managing traditional SES, are compatible aims, or whether they involve trade-offs in terms of reduction of agrobiodiversity or cultural integrity, particularly considering that global market integration has been pointed out as the single most important driver of both agrobiodiversity loss and cultural erosion (see Chapter 5).

It is important here to reiterate some of the differences between traditional subsistence societies and market-based societies. The impact of a subsistence-oriented society on its environment is, as Alvard (2002) argued, 'largely a function of its population density, and by extension its access to markets.' Using the example of meat, Alvard argues that, once a threshold is reached where each member of the society has fulfilled its requirements for meat consumption, the 'benefits of more meat have diminishing returns to scale, which is true for many commodities in subsistence economies'. Once the optimal amount is consumed, people allocate their time and energy to other activities. However, cash has no specific use value but rather can be exchanged for a multitude of goods and services: 'Cash suffers much less from diminishing returns than does a commodity like meat', so that the demand for it can potentially be great, and thus the need for the resources to generate it expands on a par with the need for cash. This is not to say that a myriad of variables do not intervene between society, resources and market demand that mitigate against the infinite pursuit of cash and the infinite exploitation of natural and human resources; in fact market production and exchange have been an intrinsic feature of most traditional SES for hundreds of years, at least since the colonial era if not for a far longer time period. What varies considerably between and within these systems over time is the pervasiveness of monetised relationships and the degree to which the logic of markets and their social and technical relations have replaced non-market or 'pre-capitalist' relations of production and exchange. The types of societies that are discussed in this concept paper are largely subsistence-based where non-monetary values and non-monetised forms of co-operation and exchange (including, e.g. barter markets) predominate and, where modern market relations are certainly evident, competition and maximisation of profits are not primary determinants of individual or even collective behaviour or systemic relations: if they are, a different conceptual framework is required (Chapter 1).

It is further necessary to make a distinction between types of markets. Local and regional markets have existed for millennia and traditional subsistence societies have participated in them but, with important exceptions, these markets have not usually driven biodiversity or cultural loss. Such markets are based on other types of rule making (e.g. they are often are not based upon profit maximisation, but rather consider other types of social relations and the social positions of those involved in the transaction) that have been the subject of much anthropological research. What distinguishes modern capitalist markets from these older types of markets is that the former are based on profit-seeking (entrepreneurs seek a profit rather than simply seeking a wage); they are generally integrated at multiple scales through supply chains; and they are related to mass demand for relatively homogenous products. Prices in them do not generally reflect external costs, and governance of these markets is generally oriented toward maximising economic benefits for specific interest groups, states or regions (e.g. through subsidies and trade barriers). Other governance measures can potentially be positively used to regulate markets in favour of small-scale, biodiverse production systems and producers (e.g. standards and labelling), as well as to protect consumers and the labour force, but these are still the exception rather than the rule in developing economies and in global trade. While measures that seek to protect small-scale rural producers may help to ensure environmental integrity and a fair price for their products, the repercussions of greater market integration in terms of other risks (discussed below) remain uncertain.

This section focuses on the literature that considers the effects of markets on biodiversity conservation (without considering those that are regulated by environmental or social standards and labels), and that reviews the empirical evidence. It is impossible

to cover what is a very broad set of literature that often has divergent ideological ends, and this analysis is therefore subject to a great deal of criticism from a variety of perspectives – both pro- and anti-market. It is obviously a daunting task to conceptualise and assess the relationship between markets, culture, and agrobiodiversity, much less markets and SES. No literature review has been found that focuses on the relationship between markets and agrobiodiversity conservation with respect to domesticated plants and animals in developing countries that is based on empirical data and, although there is a growing body of theoretical work in ecological economics focusing on crop diversity, it barely considers cultural diversity, SES complexity, or adaptive management and resilience, and hence to date can only be applied with considerable difficulty.[iii] By contrast, a large body of literature considers the relationship between markets and wild species (including animals, trees, fish, and plants), which reflects long-standing concerns and empirical research related to forestry, fishing stocks, wild game and (to a lesser extent) the wild plant trade, but such literature does not consider SES resilience or cultural diversity. With respect to the effects of markets on culture in general, the literature is simply too substantial to review, although certain drivers toward cultural homogenisation are discussed in Chapter 5. Other recent, partial literature reviews are drawn upon here insofar as they are particularly relevant to GIAHS (Agrawal & Redford 2006, Freese 1998, Godoy et al. 2005, Ruiz-Pérez et al. 2004), but much more literature has not been considered. From what is covered, we attempt to distil opportunities and risks when considering modern markets as important options to enhance traditional SES adaptive capacity and resilience.

It is well established that certain types of markets in certain contexts are strongly associated with the loss of agrobiodiversity. Virtually every text on crop agrobiodiversity loss attributes this principally to the introduction of modern varieties, the intensification of agriculture with the concomitant use of agrochemicals and, often, irrigation; many also relate this to the 'demand' side and discuss the homogenisation of products that is entailed in globalisation with the attenuate requirements for standardisation (see e.g. FAO 1997, 1999). The incorporation of modern varieties that occurs together with intensification and specialisation implies not only loss of crop diversity due to simplification, but as well loss of soil biota, wildlife, and ecosystem services (see Chapter 3.2).

Freese's (1999) review is related to marketing and wild species conservation, which does not address all agrobiodiversity, but which does address a very important component. It can be posited to be representative of problems associated with agrobiodiversity conservation more generally since much of the theory underlying this review is derived from environmental economics which is meant to apply to all kinds of ecosystem products and services, and also because it particularly addresses a concern with conservation of species. It does not, however, address the problem of conservation of entire ecosystems. The review was carried out with the objective of determining how commercial consumptive use (CCU) of wild species (trees, plants, fish, game) could be managed 'in order to minimise its negative effects on biodiversity and maximise its potential as a conservation tool'. The review was based on 15 case studies commissioned by the World Wildlife Fund as well as an extensive literature review. He provided a detailed overview of the issues involved, which is too detailed to summarise here, but it is useful to summarise some of the negative and positive drivers.

First, Freese defined sustainable off take as 'the population size is not reduced or the ecosystem degraded to the point at which harvest levels are greatly diminished'. Further, he defined socio-economic sustainability, which means that

> *the incentives provided by CCU engender support for sustainable management both from the primary stewards of the resource, such as landowners, and from other key decision makers, such as government agencies whose policies affect management. Socioeconomic sustainability must be defined in terms of how successfully the socioeconomic incentives generated by a given use meet the conservation goals for the area under management…which [also] depends on…socioeconomic competitiveness with alternative uses of the land or water* (Freese Ibid).

Freese explains the failure of markets to internalise costs and benefits from the perspective of environmental economics. Resource owners are only rewarded through markets for tangible direct-use values, and not for the non-tangible values (indirect use values, option, bequest, existence) of the resources they manage. If resource owners only produce for exchange, then they only manage resources to produce those exchange values. It is market failure and 'missing markets' that are the culprits. 'At best, if the CCU…is financially competitive with alternative uses [of an ecosystem], the ecosystem is maintained…At worst, revenues from CCU are not competitive with alternative uses and the ecosystem is

BOX 4.1 → The Natural Capital Project (http://www.naturalcapitalproject.org/)

Our Solution: Ecosystems valued as precious natural assets

Imagine now a different kind of world: a world of greater economic realism, where societies would manage ecosystems like the precious natural assets they are. This is the world envisioned by The Natural Capital Project, a new and unprecedented partnership between The Woods Institute for the Environment at Stanford University, The Nature Conservancy, and World Wildlife Fund. The Natural Capital Project, launched 31 October 2006 in Washington, D.C., aspires to provide maps of nature's services, assess their values in economic and other terms, and - for the first time on any significant scale - incorporate those values into resource decisions. Achieving this vision will require new scientific methods, new financial instruments, and new governmental policies. The Natural Capital Project will work toward providing all three, combining the strengths of one of the world's leading research universities and two of the world's most experienced and effective field conservation organizations.

Developing New Tools for Decision-Makers

Our first tool, InVEST, models and maps natural capital: the delivery, distribution, and economic value of ecosystem services and biodiversity. The National Center for Ecological Assessment and Synthesis (NCEAS) has been an integral collaborator in the early development and application of InVEST, helping to make it a highly flexible and publicly available tool. Future tools include innovative policy approaches, including private markets, to motivate and finance conservation.

Which parts of a watershed provide the greatest carbon sequestration, biodiversity, and tourism values? Where would reforestation or protection achieve the greatest downstream water quality benefits?

We are developing new tools to answer questions like these…Building on pioneering efforts led by TNC and WWF, and the modeling tools used in the United Nations Millennium Ecosystem Assessment (MA), our approach is designed to illustrate the impacts of potential land-use decisions on human well-being and biodiversity. Our goal is to provide the most comprehensive, systematic, and broadly applicable method to date for understanding the environmental and economic costs and benefits of changes in land-use and policy.

An Example: The Eastern Arc Mountains, Tanzania

The Eastern Arc Mountains are one of Africa's most ancient and precious resources. Magnificent rainforests, nurtured by winds from the Indian Ocean, have thrived here for more than 20 million years. But today, after decades of steady logging, fires and farmland conversion, these forests have been reduced by approximately 70% in area; only 3,300 km^2 of forest remains, fragmented across 13 mountain blocks. Local villagers depend on the woodlands for firewood, medicinal plants, lumber and meat. The forests also sustain half a dozen rivers flowing into populated regions of Tanzania, maintaining a fresh-water supply for more than 3 million people. The region's pleasant climate, exceptional beauty and rare wildlife, including dozens of birds, chameleons, tree frogs, and other species found nowhere else, draw increasing numbers of tourists from all over the world. The mountains also harbor more than 2,000 plant species exclusive to this area. Environmental organizations including Birdlife International, Conservation International, Wildlife Conservation Society and World Wildlife Fund have been working in the Eastern Arc for more than a decade to try to preserve life-support systems threatened by regional development. In recent years, for example, deforestation has contributed to low flows on the Ruvu and Ruaha Rivers, leaving millions of people and major industries short of water in Dar es Salaam and hundreds of thousands without hydropower-derived electricity. The Natural Capital Project is collaborating in the Eastern Arc Mountains with an international team of scientists and policy experts funded by the Leverhulme Trust and the Packard Foundation. This partnership, named, "Valuing the Arc," began with a November 2006 workshop in Dar es Salaam, attended by experts in the science and conservation of ecosystem services from seven countries. Since then, work has begun on analyzing five of these life-support systems including water supply, carbon storage and sequestration, ecotourism, and non-timber and timber products. Working arrangements with Tanzanian university collaborators have been solidified and meetings with key decision-makers and international donors based in the region have been held. The major goal for this demonstration site is to provide a scientific basis for new programs in which local residents can receive payments for maintaining natural assets, such as forests that regulate water supplies. To support these efforts, a team of Tanzanian, British, South African, and American researchers aims to calculate and map the remnant forest's economic value to Tanzania's citizens and others, and to show the economic consequences of different policy options.

converted'. The way in which people value future benefits is also a major driver of biodiversity loss and ecosystem decline: 'the economic value of a wild species or its products is greatest for current benefits and decreases for future benefits,' where the rate of decrease over time is the discount rate. Quoting Lee (1993), 'If resources are traded in markets, the value of conserving them for ecologically significant lengths of time is set by markets, not by biology: usually, biological conservation turns out to be worth very little.' Whereas the discount rate is usually equal to the prevailing rate of return on investments, it becomes higher if there is uncertainty about the future, such as the future availability of a wild resource; as the discount rate increases, the rationality of exploiting a resource immediately and fully also increases. Uncertainty about wild species is often great because of '"boom-and-bust population fluctuations" evident in many wild species resources, from seed production of tropical trees to marine fish stocks'; when species are highly migratory and hence open-access resources; when there are 'unstable or poorly defined social and political conditions' such as civil war, land use change or tenure change and, when there are slow regeneration rates, as are often encountered in forestry, this leads to both unsustainable logging and the search for fast-yielding alternatives, either in fast growing single species plantations or in agriculture (see also Ruiz-Pérez et al. 2004). 'A positive discount rate means that effectively no weight is given to resource conservation or human welfare beyond a generation or two into the future' (Freese 1999), which is often the minimum time scale required to realise investments in slowly regenerating species.[iv]

Aside from the problem of the discount rate, Freese notes how prices (or profits) also have an effect on sustainability of CCU exploitation, where we have attempted to suggest where the effects might be the same for crop diversity [in brackets]:

- Low prices may mean low sustainability because the current activities are uncompetitive with an alternative use of land or water [The same holds for crop diversity]
- Low prices may mean insufficient investment in research and management of the wild species, and may increase risk of over-harvesting and bad management [here, low prices for landraces compared with modern varieties may mean that landraces are lost]
- Low prices may lead to over-harvesting when the harvest of the low-value species is incidental to, or a condition for, the harvest of high-value species [applicable particularly to crop wild relatives and other on-farm diversity that can be lost e.g. due to mechanical harvesting, or to species loss from the use of chemicals]
- Higher prices per organism harvested under secure ownership can increase sustainability by allowing greater investments in managing the species and by offsetting opportunity costs of alternative use of land and water [The same holds for crop diversity]
- Unusually high prices may jeopardise sustainability because clandestine harvesters are willing to assume high risk and enforcement of property rights becomes difficult;

Government agencies may weaken, ignore or nullify the communities' tenure rights to gain access;
If it is perceived that prices are likely to fall again the entire population may be harvested now;
High profits may lead to the incentives and financial ability to invest in specialised production, thus rather than being over-exploited, the targeted species becomes over-abundant. Specialisation generally leads to ecosystem simplification and the erosion of biodiversity at the site [This applies equally to crop diversity]

Over-harvesting can create a self-escalating environment of scarcity since, as the resource species becomes increasingly scarce, its commercial value increases, which enables greater investments in going after the remaining population.

The potential beneficial effects of CCU for communities and for conservation of wild resources are summarised in Table 4.1.

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[i]This is not the case, however, for tangible cultural heritage, which has been the subject of valuation literature.

[ii]See the website for the Multidisciplinary Landscape Assessment (MLA) project at The Center for International Forestry Research (CIFOR), http://www.cifor.cgiar.org/mla/

[iii]Indeed, it could be argued that such literature virtually precludes consideration of cultural diversity and adaptive management because it assumes that farmer's decisions are reactive and based exclusively on market cues, whereas institutions are presented as 'constraints' (see e.g. Pascual & Perrings 2007). Such simplifying assumptions are necessary to the construction of models.

[iv]Here it is obvious that Freese is not referring to the discount rates of traditional people living in subsistence SES. What is clear, however, is that increasing market integration and dependency could lead to a generalisation of lower discount rates such as those which prevail in global markets.

TABLE 4.1 | Potential Benefits of Commercial Consumptive Use for Biodiversity* (Freese 1998)

Type of Benefit	Potential Examples
Production specialisation at one site benefits other sites of high biodiversity	Industrial timber production from forests on highly productive soils reduces pressures for more extensive logging of low-productivity, high-biodiversity forests and may generate revenues for their conservation [the dedication of certain fields to modern crop production may allow other fields to be set aside for landraces as long as ecosystem functions are not disrupted].
Harvest of wild populations used to restore and maintain natural processes and biodiversity destroyed or degraded by other human activities	Hunting and culling used to control populations of ungulates where predators have been eliminated, thereby avoiding habitat degradation from over-browsing. Forest cutting used to mimic natural disturbance of wildfires in regions where wildfires have been suppressed.
Socio-economic benefits from CCU offset the opportunity costs of alternative land or water uses and the costs of living with pest species	Hunting fees and conservation easements purchased by non-profit hunting organisations may yield greater profits e.g. than cattle ranching, providing an incentive to maintain wildlife and their habitats. Hunting fees for large predators that prey on livestock or for herbivores that damage crops make these species an asset rather than a liability [ecotourism may be a relatively benign way to provide incentives to maintain agrobiodiversity and landscape and cultural amenities].

**Types of benefits accruing principally at national scale (e.g. substitution of synthetic substitutes that are highly polluting or require substantial amounts of energy) are not included since these are considered as benefits that are largely exogenous to traditional SES.*

When considering market creation or enhancement, other factors that have been identified as impeding improved incomes in rural areas include difficult market access, high transport costs, little access to market information, lack of storage facilities, low levels of value added, price fixing on the part of intermediaries or processors, volatile markets for tropical products (e.g. rubber, coffee, oils, fruits), very high levels of competition and low profits due to the incapacity to compete due to lack of access to capital, credit, etc. Further, traditional producers are often unable to compete in domestic markets with imports, a phenomenon which has been responsible for major changes especially in the production of staple crops and livestock (e.g. through wheat imports and use of wheat as food aid in Latin America). However, in general, market problems and opportunities must be assessed in specific contexts with respect to specific markets, since institutional factors such as harvesting controls and other regulations, taxes, market channels and institutions (e.g. co-operative, private, degree of integration), and consumer demand and preferences, etc. all influence market outcomes and social relations. All such factors are also likely to change over time and space, especially given major change drivers (see below).

4.4 Markets, Cultural Institutions and Equity

In preceding sections, it was made clear that the relations between people and agrobiodiversity are based upon a multitude of values related to spiritualism, cultural identity, nutrition, health, and social status and the respective rights and obligations of individuals and groups. The diversity of biological resources also forms the principle physical and natural capital of such societies, and their production and forms of exchange are the currency of social relations. The particular forms that subsistence assumes, and the means by which its products are exchanged, are part and parcel of traditional SES. It is clear that the introduction of new forms of exchange in the form of new markets that entail increasing monetisation of traditional SES, whether these are for ecotourism or for specific landraces or Non-timber Forest Products (NTFPs), can have a substantial effect on the flow of goods and services in and out of SES, and

GIAHS Principle 11

Economic rationality will need to be carefully balanced with cultural rationalities when promoting change in resource use and values. Resource use and exchange in GIAHS is often dictated by the need to maintain family ties, social networks and political power, rather than just to feed people or obtain cash. The introduction of new forms of exchange in the form of new markets that entail increasing monetisation of GIAHS can have a substantial effect on the flow of goods and services in and out of SES, and also substantial implications for traditional social relations, a**BOX 4.2 | Effects of marketing Non-timber Forest Products on rural subsistence households: A review of 61 cases** (Ruiz-Pérez et al. 2004)

also substantial implications for traditional social relations, and so certainly imply trade-offs (see Box 4.2 and below, and *GIAHS Principle 11*).

Participation in markets has been shown to affect traditional subsistence-oriented peoples' management of natural resources (including agrobiodiversity) and cultures:

- Markets and market production may increase the use of inputs, such as water, fossil fuels and other fuels, and therefore may mean greater dependency of communities on external actors and resources, which may increase vulnerability or threaten a limited resource base (e.g. for water or fuelwood); on the other hand, markets and resultant income may enhance the capacity of local people to substitute external goods for SES goods and services that are under stress and thus reduce pressure on such goods and services (e.g. if labour is scarce then labour saving technology may be purchased; if game is scarce, then substitute meat may be purchased);

- Markets may result in a reduction or an increase, or a change in distribution, of social reciprocity and other forms of social capital that in turn affects well-being. Reductions in social reciprocity and other mechanisms of indigenous social security would lead to greater economic vulnerability of people who benefit less from market advantages; on the other hand, if increased income enters into such circuits without changing social reciprocity, it could have a general positive effect on well-being (see e.g. Godoy et al. 2005).

- Markets may result in greater or less vulnerability to risk. Markets are often highly unpredictable and, without market diversification and other buffers against fluctuations in price and demand, greater vulnerability may be introduced if resilience in the system is lost due to reductions in agrobiodiversity or losses of social capital.

- Increasing participation in markets will require adaptations in existing cultural institutions and participation in, or creation of, new institutions, which may undermine or strengthen the power and capacity of local communities to determine their own futures. For example, the optimal level of authority required to preserve biocultural diversity may be lower than what economies of scale dictate, so that power is shifted away from the local level; property entitlements may shift as a function of terms of trade or indebtedness; and, if fairness or equity are perceived to be compromised, new types of conflict may emerge that are not readily managed. On the other hand, greater market integration may stimulate the emergence of greater institutional diversity and new social networks, leading to greater capacity to avoid or manage external disturbances (Gatweiler 2005).

This demonstrates clearly that question of the effects of markets and the new streams of benefits and costs to be derived are complex as well as context specific. Many, however, would argue that certain types of markets are likely to reinforce, rather than disrupt or dissolve, cultural continuity and maintenance of agrobiodiversity. There is substantial literature that provides evidence that small-scale marketing of agrobiodiversity (especially of indigenous crops and wild species) provides vital sources of cash for subsistence-oriented producers, and could potentially provide more cash income without eroding foundations of TEK, culinary traditions, nutrition, social relations or agrobiodiversity itself. Nevertheless, this same literature draws attention to barriers to increased income such as decreasing demand for such local products due to increasing demand for exotics, very high levels of competition among providers (and hence depressed prices, which can have the effects mentioned above), pressures on the part of extension services to plant exotics instead of traditional foods, difficulties with market access, lack of access to credit, etc. (see e.g. Chewya & Eyzaguirre 1999, Guarino 1997, and the Appendix). With regard to NTFPs, commercialisation is unlikely to produce substantial rises in income or alleviate poverty unless householders specialise, intensify production, and have good economic, institutional and infrastructure support. Specialisation runs the risk of drastically transforming traditional SES (Ruiz-Perez et al. 2004). It can be argued that, to the degree that trade occurs within SES, the demand for goods and services will be more compatible with maintaining local agrobiodiversity, social relations, knowledge, cultures and technologies. The threats appear to come more from the requirements of extra-regional or international markets than from local markets, but this may depend on the character of local markets, who participates in them and how, whether demand within them is for exotic or local goods, finite or infinite, whether supply is equitable or inequitable, stable or unstable, etc. However, as is the case with the question of biodiversity valuation, the answers to these questions are context specific.

Ecotourism has been seen to present a viable means to maintain biological diversity, support local communities and cultural heritage, and improve income and hence well-being. Agrawal & Redford (2006) recently conducted a review of the literature that reports on the impacts of ecotourism with regard to the conservation of biodiversity and changes in human well-being. They concluded that there is so far little empirical evidence that supports the suggestion that ecotourism either alleviates poverty or maintains agrobiodiversity. 'In the past decade, ecotourism has emerged as the fastest developing sector of the tourism industry, itself ranked as the second largest sector of the global economy after oil'. While there is no definitional consensus about what ecotourism is, there are two common, core goals: 'It should generate low visitor impact and help con-

TABLE 4.2 | Potential impacts of environmental service markets for the poor in Latin and Meso-american cases (compiled from Grieg-Gran et al. 2007 and Corbera et al. 2007)

Possible Benefits	Possible Risks and Equity Considerations
Natural assets - Higher forest values due to improved management and market opportunities - Positive spin-offs for other natural assets: soil fertility, pollination, water flows and quality	- Lost use values (e.g. timber and NTFPs) if harvesting restrictions are imposed, and lost options for forest conversion to agriculture - Conflicts possible regarding access to forest resources - Marginalisation of poor households due to limited land access
Physical assets -Infrastructure development; transport, marketing, research, health care	-Dismantling of infrastructure compromising the environmental service, for example roads - Lost use values (e.g. timber and NTFPs) if harvesting restrictions are imposed, and lost options for forest conversion to agriculture
Human assets -Education and training: forest and project management, enterprise development, negotiations -Improved health: from better water supply, investment in health care, higher incomes	-The poor capture few educational and skill development opportunities since offered only menial jobs -Reduced health if poor are excluded from collecting NTFPs for domestic consumption and for disposable income
Social assets - Increased tenure security where markets spur rights formalisation - Strengthening of community-based institutions - Protection of forest-based cultural heritage - Increased visibility and representation of community vis-a-vis government, donors, etc.	-Erosion of co-operative arrangements due to increased inequality -Communities marginalised in project design -Limited participation of service providers in decision making -Women marginalised due to a local patriarchal system of decision making involving management of forest commons -Higher competition for land causing displacement of poor who lack formal property rights -Markets and commercialisation undermine local value system
Financial assets -New income from sales of environmental services -Higher income from forest-related sources: NTFPs, fuelwood, timber, ecotourism -Improved security and stability of income due to diversification -Provides partial coverage for protection costs and partial coverage of land use opportunity costs	-New restrictions on forest exploitation and conversion result in income loss -Reduced flexibility arising from long-term land-use contracts hampers livelihood responses to short-term shocks -Communities outside reserve area involved in complementary activities (i.e. ecotourism) but only in early stages -Provision of some paid employment to members of the community as guards and cooks -Partial compensation of land opportunity costs (more for wealthier farmers) -Small addition to providers' total income -Uncertainty about continuation of payments in the future

serve biodiversity, and it should generate beneficial socio-economic outcomes for local populations to help reduce poverty' (Ibid.). However, the core concepts of poverty and biodiversity in such studies are 'generally dealt with as self-evident' and are simplified: 'most studies of ecotourism ignore the conceptually complex nature of biodiversity and poverty, opting instead to focus mainly on economic measures of poverty and general measures of conservation…Ultimately, what makes it exceedingly difficult to generalise about the effectiveness of ecotourism is the fact that there is a lack of baseline data and a lack of attention to the specific causes of observed outcomes.' When studies to attempt to explain why an ecotourism project succeeded or failed, only very general factors are mentioned, and the focus is on the programme itself rather than on effects. Long-term assessments are not yet forthcoming (see Chapter 6.4 for lessons about tourism from joint management of heritage programmes).

In summary, evidence for the link between markets and either biodiversity conservation or biodiversity loss is substantial, but details of the causal relationships that link these and fine grained data from longitudinal studies in a variety of contexts are lacking, which makes predicting the effects of introducing markets into particular contexts quite problematic. The introduction of commercial crops and intensified agriculture generally does lead to the loss of crop diversity and overall agrobiodiversity. The use of markets as a conservation tool to commercialise some wild resources for cash income and deflect destructive uses of other wild resources, such as tropical timber, shows generally poor results, although

studies that attempt to document effects are either flawed or incomplete. The data from NTFP studies suggests that, when markets are successful at increasing the incomes of communities that live in or near forests, they are linked to increased specialisation of household economies and intensification of production including cultivation, which potentially secures wild resources but which reduces the diversity of household subsistence strategies and, potentially, overall levels of agrobiodiversity. In essence, it substantially transforms the SES.

There are also increasing opportunities for uses of biodiversity to generate income through the provision of ecosystem services for payment, such as Markets for Ecosystem Services (MES) and Payments for Ecosystem Services (PES), which pay resource providers for the rights to use the service. MES are based on rules for trading well-defined ecosystem services and commodities for which a market exists. PES, on the other hand, are usually mediated by governments which direct payments from consumers to a fund that is then used to distribute resources to the providers, but they may also be mediated through private organisations who negotiate a price. The types of ecosystem services that are entailed in both MES and PES include carbon dioxide fixation, and watershed, forest and biodiversity conservation, among others. Such payments are promoted globally because it is considered that they can alleviate poverty, strengthen local institutions, and promote conservation in ways that are more efficient and effective, providing an equitable distribution of benefits (Corbera et al. 2007).

While environmental service payments are recent and thus their impacts are difficult to assess, two recent articles review the lessons to date in Latin America (Grieg-Gran et al. 2007) and in Mesoamerica (Corbera et al. 2007). Table 4.2 presents a summary of their conclusions regarding the benefits, risks, and equity considerations of the cases they reviewed, most of which were related to forest environmental services. Since these payments are generally institutionally mediated, many of the possible benefits and risks are related to the power and decision making capacities of the service providers and those who pay. Local institutions can be strengthened in this process, but there is the risk, backed up by evidence especially from the Meso-American cases (Ibid.), that local communities will not be involved in project planning and rule making. Selection criteria regarding who to involve as service providers is usually determined by administrators, and rules can often exclude those potential service providers who have insufficient assets or insecure tenure over resources, therefore disproportionately benefiting wealthier and more secure households; on the other hand, communal and individual rights to natural resources can also be strengthened. When poor people participate, there has been an important addition to cash income, although this only serves to diversify livelihood portfolios and some income increases take considerable time to materialise (i.e. when timber can be harvested) (Grieg-Gran et al. 2007).

Non-financial livelihood impacts have been mixed, where communities can benefit from enhanced environmental services but can also be deprived of access to certain forest resources where restrictions are imposed. In Meso-America, is was found that payments had relatively low impact due to limited monetary compensation of opportunity costs. Farmers are still willing to participate because, at times, this involved very little investment of resources or labour, and because of the implicit environmental benefits from conservation and management, where payments provide an additional small incentive. However, overall there is a lack of equity 'in access, process and outcome...access to project activities can be strongly influenced by land endowment and the existence of viable collective action institutions at local level', where especially property rights over resources that provide ecosystem services play a determinant role...social outcomes will be strongly mediated by project developers' willingness to deal with competing interests and re-negotiate the status quo in what concerns property rights (both formal and informal) and decision-making power' (Corbera et al. 2007). Economic resources for payments remain scarce, and the power structures governing MES and PES exclude beneficiaries in negotiations: these arrangements 'represent a virtual transfer of property rights from service providers to resource users, who often control the nature of this transaction' which can reproduce unequal power relations.

Another set of factors that must be considered when assessing the potential costs and benefits of greater market integration for GIAHS-type SES is related to the major change drivers, including climate change and mitigation, biodiversity change, energy shortages (especially fossil fuels), and potential global economic disruptions (see Chapter 5). Ecotourism appears to be highly dependent upon high incomes and cheap air travel, whereas climate change mitigation efforts are likely to change the cost of air travel, and pressures on incomes from increasing energy and food prices and the costs of mitigation and adaptation measures may mean that consumers have less disposable income to visit exotic places. In addition, tourists are greatly discouraged by factors such as water supply disruptions, disease and pest outbreaks, and political instability or violence that are likely to occur in many traditional SES as the effects of climate change intensify, which may mean that becoming dependent on ecotourism for continued revenues may not be a viable medium- or long-term option. The same, or similar, may be true for niche markets, insofar as these will provide luxury consumption goods for distant populations. Changes in species range and species loss may mean that local plant and animal-based materials that are now available in GIAHS SES may not be available in future, in spite of a populations' best efforts to conserve them. It is also likely that transport costs for such goods will increase (and possibly become more

The current emphasis on market-based approaches is largely blind to the fact that many local organizations mediate forms of economic exchange that exclude the use of money (Pimbert 2005).

Well-being has several key components: the basic material needs for a good life, freedom and choice, health, good social relations, and personal security. Well-being exists on a continuum with poverty, which has been defined as 'pronounced deprivation in well-being
(MEA - Millennium Ecosystem Assessment 2005a).

unreliable in energy-poor nations) at the same time that distant consumers may be making difficult consumption trade-offs. MES and PES are very likely to receive a major impetus as part of global climate mitigation and adaptation measures, but their success depends both on adequate governance structures and on long-term revenues, which are also at risk from due to the drivers discussed in Chapter 5. On the other hand, short-term revenue gains and positive institutional developments achieved through such endeavours may offer much needed capital that can be used to enhance SES resilience for the future. GIAHS projects that are contemplating commercialisation of either domesticated or wild biodiversity to enhance adaptive capacity and resilience might be better off to err on the side of caution and seek possible alternatives (see below). Those that do decide to pursue this strategy will need to develop clear criteria and indicators, ensure appropriate institutional frameworks, establish good baseline data, conduct periodic monitoring in order to assess impacts for social learning, and assess future risks.

4.5 Alternatives or Complements to Market-based Means to Increase Well-being and Enhance Subsistence SES Resilience

GIAHS has the goal of improving human well-being while supporting adaptive management and resilience of traditional SES. The question of how to define and understand well-being and poverty, as well as how to measure them, have been the subject of very substantial scientific and policy debate for a long time. Consensus has emerged that well-being and poverty cannot be conceived of, or measured, in simple economic terms, e.g. in relation to per capita income. Irrespective of the importance of and need for 'objective' definitions and indicators, well-being, like social status and poverty, is ultimately defined by cultural norms and perceptions. These perceptions may or may not strongly overlap with official or scientific definitions, depending on the populations and dimensions in question. As expressed in the MEA, 'How well-being and ill-being, or poverty, are expressed and experienced is context and situation dependent, reflecting local social and personal factors' (MEA 2005a). Pimbert (2005) argued that such local definitions 'usually sharply contrast with the indicators and criteria used in mainstream definitions of poverty, well being and economic exchange'.

From the standpoint of a consensual Western scientific approach to poverty, the World Bank (2002) spelled out, in simple terms, some of its dimensions that are characteristic of contemporary thinking:

Poor people live without fundamental freedoms of action and choice that the better-off take for granted. They often lack adequate food and shelter, education and health, deprivations that keep them from leading the kind of life that everyone values. They also face extreme vulnerability to ill health, economic dislocation, and natural disasters. And they are often exposed to ill treatment by institutions of the state and society and are powerless to influence key decisions affecting their lives. These are all dimensions of poverty.

It is well established that there are many interrelationship between these dimensions, e.g. between the lack of adequate food and poor health, and between ill treatment by state institutions and eco-

GIAHS Principle 12
Well-being is both tangible and intangible and it is context-specific. What needs to improve, why, and how are major questions, where answers should not be provided beforehand, but rather consensus should be sought about needs for improvement in particular dimensions of well-being, the causes of a lack of well-being still remain, and the means to address the causes, where multiple entry points are certain to emerge, of which some are potentially more and some potentially less consequential for overall adaptive capacity and SES resilience. There are a very substantial number of options for enhancing well-being and security that build upon, rather than potentially undermine, traditional forms of collective organisation, rationality and cultural notions of well-being that are based on 'good social relations' and that provide forms of security that governments and markets are generally unable to provide.

nomic dislocation. But such interrelationships are also context specific. Within traditional SES, people may be poor on the basis of per capita income but may not be poor in relation to other poverty indicators (e.g. access to adequate food) or concepts of well-being (e.g. good social relations); perceptions of poverty or lack of well-being may be more related to issues of vulnerability and risk due to lack of clear property rights to natural resources than to lack of monetary income. Assumptions that all people in GIAHS are poor are linked to the perception that poverty is defined by the lack of monetary income and are based on external value systems. External value systems have certainly changed and continue to change the way that many traditional peoples define poverty and well-being, but adopting such external value criteria does not always mean that well-being is improved: often the standards of well-being that are adopted are based on an explicit devalorisation of traditional people's ways of life, as can be seen in the discussion of some of the drivers toward cultural erosion that follows in Chapter 5 (see *GIAHS Principle 12*).

It is tempting to declare that the best (or only) way to address poverty is through market mechanisms, since only monetary income provides people with the freedom of choice to allocate their resources on the basis of personal preference. However, there are a very substantial number of options for enhancing well-being and security that build upon, rather than potentially undermine, traditional forms of collective organisation, rationality and cultural notions of well-being that are based on 'good social relations' and that provide forms of security that the State and markets are generally unable to provide, such as care for those who are old, infirm, or unable to work. Here it is not possible to enumerate anywhere near the range of possible alternatives to markets that do

BOX 4.3 → Building on local resources for drought recovery in Kenya (based on Orindi and Ochieng 2005).

Much of the post-drought recovery strategy in dryland areas of Kenya focused on food aid and emergency seed supplies. Contrary to the assumption by many aid and development agencies that during drought there is a seed shortage within affected communities, seed fairs show that communities may still have seeds, and that the problem sometimes has more to do with access than actual scarcity. Local communities in Eastern Province, Kenya, mainly practice agriculture together with livestock keeping. The majority are small-scale farmers who produce mainly for consumption but also sell some of the produce. Crop failures are frequent due to erratic rainfall and alternative sources of income are marginal. Some households find it difficult to recover from drought due to lack of access to the right seed at the right time. Most farming communities are rapidly losing their traditional food crops partly due to replacement by a narrower choice of improved crop varieties and crop types. Both government and a number of NGOs used the conventional seed distribution approach whereby seed is sourced from seed companies and distributed to needy households through the government or administrative structures. Catholic Relief Services and other local partners, together with the FAO, used a novel approach with seed vouchers and fairs to distribute seed to over 35,000 households in seven districts. Lessons had been learned from other Seed Voucher and Fair (SV&F) approaches in other countries, where farmers were given vouchers and had to look for their own seeds, resulting at times in poor quality seed.

Around 90% of farmers in dryland areas use local seed; only a small percent rely on commercial seed, therefore there is a need to strengthen local seed systems. Conventional seed aid was found to undermine rather than strengthen local seed systems; farmers remained passive recipients of seeds and could not select the types of seed distributed. Foreign seed was often distributed that was not adapted to local conditions, and did not perform well. Improved varieties that were distributed did not appear later in local markets where local cultivars continued to dominate. The use of seed fairs was meant to address these weaknesses. They aim to showcase what the community has and provide a market for such products, moving beyond just relief and building capacities of local communities. While seed vouchers are given to the poorest in the community (those who are unable to purchase seed, who are selected on a participatory basis at community level), seed shows bring farmers together to display their best seeds and other produce, a few weeks before the onset of rains to ensure immediate planting. They enable farmers to access seeds of crops and varieties that they need and choose, strengthening of local economies through sale of seeds by local suppliers (farmers and grain/seed stocklists), expose farmers to new germplasm from research organisations; an exchange of information experiences on farming under changing local conditions, including strengthening of community-based institutions and seed systems; distribution could be carried out in a short time frame (the need to establish stores was significantly reduced), on time, and at lower cost compared to conventional seed relief systems. From the seed diversity and cultural fairs that have been largely promoted by the development organisations, farmers have formed self-help groups that engage in other activities including seed bulking. The seed fairs have also been used to encourage farmers to maintain crop diversity on their farms. Through seed shows, traditional crops that were being forgotten are getting renewed interest and attention from participants, including outsiders. Farmers say that they want to attend seed shows because they are exposed to different crop varieties growing in their areas, they learn about sources of various types of seed, and they learn about seed preservation from other farmers. Seed supply was adequate despite three successive crop failures, indicating that local seed systems are resilient, and that local farmers and markets can supply the required seeds. Seed aid should focus first on local resources.

not undermine local SES resilience since this would be equivalent to discussing everything that humans have come up with to improve their well-being over millennia. However, some examples can be provided that clearly point toward improvements that do not imply major trade-offs.

Pimbert (2005) presented a number of non-market alternatives for enhancing local food systems. One example is that of a barter market, held weekly in the Lares-Yanatile Valley in Peru, where nearly 50 tonnes of food originating from different ecological zones of the valley including the high Andes and the lowland rainforest are traded each market day. Fruits, such as banana and citrus, are traded up hill, while starchy carbohydrates such as potatoes and maize are traded down hill, thereby helping to supply food for a balanced diet for all. 'Women are key players in this non-monetary market, which is vital in ensuring that their families have enough to eat, and that they have a balanced diet.' The barter markets promote well-being in the area by ensuring access to food security and nutrition, conserving agricultural biodiversity through continued use and exchange of food crops, maintaining ecosystem services and landscape features in different agroecological belts along altitudinal gradients and at multiple scales, and promoting local, autonomous control over production and consumption, specifically, control by women over key decisions that affect livelihoods (Marti 2005, in Pimbert 2005). Pimbert (Ibid) also notes that 'the volume and economic value of food exchanged through these webs of polycentric local organisations can be significantly higher than that sold in money-based markets. However, most development economists, policy think tanks and international donors largely ignore the huge potential of these forms of economic organisation and exchange in meeting human needs....'

There are currently very substantial efforts being made worldwide to improve SES resilience and maintain or enhance *in situ* conservation of agrobiodiversity by supporting local people's access to seed and planting material through participatory plant breeding, seed fairs and other forms of seed exchange and seed banking based on existing farmers' practices, knowledge, and networks.[v] An example of an effort to provide relief for farmers experiencing major external shocks (in this case, drought) is provided in Box 4.3.Another important means to achieving well-being while working within the framework of local knowledge systems is through access to information, but often the means to communicate new ideas between farmers and communities is lacking. Pimbert (2005) describes the development of local institutions among the Peruvian Quechua that facilitate knowledge transfer. 'For the Quechua, the ecological, social, economic and cultural realms of human life are integrated through local organisations, institutions, laws and policies that transform assets (natural, physical, financial, human, social, cultural) into livelihood outcomes' (Ibid). The Quechua have developed community-to-community and farmer-to-farmer learning networks based on the principle of ayni, or 'reciprocity'. Each community elects an organisation of 'barefoot technicians' to network with other communities and create opportunities to share and transfer innovations in TEK. There are again a very large number of initiatives worldwide to promote knowledge exchange both within and between traditional communities. Agencies such as the World Bank are becoming very involved in promoting such knowledge exchanges. For example, in the context of the Convention to Combat Desertification, it is promoting a programme entitled 'Enhancing Indigenous Agricultural Knowledge in Southern Africa (ENIAKA), which has a Community Exchange and Training Programme aimed at 'mobilising and dissemination of available traditional technology and knowledge on sustainable management of natural resources and alternative livelihoods in areas prone to land degradation'.[vi]

Box 4.4 provides a few examples of programmes oriented toward enhancing biodiversity and ecosystem services as a means to protect these and to enhance human well-being. The outcomes of many biodiversity conservation efforts in the past have not been positive for many rural people since they have effectively closed areas to local use and management. Currently, however, many efforts are orientated toward both enhancing biodiversity and improving quality of life and human well-being.

It is also clear that most rural subsistence communities could benefit from health improvements. Traditional health systems are an important part of people's culture, a major motivation to maintain agrobiodiversity (the majority of all plants that are used by most traditional communities are for medicine) and are important to maintain because they are vital to their health and well-being. Nevertheless, many traditional communities are eager to improve access to formal medical services, and this can be done in a way that combines the strengths of both formal and traditional health systems. Again, there are a multitude of examples where formal health care providers are working closely with traditional health care providers (healers, midwives, herbalists, housewives) and are building on TEK and community social relations to address major health problems. An example is again provided by

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[v] See, for example, http://www.ciat.cgiar.org/africa/seeds.htm; http://www.gsi-cabi-bioscience.org/www/underside.asp?id=633&version=2

[vi] See 'A proposal for action' at http://www.worldbank.org/afr/ik/ikmarket/prop_ccd_aztrec.pdf. See also traditional knowledge exchange: http://web.worldbank.org/WBSITE/EXTENAL/COUNTRIES/AFRICAEXT/EXTINDKNOWLEDGE/0,,contentMDK:20712935~menuPK:1692773~pagePK:64168445~piPK:64168309~theSitePK:825547,00.html

BOX 4.4 → Enhancing ecosystem services and welfare

The Center for Applied Biodiversity Sciences' (CABS) programmes, carried out in collaboration with Conservation International (CI) seek means to enhance ecosystem services and, by this means, improve human welfare. In South Africa, CI and 16 local communities are establishing the 358,000-ha Namaqua Wilderness Corridor in the Succulent Karoo region to conserve the extraordinary flora in the region's wetlands and unique dwarf shrublands. This corridor, along the west coast of South Africa and Namibia, is to protect the water supplies for all of the communities and to allow plants to adapt to subtle but significant climate changes that may affect the ecosystem's fragile balance and the survival of the region's flora.

In Thailand, Laos, Cambodia, Vietnam (lower Mekong delta), the inland fishery of the Mekong Basin accounts for at least 2% of the world's fish production. It is threatened by flood control measures in the upper stretches of the river. In collaboration with CABS, the IndoBurma office of CI is researching ways to allow the lower Mekong countries to control flooding by protecting the forests of the tributary watershed. This will also improve food security and the livelihoods of local communities that depend on fishing.

the World Bank, in an initiative in Tanzania called the Tanga AIDS Working Group (TAWG). The goal of this group is

> *...to alleviate suffering from HIV/AIDS using indigenous knowledge…The group has treated over 4000 AIDS patients with herbs prescribed by local healers. The impact has been most significant in alleviating the opportunistic diseases brought on by the AIDS virus. The patients who have responded most positively have lived longer, by up to five years. The Tanga regional hospital has allocated a floor to TAWG workers to enable them to test patients for HIV, treat them and provide counselling. They have also set up an information centre in town, which conducts active AIDS awareness campaigns and offers a support network to people living with AIDS. With support from the World Bank's IK for Development Program, TAWG has organized community-to-community exchanges, involving their healers, people living with AIDS and staff working with patients to provide medical care and alternative income generating opportunities, in exchanges of IK with other communities in Tanzania.*

The approach has been highly successful, and has given rise to numerous 'lessons learned' that can be found on the Bank's website.[vii]

Recovering, conserving, mobilising, and exchanging indigenous technologies is another very important area where much effort is currently being invested, for example in the area of water management (e.g. the UNDP Community Water Initiative, UN University's Traditional Water Management in Dry Areas programme). Many types of technological innovation are also at times clearly desirable and necessary and do not have to change social relations, traditional resource management, dietary patterns, etc.

Box 4.5 presents a few examples of the work of the international NGO Practical Action which is supporting local communities adaptation to climate change. Practical Action is part of the Intermediate Technology Development Group, which was founded in 1966 by Dr. E.F. Schumacher, author of the influential book Small is Beautiful (1973). The organisation has been working for decades with traditional rural communities to improve livelihoods, reduce vulnerability, and enhance their adaptive capacity and resilience in ways that mobilise traditional knowledge and local resources, and that incorporate technologies that are appropriate to their cultures and environments.

Another critical area in which interventions can support GIAHS communities is in the area of education and training. The problem of the devaluation of traditional cultural institutions and TEK on the part of 'outsiders' and even on the part of those living within traditional SES is one of the most important that such communities face, and it is a major goal of the GIAHS Programme to change such perceptions. Throughout the world, formal education and training institutions, as well as mass media, are seriously implicated in this process of devaluation. Formal education and training programmes are executed mainly by people who do not pertain to these communities and their curriculum is very often not only inappropriate, but demeaning to traditional peoples. Initiatives to change this – to incorporate traditional 'experts' (what is called 'peer-to-peer' education and training), TEK and a respect for cultural traditions into formal education and training, are reflected, for example, in the emergence of the 'placed-based education' movement which arose out of environmental education in the United States (see e.g. Powers 2004), which is being productively combined with cultural heritage programmes.[viii]

The most important message that can be conveyed in this very brief review is that the GIAHS Programme must not advocate 'recipes' for enhancing human well-being while enhancing adaptive capacity and resilience. Because one of the aims of the GIAHS Programme is to enhance human well-being while at the same time enhancing adaptive capacity and resilience of the SES, the Programme must seek means to build upon, work with, and en-

hance existing social relations, cultural institutions, concepts of heritage, subsistence strategies, and technologies. Because these systems are so complex and are in many ways unpredictable, they must be adaptively managed principally by their keepers. These insights are not new: innumerable programmes run by NGOs, international organisations, research institutions and governments have also come to such conclusions as they have worked with rural communities to conserve or enhance water and soils, crop diversity, health, education, housing, infrastructure, etc. This wealth of knowledge and experience is very important to the GIAHS Programme and it is considered that a scholarly review of 'best practices' or lessons to be drawn from such endeavours should be done at the earliest possible date.

[vii] See http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/EXTINDKNOWLEDGE/0,,contentMDK:20669617~menuPK:1856305~pagePK:64168445~piPK:64168309~theSitePK:8255 47,00.html#impact

[viii] See e.g. http://www.unesco.org/education/tlsf/TLSF/theme_c/mod11/uncom11t05.htm; http://www.loc.gov/folklife/edresources/ed-heritage.html; http::/ /www.ankn.uaf.edu:8080/resources/courseview.php?id=7; http://www.mainemountains.org/education/home.htm (accessed 17.10.06)

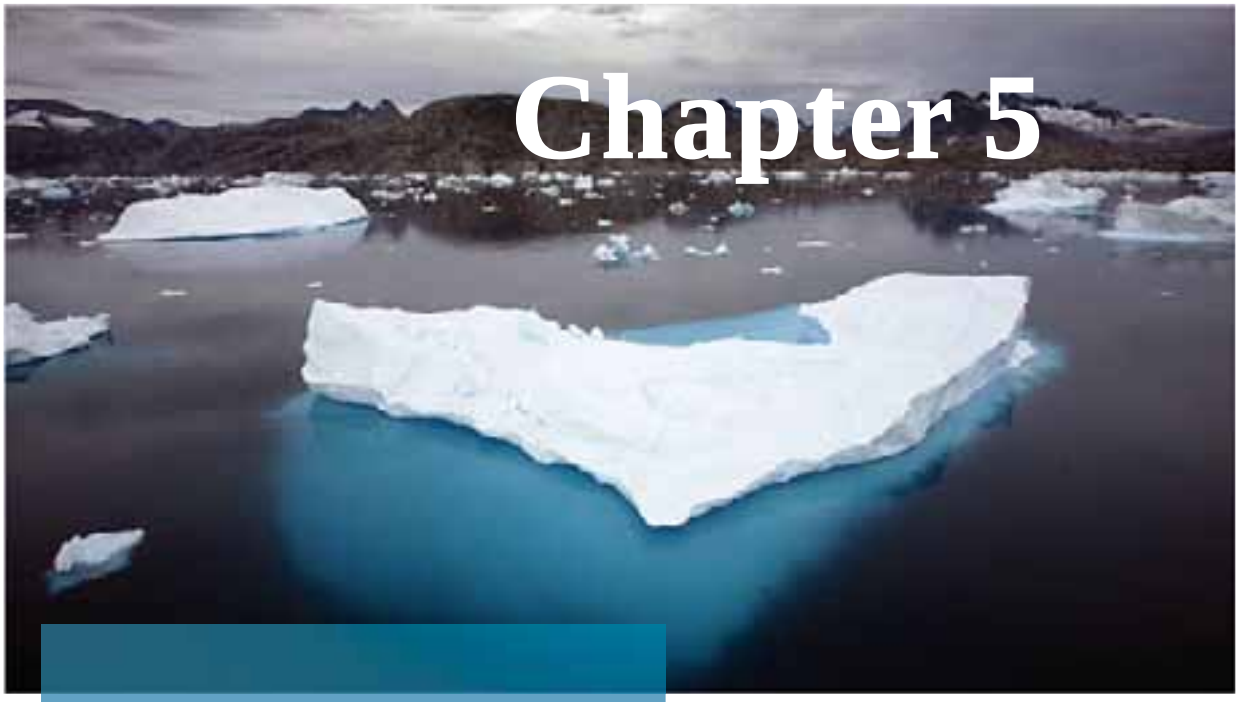
BOX 4.5 → Adapting to climate change with the NGO Practical Action (http://practicalaction.org/id=climatechange_adaptation)

Floating gardens: Adapting to climate change in Bangladesh

Much of the land in the Gaibandha district of Bangladesh is covered by water during the monsoon season, making it impossible to grow crops. Practical Action has developed a technology to allow farmers to grow food on flooded land. A floating garden is built using water hyacinth, which is collected to construct a floating raft. This is covered with soil and cow dung, in which vegetables can be planted. A new raft needs to be built every year, but the old one can be used as fertiliser during the dry season. The rafts, eight metres long and one metre wide, are made from hyacinth which is available for free locally. Soil is put on the surface of the raft and then the seeds planted in the soil. Summer and winter vegetables such as gourd, okra and leafy vegetables are grown. The floating gardens provide food for people even during the annual monga (period of food shortages) and they can also provide an alternative source of income through sale of any surplus in the market. They are suitable for farmers who need to diverse from traditional land use, and, as the rafts can be moved from place to place, they are also suitable for those that have temporarily or permanently lost their homes and land. The floating vegetable gardens are also created in ponds, canals and other water sources. Families are trained in pit cultivation – making 30cm x 30cm holes for planting vegetable seed. Every household has ten pits to grow vegetables and is given ten different high yielding varieties of fast growing vegetable and groundnut seeds. Training is provided in new techniques to cope with the conditions, grow more and better crops, and throughout the year. People are shown how to protect against plant disease and insect attack using organic control methods (e.g. home made botanical insecticide). Advice is also given in making seed-beds, preparing compost and enriching the sandy soil with compost and manure. The crops not only provide vital food but any surplus can be sold to generate an income.Tara Begum, a mother who was trained by Practical Action, managed to build her own floating garden with her family and grew a number of crops including red onion, sweet pumpkin and okra. "This has made a great difference to my life. Now I have enough food in the floods and I can give some to help my relatives as well." — Tara Begum

Rainwater harvesting in Zimbabwe

Climate change is disrupting the world's rainfall patterns, meaning some parts of the developing world are suffering from a drastic drop leading to a fall in water levels in many reservoirs and rivers. In sub-Saharan Africa 90% of agriculture is rain-fed, making it even more vulnerable to changing weather patterns. Rainwater harvesting is a way of capturing rain as it falls and retaining it in the soil or in tanks below ground so it can be later used as a source of clean water. By constructing ridges of soil along the contours of fields rainfall is held back from running off the hard-baked soils too quickly, so that crops have enough water to grow. Even when rainfall levels are low, families can harvest enough food. Practical Action has worked with farmers in Zimbabwe for 20 years, where soils are poor and rainfall is low. Before a rainwater harvesting project had been introduced to Humbane village in Gwanda, Zimbabwe, a good harvest was rare. But by 2003 a quarter of all the households had produced enough food to last the year. Tias Sibanda is Chairman of the Rainwater Harvesting coordinators in Ward 17, South Matebeleland. He is also one of the 100 farmer trainers. He cultivates 4.5 hectares of maize and also has a homestead plot of 2 hectares for sorghum. Before he was introduced to water harvesting techniques by Practical Action, he used to plant maize on the 4.5 hectares but frequently harvested nothing because of the drought. He was able to grow sorghum at his homestead, as the crop needs little water, but this provided insufficient food for himself and his family and they could only survive by buying food with the proceeds from selling livestock. He was one of the first farmers in the ward to build contours for conserving rainwater. This led to a big improvement in food supplies: last year, he had two crops of maize, the first producing 1.5 tonnes and the second 0.75 tonnes. He retained all of this for food and sold nothing. As a result, he no longer had to buy food and has sufficient stocks at home to last until next season. He calculates that he has avoided having to spend money on food equivalent to 12 goats. With a goat selling at some Z$300,000 (about £17), this means that he saved over £200. "Thanks to the water harvesting techniques shown to us by Practical Action," says Tias, "and with the contour field structures, we are now more 'food secure' and have no worries about soil loss. I am sure of further improvements in the future and, if the drought eases, would soon be able to sell some of my maize crop".



Chapter 5

Drivers of Change in Subsistence Social-ecological Systems

5.1 Defining and Understanding Drivers

This chapter focuses on selected major drivers of change that threaten and can undermine traditional social-ecological system adaptive capacity and resilience, as well as those that tend to reinforce them. Major change drivers of the 21st century and beyond are discussed that have clear relevance for GIAHS systems and sites, including climate change, biodiversity change, energy, cultural change, and some of the synergies among these drivers are also addressed. Further, possible adaptations and maladaptations in GIAHS-type SES are illustrated. The discussion of drivers has implications for the goals of the GIAHS Programme, which are drawn out in the form of Principles.

Some of the general dynamics inherent in traditional SES have already been discussed, especially endogenous factors characteristic of complex adaptive systems that are constantly evolving as their biophysical, cultural and social components change (chapters 2.4, 3 and 4). In these discussions, it has been made clear that ***change is always context specific,*** since exogenous drivers always have an influence via endogenous drivers, that is, global environmental, cultural and economic change are always mediated at local level by local human and biotic and abiotic conditions and responses.

There are clearly numerous interacting global drivers that are disrupting the world's natural resource base and leading toward the massive loss of cultures, languages, and SES resilience across all world regions and subregions. It is not possible to mention all of the endogenous and exogenous drivers and 'shocks' or their interrelations, nor to review the literature about the past implications of such drivers, or to regionalise them, or discuss their interrelations in specific contexts. Each region, country, and SES is subject to its own endogenous drivers and conditions, and is subjected to, interprets, adapts, and responds (both intentionally and unintentionally) to exogenous drivers and shocks (e.g. drought, disaster, conflicts) in different ways. Efforts such as the Millennium Ecosystem Assessment, the UN World Water Development Report, the Status Reports on the Millennium Development Goals, The Global Environmental Outlook, the World Resources Series on the Global Environment, the State of Food and Agriculture (FAO), the Global Biodiversity Assessment, the Global Forest Resource Assessment, Mountain Watch, the State of the World's Animal Genetic Resources (FAO), and the State of the World's Plant Genetic Resources (FAO)[1] offer diverse indicators, trends and analysis of change drivers. The focus of such assessments and their goals are diverse, and a 'mega-analysis' of such drivers and their interactions has yet to be conducted. Indeed, one of the most important limitations of all of these assessments is that they fail to adequately capture the synergies between change drivers, which is a topic taken up in this chapter.[2]

Rather, drivers of change and continuity that are expected to have the greatest importance for GIAHS-type SES are reviewed, emphasising both present trends and projected future trends as well as the synergies between these. The major drivers of interest to GIAHS are those that undermine resilience, or render traditional SES unstable or maladaptive, leading ultimately to the loss of much of their cultural and agroecological integrity (e.g. leading to material deprivation, cultural absorption, ecological degradation and biodiversity loss). Of particular interest are those global change drivers that clearly threaten GIAHS ecosystems (climate change and biodiversity change), and those that are most likely to have major economic (peak oil) and cultural consequences (drivers of cultural homogenisation). Climate change is considered to be a driver of drivers since it will influence nearly every other change process in the foreseeable future; biodiversity change reflects the interactions between many direct drivers such as land use change, invasive species, over-exploitation, pollution, etc. and it calls for a fundamental rethinking of some of the goals of the GIAHS Programme; peak oil is a direct global driver that is and will increasingly also drive many other drivers over much of the 21st century, and cultural change is an indirect driver that has very specific importance for traditional GIAHS SES adaptive capacity and resilience.

The concept of drivers has been given particular relief in the Millennium Ecosystem Assessment in its conceptual framework:

> *A driver is any natural or human-induced factor that directly or indirectly causes a change in an ecosystem. A direct driver unequivocally influences [social-]ecosystem processes....An indirect driver operates more diffusely, by altering one or more direct drivers... Changes in ecosystem services are almost always caused by multiple, interacting drivers that work over time and over level of organization and that happen intermittently. Changes in ecosystem services can feed back to alter drivers* (Nelson 2005).

The MEA categories of ***indirect drivers*** of change are 'demographic, economic, socio-political, scientific and technological, and cultural and religious,' whereas the ***direct drivers*** include 'climate change, nutrient pollution, land conversion leading to habitat change, over-exploitation, and invasive species and diseases' (Ibid). In some of the chapters of the MEA, for instance in the chapter on Food and Ecosystems, examples of drivers are somewhat different: direct drivers are identified as 'changes in resource availability (land, water, fish biomass, biodiversity), intensification of production, and climate change,' and indirect drivers are 'population growth or international trade regimes' (Shah et al. 2005). Ultimately, of course, the principle drivers are the sun and genetic evolution: it is widely agreed that, even if most current societies collapse in the near future, the earth's ecosystems and the remaining biodiversity will continue to evolve without our massive interference, albeit in a highly altered form.

For the purposes of understanding subsistence SES dynamics, drivers may be characterised as ***endogenous*** or ***exogenous*** to a particular system depending on the scale of analysis, where drivers originate, their scale of influence, as well as at what scale drivers can be changed positively or negatively). ***Direct drivers are in effect proximate (immediate) causes***, which are generally easier to identify than ***indirect drivers which are ultimate, or underlying causes of proximate drivers*** (Geist & Lambin 2002).

Different people (i.e. local population groups, policy makers, scientists) have different theories about drivers, which stems in part from the fact that they occupy different points of view, have different interests, cultures, and different knowledge or means of understanding SES. Scientists are often given the task of adequately describing direct drivers and discovering the indirect drivers underlying them, since they are considered to be more 'objective', to have the conceptual frameworks and measurement tools and methods to discover underlying drivers that are usually highly complex and very often not manifest at the level of appearances or experiences. Science is, in fact, about understanding causal relations within hierarchies of influence but, as discussed in Chapter 3.5.2, theories also contain 'black boxes' where understanding is lacking, and there is knowledge other than scientific knowledge (e.g. local knowledge) that scientists lack. Scientists also have cultures and values that influence how they see and interpret the world. In addition, the science associated with global change processes and SES are meant to deal with complexity and integration at multiple

scales, which means, essentially, that everything is related with everything else, systems are open, conflicting (or antagonistic) and compounding (synergistic) processes and trends are occurring simultaneously, which makes uncertainty and surprise the rule rather than the exception. Further, scientists bring specific disciplinary points of view and tools and methods to bear on understanding change, so that all such views are partial. At this moment in time, as is discussed further below, scientists' capacities to recognise and inter-relate different important change drivers is still quite limited due to disciplinary bias, ideology, modelling limitations, and complexity and uncertainty.

This means that the identification of proximate and underlying drivers is highly complicated, problematic, and often open to interpretation and dispute, since different actors have different opinions about the underlying drivers, these drivers may have their own underlying drivers, which in turn may be both direct and indirect, and most phenomena that are important drivers of change are subject to much uncertainty. ***What is important in the attempt to distinguish between direct and indirect drivers is that a superficial understanding of change processes within SES can lead to policies and actions that may actually fuel negative change drivers (GIAHS Principle 6)***, as can be seen in a hypothetical example in Box 5.1 which was derived from two different case studies.

The search for a better understanding of direct and indirect drivers is crucial to adaptive capacity and resilience, and it represents a continual learning process for all of the actors involved. New knowledge is continuously emerging; such knowledge is used in practice for adaptation, and this adaptation itself becomes a direct driver. It is only necessary to consider what is occurring globally in relation to knowledge about climate change, where knowledge is contested and evolving and this new knowledge is generating adaptive strategies which may begin to mitigate climate change; but unless the indirect drivers of climate change are well understood and addressed, adaptation may accelerate the indirect drivers rather than mitigate them. A clear case is that of agrofuels, which initially were considered by many scientists and policy makers to represent an attractive, viable alternative to fossil fuels that would reduce greenhouse gas emissions.[3] As agrofuel production began to increase, however, prices for food and animal feed began to rise, and many scientists as well as so-called 'watchdog' NGOs[4] began to call attention to the implications of biofuel production, questioning whether their production in fact reduces greenhouse gas emissions, or whether it increases them both directly and indirectly, depending upon which species are produced, and how and where they are produced (Crutzen et al. 2007, Pimentel et al. 2006, Searchinger et al. 2008) (see also Section 5.X). A clear reason for optimism is that our understanding of such relationships is advancing daily, knowledge from multiple actors and agents are being increasingly integrated (in part as a function of the worldwide web), as are the information and the tools that are required to make as much sense as is humanly possible out of this complexity and these change processes. The ideological and informational barriers to understanding SES dynamics and global change processes are tumbling down as the world comes to grips with the dire future scenarios that it is presented with almost daily.

BOX 5.1 | A hypothetical example of the complexity of, and perspectives on, change drivers

Land clearing for agriculture is a direct driver of deforestation in a particular tropical dryland region. Researchers indicate that this is due to other direct drivers such as land fragmentation and decreasing farm size. Indirect drivers are population growth together with land tenure regimes (a prohibit on sales of land) that have together led to land fragmentation and decreasing farm size, so that young couples must search for new farmland. Population growth has its own indirect drivers which include a pervasive cultural belief in the importance of having many children, the practice of polygamy, and a subsistence system that requires a great deal of labour, which are all outcomes of long historical processes. High fertility is also the result of improvements in health and sanitation as well as food aid that reduce infant mortality, which in itself a result of national economic growth combined with policies to improve services to rural areas that do not include family planning since this is against cultural norms. Food-for-work programmes provide an additional incentive to maintain high fertility levels since household well-being is directly tied to the amount of labour available.

Pressure on land for agriculture and deforestation are also ironically driven by policies that create conservation areas. Economic growth contributes to increased consumption of timber and fuelwood, which in part drives the policies toward conservation of forests. Another underlying driver is drought, which reduces farm yields and creates pressure on timber resources, driving prices for forest products up which leads to illegal exploitation of local forest resources on the part of outsiders. Regional drought is the result of deforestation as well as of global climate change. Global climate change is worsened by deforestation. Together with drought and high fertility levels, scientists consider that government policies reduce land access and generate poverty.

Government actors tend to see poverty as the indirect driver; locals attribute forest clearing ultimately to climate change whereas they identify the over-exploitation of timber resources on the part of outsiders as the proximate cause; and international donors pinpoint government policies around land markets as well as climate change as the indirect drivers.

5.2 Climate Change as a Driver and as a Driver of Drivers

The rise in carbon dioxide and other greenhouse gases is positively correlated with an increase in global average temperature of 0.6 degrees C in the 20th century, with forecasts of global warming of between 2 to 5 degrees C by 2100 (IPCC 2007a). Global warming is already responsible for changes in evaporation, evapotranspiration, precipitation, soil moisture, water storage and river flow (UNEP 2006). There are now readily visible increases in the melting of the Greenland ice sheet and mountain glaciers around the world, and global warming may be responsible for the increase in extreme weather events such as the strengthening of hurricanes in the Western Atlantic-Caribbean and the increasing frequency and intensity of EL Niño Southern Oscillation (ENSO) events in the southern Pacific Region (Tudhope et al. 2001). The projected effects of continued warming are summarised in Box 5.2. They can best be summarised as alarming and generally highly negative for most parts of the globe if action to substantially reduce greenhouse gas emissions is not taken soon (Risbey 2007; see also Flannery 2007, Monbiot 2007, Pielke et al. 2008). Climate change acts as a driver of

BOX 5.2 | IPCC projected climate change impacts on systems and sectors of particular relevance to subsistence social-ecological systems (IPCC-WGII 2007)

Ecosystems

• The resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances (e.g. flooding, drought, wildfire, insects, ocean acidification), and other global change drivers (e.g. land-use change, pollution, fragmentation of natural systems, over-exploitation of resources).

• Over the course of this century, net carbon uptake by terrestrial ecosystems is likely to peak before mid-century and then weaken or even reverse, thus amplifying climate change.

• Approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5oC (medium confidence).

• For increases in global average temperature exceeding 1.5-2.5°C and in concomitant atmospheric CO_2 concentrations, there are projected to be major changes in ecosystem structure and function, species' ecological interactions, and shifts in species' geographical ranges, with predominantly negative consequences for biodiversity and ecosystem goods and services, e.g. water and food supply.

Food

• Crop productivity is projected to increase slightly at mid- to high latitudes for local mean temperature increases of up to 1-3°C depending on the crop, and then decrease beyond that in some regions (medium confidence).

• At lower latitudes, especially in seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1-2°C), which would increase the risk of hunger (medium confidence).

• Globally, the potential for food production is projected to increase with increases in local average temperature over a range of 1-3°C, but above this it is projected to decrease (medium confidence).

Coasts

•Coasts are projected to be exposed to increasing risks, including coastal erosion, due to climate change and sea level rise. The effect will be exacerbated by increasing human-induced pressures on coastal areas (very high confidence).

• By the 2080s, many millions more people than today are projected to experience floods every year due to sea level rise. The numbers affected will be largest in the densely-populated and low-lying megadeltas of Asia and Africa while small islands are especially vulnerable (very high confidence).

Industry, settlements and society

• The most vulnerable industries, settlements and societies are generally those in coastal and river flood plains, those whose economies are closely linked with climate-sensitive resources, and those in areas prone to extreme weather events, especially where rapid urbanisation is occurring.

• Poor communities can be especially vulnerable, in particular those concentrated in high-risk areas.

Health

• The health status of millions of people is projected to be affected through, for example, increases in malnutrition; increased deaths, diseases and injury due to extreme weather events; increased burden of diarrhoeal diseases...and the altered spatial distribution of some infectious diseases.

•Climate change is projected to bring some benefits in temperate areas, such as fewer deaths from cold exposure, and some mixed effects such as changes in range and transmission potential of malaria in Africa. Overall it is expected that benefits will be outweighed by the negative health effects of rising temperatures, especially in developing countries.

• Critically important will be factors that directly shape the health of populations such as education, health care, public health initiatives, and infrastructure and economic development.

Water

• Water impacts are key for all sectors and regions. Climate change is expected to exacerbate current stresses on water resources from population growth and economic and land-use change, including urbanisation. On a regional scale, mountain snow pack, glaciers and small ice caps play a crucial role in fresh water availability. Widespread mass losses from glaciers and reductions in snow cover over recent decades are projected to accelerate throughout the 21st century, reducing water availability, hydropower potential, and changing seasonality of flows in regions supplied by meltwater from major mountain ranges (e.g. Hindu-Kush, Himalaya, Andes), where more than one-sixth of the world population currently lives. Changes in precipitation and temperature lead to changes in runoff and water availability. Runoff is projected with high confidence to increase by 10-40% by midcentury at higher latitudes and in some wet tropical areas, including populous areas in East and South-East Asia, and decrease by 10-30% over some dry regions at mid-latitudes and dry tropics, due to decreases in rainfall and higher rates of evapotranspiration. There is also high confidence that many semi-arid areas (e.g. the Mediterranean Basin, western United States, southern Africa and northeastern Brazil) will suffer a decrease in water resources due to climate change. Drought-affected areas are projected to increase in extent, with the potential for adverse impacts on multiple sectors, e.g. agriculture, water supply, energy production, and health. Regionally, large increases in irrigation water demand as a result of climate changes are projected. The negative impacts of climate change on freshwater systems outweigh its benefits (high confidence). Areas in which runoff is projected to decline face a reduction in the value of the services provided by water resources (very high confidence). The beneficial impacts of increased annual runoff in some areas are likely to be tempered by negative effects of increased precipitation variability and seasonal runoff shifts on water supply, water quality and flood risk. Available research suggests a significant future increase in heavy rainfall events in many regions, including some in which the mean rainfall is projected to decrease. The resulting increased flood risk poses challenges to society, physical infrastructure and water quality. It is likely that up to 20% of the world population will live in areas where river flood potential could increase by the 2080s. Increases in the frequency and severity of floods and droughts are projected to adversely affect sustainable development. Increased temperatures will further affect the physical, chemical and biological properties of freshwater lakes and rivers, with predominantly adverse impacts on many individual freshwater species, community composition and water quality. In coastal areas, sea level rise will exacerbate water resource constraints, due to increased salinisation of groundwater supplies. Projections and model consistency of relative changes in runoff by the end of the 21st century.

other drivers, as is illustrated in different sections of this chapter.

The findings of the Assessments of Impacts and Adaptation to Climate Change (AIACC) project (Leary et al. 2008a, b), a contribution of the IPCC Fourth Assessment Report 2007 (IPCC-WGI 2007a, b, IPCC-WGII 2007, IPCC-WGIII 2007), suggest that 'the biggest challenge in confronting the negative impacts of climate change lies in the developing world, where people and systems are most vulnerable. Not only are these negative impacts likely to

be most serious in the subtropics and tropics, where most developing societies reside, but the capacity to adapt to them is also limited in these regions' (Pachauri 2008).

Some of the most recent research concentrates on local climate change risks, where models predict the emergence of 'novel' climates as well as the complete disappearance of some existing climates, mapping these out on the basis of IPCC 4th Assessment models (Williams et al. 2007). Local climate change is expected to be substantial across the globe but especially over most of Africa, South America, southern and eastern Eurasia, parts of eastern North America, and the Arctic. The two phenomena, disappearing climates and novel climates, do not overlap geographically, and the risk of these climates increases linearly with increasing global warming. Novel climates are those which have no analogue in the 20th century: 'Because the pre-Industrial Revolution climate system was already in a warm state, further increases in temperatures are likely to be novel not just relative to the 20th century but also to climates for at least the last million years' (Ibid.). Projected novel climates result mainly from the poleward shift of thermal zones and are concentrated in tropical and subtropical regions, where the Amazon and the Indonesian rainforests are predicted to experience the greatest differences compared with the present. Novel climates are projected for the western Sahara, low-lying portions of east Africa, eastern Arabian Peninsula, the south-eastern U.S., eastern India, Southeast Asia, and north-western Australia.

Disappearing climates, on the other hand, are concentrated mainly in tropical mountains and on the poleward side of continents, where the specific regions that are projected to lose their 20th century climates include the Columbian and Peruvian Andes, Central America, the African Rift Mountains, the Zambian and Angolan highlands, the Cape Province of South Africa, south-east Australia, portions of the Himalayas, the Indonesian and Philippines Archipelagos, and some circum-Arctic regions (Ibid.).

GIAHS pilot sites, as well as most of the world's subsistence SES, are located primarily in these regions, and the consequences of increasing global warming are likely to be both direct and indirect drivers of change for these systems throughout this century and beyond. Those SESs found in developing countries are likely to be even more vulnerable to climate change because of already existing stressors. How climate change may add to these existing stresses is impossible to say at the moment, given the uncertainties discussed in this chapter and the limited research on the likely impacts and responses to climate change among small-scale agricultural and pastoral societies worldwide. R.K. Pachauri, the Chairman of the IPCC, has written that 'even with the most ambitious mitigation actions, the inertia of the system will ensure that the impacts of climate change will continue for centuries, if not beyond a millennium. Knowledge of impacts and the manner in which they would grow over time is therefore critical to the development of capacity and measures for adaptation to climate change' (Pachauri 2008).

Encouragingly, a number of studies and conferences are beginning to appear that report on past responses to climatic variability, offering a glimpse of current climatic conditions and local responses and make predictions of what might happen more generally as well as specifically for subsistence SESs in particular regions of the world (Leary et al. 2008a & b, Morton 2007, Puri 2007, Salick & Byg 2007). The findings of these studies, summarised below, suggest that GIAHS sites are likely to suffer severe stresses very soon, if not immediately, from a variety of climatological, hydrological, ecological, biocultural and sociological changes related to climate change. Attempts to support adaptive management in GIAHS sites will be hijacked by these changes and their consequences unless they are planned for. Vulnerability and adaptive capacity assessments, as well as impact assessments, are thus key prerequisites.

5.2.1 Expected Impacts

As global warming continues, subsistence SES will likely see increases in annual average temperatures and daily temperature ranges, changes in total precipitation and its distribution, changes in start dates and lengths of dry and wet or hot and cold seasons, changes in wind intensity and frequency, more extreme storms associated with warmer ocean water, increased melting of glaciers and reduced runoff from snow melt. Thus, changes in water availability in time and space are likely to be critical direct drivers of change in SES. As Barnett et al. (2005) report, an earlier spring melt caused by warming will shift peak water supplies to winter and early spring, leaving less for the summer when it is needed most. This could be catastrophic to farmers with increasing water needs, little capacity to store water, and pre-existing vulnerabilities.

Reduced water availability is likely to affect soil moisture and, where overall precipitation is reduced, contribute to soil erosion and eventual desertification. All soil

Changes in the Qori Kalis Glacier, Quelccaya Ice Cap, Peru, are shown between 1978 (top) and 2002. The glacier retreat during this time was 1,100 meters.

processes are likely to be affected, including accelerated decomposition of organic matter and depression of nitrogen fixing activity (see Rosenzweig & Hillel 2000). Decreased precipitation would also be a driver of forest conversion to dry savannah or woodland vegetation. Annual extreme precipitation—the maximum amount of precipitation in a five day period in a given year—is also predicted to increase nearly worldwide, resulting in ***increased risk of flooding***, which can also directly cause soil erosion and/or siltration, crop failure, and damage to infrastructure. Climatic change has already caused shifts in the ranges of plants and animals (see the following section on biodiversity change). Another of the major impacts of climate change is expected through sea level rise (SLR). A recent World Bank study proclaimed that 'Continued growth of greenhouse gas emissions and associated global warming could well promote SLR of 1m-3m in this century, and unexpectedly rapid breakup of the Greenland and West Antarctic ice sheets might produce a 5m SLR' (Dasgupta et al. 2007). They project that 'hundreds of millions of people in the developing world are likely to be displaced...and accompanying economic and ecological damage will be severe for many.' The worst effects are limited to a few countries where implications are 'potentially catastropic' (Vietnam, Egypt, the Bahamas), but for many others (e.g. China) 'the absolute magnitudes of potential impacts are very large' (Ibid.) Regions that are most impacted are East Asia and the Middle East/North Africa. SLR will have very negative implications in East Asia for large population segments (from 37 to 162 million people), GDP (losses from 2-10%), agriculture (losses from 1-4% of total area) and the environment. Further, apart from reducing the amount of land available for cultivation, SLR will also lead to salt-water intrusions in coastal wetlands, flooded fields and water tables (SBSTTA-CBD 2007). One of the current GIAHS sites is an island (Chiloe) and islands are, of course, especially vulnerable to SLR.

Other proximate drivers of change that are driven by climate change are biological (see next section), demographic, especially through migration; political, as conflicts increase over access to resources and environmental degradation (Schubert et al. 2008), and economic, as energy, food and other commodity prices increase and stagflation and economic depression results. Some of the implications of the synergistic effects of climate change and other drivers are discussed in Section 5.7.

Morton (2007) reviews the scientific studies that have specifically dealt with the effects of climate change on the types of subsistence SES that the GIAHS programme is concerned with. Some of these studies involve modelling future impacts on key crops or ecosystems, such as Jones & Thornton (2003), who predict a 10% decrease in maize yields in rain-fed small holder farms across Africa and Latin America by 2055; others use qualitative data to focus on adaptation, often taking recent or current climatic variability as a proxy for future climate change and emphasising the impacts of extreme events, such as tropical storms. Morton (2007) argues that there is a need to link these ecological studies to livelihood features of subsistence SES. His conceptual framework recognises their complexity and location-specificity, and incorporates 'non-climate stressors' on rural livelihoods and their contribution to vulnerability. He emphasises three categories of climate change impact upon SES livelihoods: 1) biological processes affecting crops and animals at the levels of individual organisms or fields; 2) environmental and physical processes affecting production at a landscape, watershed or community level; and 3) impacts on human health and on non-agricultural livelihoods. Expanding on these points, he describes several examples of the complexity of potential impacts, such as different crops in the same systems being affected in either positive or negative ways: for instance, Agrawala et al. (2003), studying smallholders in Tanzania, predict yield decreases for maize (the food staple) and yield increases for coffee and cotton, which are cash crops. Non-climate drivers, such as poor market access, environmental degradation, globalisation and HIV/AIDS, must be assessed and considered together with climate change to better map the vulnerability of farming systems (Morton Ibid.).

With regard to climate change impacts, the IPCC (2007b) predicts, for moderate global temperature increases (1-2°C), negative impacts on wheat, maize and rice, which are the major food crops of subsistence farmers and smallholders worldwide. Even where models include adaptation strategies, yields still decline for all levels of warming. Irrigation water requirements, particularly for rice in Southeast Asia, are expected to rise, increasing water stress. Studies on the effects of thermal stress on livestock show reduced productivity, conception rates and poorer health (Morton 2007), while there is increasing risk of crop pests diseases, such as spread of Maize Streak Virus or Cassava Mosaic Virus where rainfall increases, and sorghum head smut where it decreases. The latter is more likely to spread because farmers often switch to sorghum if maize crops fail. Habitats suitable for tsetse-transmitted trypanosomiasis and East Coast Fever are predicted to decline overall, but effects will be localised. An increased frequency of floods may increase outbreaks of epizootic diseases such as Rift Valley Fever and African Horse Sickness (Ibid.). The increased likelihood of extreme weather events (storms, floods, heat waves, droughts), particularly during critical moments in the agricultural cycle, could dramatically worsen these predictions and make the scheduling of all subsistence activities much more complicated and difficult.

Maize crop in Africa affected by drought.

Morton's framework is a helpful start to exploring climate impacts, but it does not take into account numerous synergies with other drivers (such as biodiversity change) or mention social or cultural impacts implied by

the highly interrelated subsystems and institutions of SES as have been described in this framework, and it is to these that we now turn.

5.2.2 Expected Consequences

The first point to emphasise is that climate has always been hazardous, and subsistence SES have co-evolved in the context of daily, seasonal, and inter-annual variability in weather and climate. Many of the observed innovations in agrobiodiversity, cropping patterns, inputs, infrastructure, landscape modification and social-cultural institutions are in fact risk minimising responses to weather and climate related constraints (Ellen 2007, Morton 2007, Puri 2007, Salick & Byg 2007), such as the use of irrigation systems in arid regions with high evaporation rates and reliance on surface water from snow melt, such as is found in the Maghreb (Kadi 2004). There already exists a wealth of information and local knowledge concerning forecasting and responses to climatic variability, for instance in areas subject to El Niño events (Orlove et al. 2000, Puri 2007), that may in fact be useful for adaptation to future climate change, even if changes are of a kind and/or magnitude never before seen. As discussed in Chapter 2, even in case of unexpected 'surprises', social learning processes make it likely that local communities will apply their local knowledge as well as borrow, adjust and innovate new knowledge and technologies to minimise risks and reduce vulnerabilities (see Section 5.3.2). But of course, not all communities will have access to all the information or materials that they might need, nor will all consequences of climate change be amenable to local solutions; as a recent conference at the RGS in London highlighted, there are in fact 'limits to adaptation' (Adger et al. 2008, Salick & Byg 2007) and certainly there will be maladaptation.

5.2.3 Local Responses

Anthropologists and archaeologists have shown that responses to food stress caused by drought, flood or other disaster usually follow a sequence of escalating effort as the crisis worsens (Bailey & Peacock 1988, Colson 1979, de Garine & Harrison 1988, Minnis 1985, Puri 2007, Waddell 1975, Watts 1988). Colson (1979) classified responses to food shortages into five 'devices' that reduce the risk of food stress: 1) diversification of activities rather than specialisation or reliance on a few plants or animals, 2) storage of food stuffs, 3) storage and transmission of information on what are called famine foods, 4) conversion of surplus into durable valuables which can be stored and traded for food in an emergency, and 5) cultivation of social relationships to allow one to tap resources of other regions. Minnis (1985) describes these categories giving numerous ethnographic examples of these devices, and adds other responses as well, such as the use of ritual means for the distribution of limited resources or changes in social relationships to address what are often perceived by local people as the ultimate causes of food shortages (see below).

Participants at a conference on Indigenous Peoples and Climate Change in April 2007 (Salick & Byg 2007) compiled a similar list of traditional and innovative strategies to minimise risk and respond to critical weather-related situations:

1. Diversified resource base: including many crops and varieties, varied field locations, and diversified food procurement practices, including hunting, gathering and options to sell surplus crops, handicrafts, wage labour and forest products.
2. Change in varieties and species planted, including harvest of unusual species
3. Change in timing of activities: crop harvests, wild plant gathering, hunting and fishing must be adjusted to changes in growing seasons and timing of animal migrations and reproduction. Changing scheduling can produce conflicts with other activities.
4. Change of techniques: such as smoke-house (indoor) drying of animal and plant products if hot and dry periods are shorter or interrupted. Also includes adoption of new technologies such as irrigation instead of rain-fed agriculture.
5. Change of location: shift of activities and/or settlements.
6. Changes in resources or lifestyles: such as a fall back by farmers on hunting and gathering of wild plants and animals.
7. Exchange: obtaining food and necessities through barter, reciprocity, or markets. May include an increasing dependency on emergency aid from NGOs and State.
8. Resource management: traditional techniques, often subtle, to enhance climate-sensitive resources, such as water, wild forest resources, irrigation

However, the ways in which these responses are strung together, and the ways in which changes are tracked in a developing or sudden weather event or similar catastrophe varies across societies depending on the type of event and numerous other context-dependent social and ecological variables.

Puri (2007) highlighted the differences between foragers and farmers, and argued that 'foragers move through a series of responses as drought and food scarcity increase in length and severity, from relying on their knowledge of alternative food and water resources, to increasing their range of foraging and then finally, reaching out to a wide social network of long term kin-based relationships and/or economic relationships.' On the other hand, Sahlins (1972) has argued that the costs of maintaining social relationships and relying on social networks begins to outweigh the benefits as food and water shortages become prolonged, thus intra-group sharing peaks and then tends to drop off as food stress increases.

Farmers may have similar responses, including falling back on hunting and gathering, and on the use of secondary and semi-domesticated crops. Watts describes the sequencing of responses by farmers in Africa:

> *Their behaviour, in an aggregate sense, is graduated with respect to time and the proportion of domestic resources they commit…Low order responses, such as planting changes, borrowing food from kin, or wage labouring are relatively flexible and pliant. To the extent that these coping mechanisms are incapable of securing reproduction, slower and deeper responses follow, such as the sale of livestock, grain loans, liquidation of assets, or pledging. The terminal strategies in this sequence may be, as in the case of farm sale, largely irreversible* (Watts 1988).

In other cases, terminal responses might involve dependence on government emergency aid and emigration and/or refugee status. Puri (2007), describing Bornean swidden farmers' later responses, explains that,

> *'[O]nce social networks and commercial options are exhausted, [responses] are either migration, which may involve violent take over of new territories, or appeals to colonial or contemporary States for aid. Emergency aid, in the form of food, fuel, transportation, or monetary compensation are all new and increasingly important options that farmers everywhere look to as El Niño events increase in severity. Not surprisingly, these options may depend on expending political capital, such as votes or party allegiance, and thus may not be available to all* (Puri 2007).

Morton (2007) has identified both longer term-adaptive strategies and immediate coping strategies used by pastoralists in East Africa during recent droughts:

- Mobility is the most important adaptation to variation in rainfall: in drought years, pastoralists often fall back to grazing areas that are not used in normal dry seasons.
- Herd accumulation provides insurance against drought, with livestock being sold off as needed, although market access and efficiency may limit this response.
- Multi-species herds allow numerous ecological niches and different labour abilities of men, women and children to be exploited.
- Accessing formal bank savings or informal credit from shopkeepers.
- Supplementary feed, purchased or lopped from trees, is a coping strategy.
- Intensify animal disease management through traditional and scientific techniques.
- Increasingly pay for water from solar or oil powered bore holes.
- Livelihood diversification away from pastoralism into low-income or unsustainable occupations, such as charcoal production.
- Intra-community exchange to distribute livestock products and use of live animals.
- Shift to irrigated farming.

For foragers, farmers and pastoralists, responses to food stress caused by climatic variability relies on local knowledge and usually tracks the growing severity of the crisis by adding new coping mechanisms and often expanding responses outward in space through social networks as crises become prolonged and severe. However, the exact sequence of these responses and the expenditure of social capital in any particular situation, especially if unexpected impacts or surprise events are involved, may be difficult if not impossible to predict. As described in Chapter 2, the complexity of interacting factors is just too high to be able to model usefully.

One important reason for this unpredictability, consistent with the basic structures of SES discussed earlier, is that local responses are always mediated by social and cultural factors, in this case, local perceptions, meanings and explanations of weather and climate categories and events. These are discussed in more detail below.

5.2.4 Local Interpretations

Traditional small scale societies, indigenous cultures, and even modern western communities, seldom explain weather-related events in naturalistic or biophysical terms, as meteorologists might. Spiritual or supernatural beings and forces may be invoked to explain such occurrences, for instance, thunderstorms and hail may occur due to the wrath of dieties, as is the case in Tibet (Salick & Byg 2007) and resultant impacts may also be seen as the wrath of God, as in the UK.[5] In addition, adverse weather may also be attributed to an imbalance in social relationships, since many traditional societies believe that the natural world is an extension and consequence of the social world: as Rayner (2003) comments, 'Nature is a direct source of feedback for behaviour, desirable or undesirable.' There are numerous ethnographic examples where extreme weather and other catastrophes are explained as a dereliction of ritual responsibilities to ancestors or elders, or the breaking of social norms governing marriage and fidelity. On the other hand, many societies engage in rituals, sometimes involving dancing, to positively influence the weather, such as the month-long Ihanzu of Tanzania rain rites reported by Sanders (2003). Inclement weather can also arise due to transgression of moral codes against cruelty, selfishness, and greed, as well as due to violations of hunting or food collecting taboos. Thus, in Borneo, thunder, violent winds and rain are attributed to the fact that people have disturbed the graves of ancestors or have mocked hunting dogs and other animals (Needham 1964, Puri 2005), while historical records show that there is an increase in witchcraft accusations during periods of food stress among Southwestern US tribes such as the Zuni (Minnis 1985).

Conversely, the supernatural world may instead be affected by weather-related changes. Salick & Byg (2007) report that Tibetans fear that their local deities and spirits, who are physically manifest in the mountains and glaciers, are in fact deserting them as evidenced by retreating glaciers and reduced snowfall. Many are at a loss to explain this abandonment by their protectors, which causes great anxiety and stress: having no precedents to draw on from oral history, some now blame themselves and changes in their social and economic relationships that have accompanied increased tourism and integration with China.

One increasingly important external source of influence is scientific weather forecasting. The selective incorporation of new scientific knowledge of weather and climate, including forecasts, will always be seen and assessed through local perceptions. As Rayner (2003) concludes in a recent review of anthropological studies, 'people in a wide diversity of climatological and cultural circumstances all exhibit some degree of ethnometereological or climatological competence derived from a combination of experience of past weather patterns, occupational or survival skills, and social organization.' At the same time, these competencies act as a cultural filter such that 'we tend to incorporate new information that is compatible with our existing views and reject that which is irrelevant to or in conflict with them.' Thus, Roncoli et al. (2003) in Burkina Faso, and Broad (2000) in Peru, found numerous instances where scientific forecasts were 'misunderstood' by farmers. In the former case, they concluded that this is not so problematic given that 'these misunderstandings helped reduce risks entailed in prob-

The industrial world-view has caused the extinction of more species in the past 150 years than the total species extinction from the Ice Age to the mid-nineteenth century. The same industrial way of thinking has caused the extinction of about 2,000 different indigenous peoples in the Western hemisphere alone. The extinction of species and the extinction of peoples are closely linked. And the extinction continues. The [United States] Bureau of Indian Affairs, in 1992, declared nineteen different indigenous nations in North America extinct. The rate of extinction in the Amazon rainforest...has been one indigenous people per year since 1900. And if you look at world maps showing cultural and biological distribution, you find that where there is the most cultural diversity, there is also the most biological diversity. A direct relationship exists between the two. Winona LaDuke, indigenous rights activist, 1993.

How can you have a rainforest Indian if there's no rainforest for them to live in? So this idea of 'we've got to preserve the culture' OR 'we have to preserve the rainforest' is missing the boat. In the interest of preserving the rainforest, we need to preserve cultural diversity. The best way to protect ancestral rainforests is to help the Indians hold on to their culture, and the best way to help them hold onto their culture is to help them protect the rainforest. Prof. Mark Plotkin, Ethnobotanist, 2006*

abilistic forecasts…They subsume adaptive mechanisms that build on time-honoured farming competence, keen awareness of subtle shifts in environmental conditions, and scrupulous management of scarce resources in view of an uncertain future' (Roncoli et al. 2003).

While 'local interpretations of climate change may help people better make sense of observed climate changes,' Salick & Byg (2007) emphasise that these 'do not necessarily empower them to act. This is especially the case where climate change threatens landscape features of spiritual value, or where the culprits of climate change are perceived to be outsiders. These 'others' can be other parts of society, the state, companies or western cultures, which are generally seen as being outside the sphere of local influence.' If they are empowered to act, then their actions may be constrained by a lack of access to required resources, which may also be controlled by outsiders, as Roncoli et al. (2003) report. Often farmers need equipment and animals for ploughing, seeds for short cycle varieties, fertilisers, and credit in order to implement existing coping mechanisms or to innovate.

In adapting to both short-term and long term changes in weather and climate, the current literature supports the conclusion that farmers in subsistence SES are active interpreters of both traditional and scientific knowledge of weather and climate, and have a set of coping mechanisms to reduce risk and recover from disturbances. What is often needed is improved access to resources to enable them to implement known responses or to develop new responses. Impact assessments are based on predictions of the local consequences of temperature rises, precipitation changes, and other linked effects of climate change. Most impact studies today focus on global, regional, and national trends with very few attempting to predict the local affects of variation in geography, geomorphology, hydrology and biodiversity. All GIAHS sites should consider establishing local weather stations to monitor local conditions and changes, which can be compared with more regional forecasts and be used to develop local forecasts and responses. Simultaneously, communities in the GIAHS areas need to begin to assess their vulnerabilities to these predicted changes at community and household levels, perhaps through an assessment of past extreme events and local responses to them. Adaptive capacity assessments, based on scenario building exercises, would also allow communities to imagine negative and positive impacts of climate change and how they would begin to address them through risk reducing adaptations or the use of old coping mechanisms and development of new ones.

5.3 Biodiversity Change

There are very significant changes in biodiversity that are occurring now and that will continue and accelerate over this century. Major extinctions of wild species are occurring together with major losses in crop diversity and in wild crop relatives where, for example more than a quarter of all wild potato species are expected to become extinct within the next half century, which will also imperil the abilities of crop breeders to ensure that improved varieties are adapted to climate change (CBD 200X). Changes in species range are also occurring and are predicted to accelerate due to climate change. Together these lead to changes in species richness patterns that affect ecosystem services in unpredictable ways. These changes are due to multiple drivers, nearly all of which are human-induced.

The major drivers of change are different in different world regions and their biomes will be affected in different ways. Local species extinctions and changes in species richness patterns are expected to have a disproportionately negative effect on traditional subsistence societies because they depend most directly on these species and on the ecosystem services they provide for their livelihoods and cultural integrity. Species loss clearly results in a decrease in the value of biodiversity in all its dimensions, where especially direct use values (material goods), indirect use values (ecosystem services), and option (insurance) values are of great concern. There may be means to mitigate some of these changes, especially where species loss is mainly due to habitat conversion and fragmentation, such as in tropical forests. However, it is inevitable that humans will have to adapt, and whether and how they can adapt, and the forces leading to maladaptation, are of crucial importance to the GIAHS Programme which has as a principle aim the conservation of agrobiodiversity *in situ* and the promotion of adaptive capacity and resilience of GIAHS communities and SES. *These are indeed extremely important goals, but their formulation and means of implementation require intelligent modification in light of the drivers discussed herein*. The discussion that follows must delve somewhat deeply into the fields of ecology and evolutionary biology, where the most recent insights *lead to important conclusions regarding the needs for an in-depth understanding of change processes within GIAHS SES that can only be achieved through ecological research.*

5.3.1 Types, Magnitudes and Drivers of Biodiversity Change

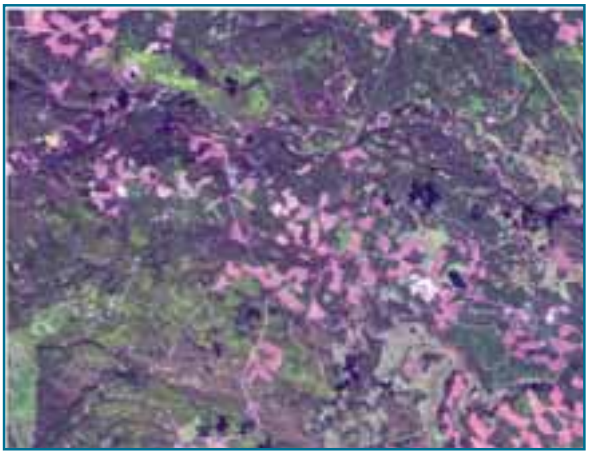
The sixth extinction of species on the planet is underway, and the rate of extinction is probably accelerated at least 100 fold over those occurring millions of years ago. The magnitude of global species extinctions that are currently tracked by the International Union for the Conservation of Nature (IUCN) is presented in Box 5.3. In addition to global extinctions, there is great concern because many more species will become extinct in particular locales. Added to these very major losses of species and biodiversity globally and locally are the potentially even more disruptive changes expected in species' range (itself a contribution to extinctions) that will result from climate change and habitat change, since these synergistic changes are expected to affect most species, communities and ecosystems in very unpredictable ways. Each of these phenomena - global species extinctions, changes in species range that results from climate change, and changes in ecosystem functions and services that result, are dealt with here in terms of their expected magnitudes and impacts. The type and nature of drivers and their interactions are important insofar as they determine to a significant extent the possibilities for mitigation (minimising change) and the needs for adaptation when changes are inevitable. The discussion of invasive species that follows in the next section highlights not only a major driver of biodiversity change, but as well lends many insights into ecological and evolutionary processes that are entailed in climate change, its likely outcomes, and implications for conservation and human adaptation.

According to the Millennium Ecosystem Assessment (Mace et al 2005), habitat change and fragmentation are the most important drivers of species extinctions at present, whereas invasive species and exploitation are the next most common, and disease, climate change and pollution follow these in importance. Scientists generally agreed that species extinctions are principally due to habitat change and fragmentation, where it is human-induced land use changes such as agricultural expansion and especially tropical deforestation that have been the most important drivers, particularly since species richness is highest in tropical forests. As a result, most conservation activity has focused on reducing habitat loss and its impacts (Lewis 2006). Nevertheless, the major drivers of change in biodiversity vary per ecosystem type, as summarised by the Millennium Ecosystem Assessment and presented in Figure 5.1. For example, it can be seen that, in tropical forests, habitat change has had a very high impact on biodiversity over the past 100 years, followed by over-exploitation, and to date climate change, invasive species, and pollution have played minor roles, whereas in boreal forests, nitrogen and phosphorus pollution have been the major drivers.

What is also of great importance to stress is the fact that, since about the 1990s, there has been growing evidence that climate change is both interacting with these drivers and increasingly as a driver of biodiversity change in and of itself, to the point where most experts now agree that it will surpass habitat loss and fragmentation as the principle driver of species extinctions (Hannah et al. 2005, Thomas 2004, van Vuuren 2006). Climate change is not only increasingly driving species extinctions: it also affects species composition in any given ecosystem through changes in range (distribution) of species, changes in timing of reproductions, and changes in the length of the growing season for plants (CBD 200X and below). What is very important is the fact that it is the synergy between habitat change and fragmentation and climate change that is considered to be the most threatening, given that habitat loss and fragmentation can prohibit species from migrating and colonising new areas in response to climate change (Lovejoy and Hannah 2005).

BOX 5.3 | The IUCN Red List and species extinctions (2004)

The 2004 IUCN Red List contains 15,589 species threatened with extinction...this figure is an underestimate of the total number of threatened species as it is based on an assessment of less than 3% of the world's 1.9 million described species...[The list shows] 12% of birds as threatened, 23% of mammals, and 32% of amphibians…Of plants, only conifers and cycads have been completely assessed with 25% and 52% threatened respectively...we know little about non-terrestrial systems (freshwater and marine), or many species-rich habitats (such as tropical forests or the ocean depths), or species-rich groups such as invertebrates, plants and fungi (which together compose the overwhelming majority of species)...Recent extinction rates far exceed the rates of extinction in the fossil record. Extinction rates based on known extinctions of birds, mammals and amphibians over the past 100 years indicates that current extinction rates are 50 to 500 times higher than extinction rates in the fossil record. If Possibly Extinct species are included this increases to 100 to 1,000 times natural (background) extinction rates. This is an extremely conservative estimate, as it does not account for undocumented extinctions. Although the estimates vary greatly, it appears that current extinction rates are at least two to four orders of magnitude above background rates. Rates of extinction are at levels equivalent to, or even higher than, those that characterized the Big Five mass extinction events on the planet, which mark changes in geological epochs.

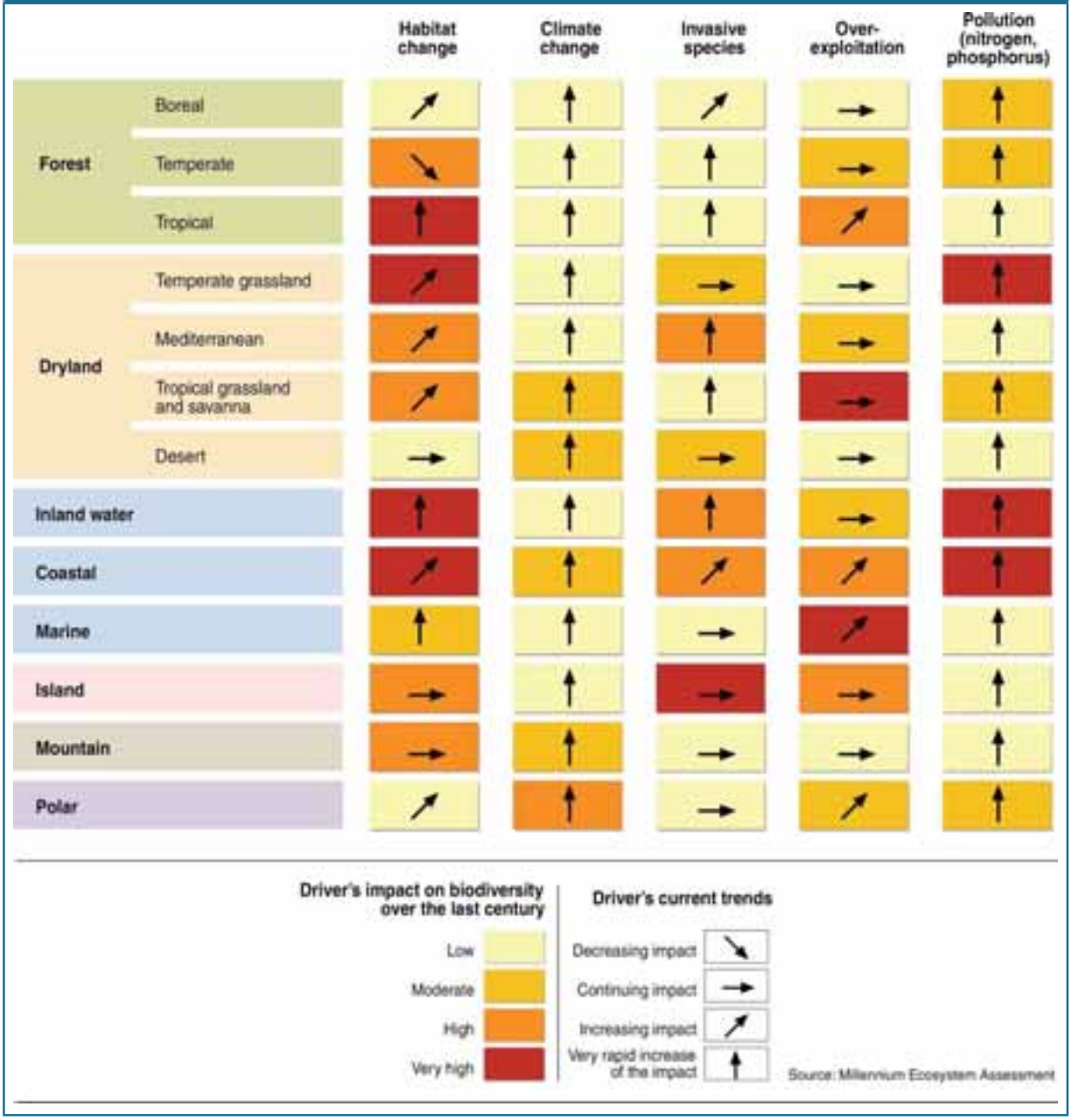


Caribou habitat fragmentation in Canada as highlighted using satellite imagery

Van Vuuren et al (2006) modelled vascular plant species extinctions under the four Millennium Ecosystem Assessment scenarios taking into account the contributions of habitat (land use) change and climate change and predicting the effects of each for different regions. Their models are conservative because they did not take into account species invasions, over-harvesting, and other drivers. They predicted that, 'In terms of absolute numbers of species, tropical forest, tropical woodland, savan-

FIGURE 5.1 | Main direct drivers of change in biodiversity and ecosystems (CBD 2006, Figure 4.1)

The cell colour indicates impact of each driver on biodiversity in each type of ecosystem over the past 50–100 years. High impact means that over the last century the particular driver has significantly altered biodiversity in that biome; low impact indicates that it has had little influence on biodiversity in the biome. The arrows indicate the trend in the driver. Horizontal arrows indicate a continuation of the current level of impact; diagonal and vertical arrows indicate progressively increasing trends in impact.



nah, and warm mixed forest account for 80% of all plant species lost at equilibrium by 2050.' The greatest decrease in area will be found in tropical ecosystems and, because these are also highest in biodiversity, they will experience the greatest biodiversity loss. The Afrotopic region (South of the Sahara) will experience the largest decreases, which will be driven by increases in agriculture and in population; the Indo-Malayan region will have the second greatest loss due principally to the expansion of agricultural land. Globally, their models forecast that, over the period 2000-2050, habitat change will be the dominant driver of extinctions given that climate change is predicted to be less important for tropical biomes, and it is these biomes that have the highest number of species. However, the recent literature review carried out by the World Wildlife Fund (Box 5.4) draws attention to numerous other studies that emphasise the dramatic effects that climate change is likely to have on biodiversity in one of the most important tropical regions, the Amazon, and particularly in the Amazon rainforest, where drought and fires are the major concerns.

Whereas many scientists have warned that climate change may drive certain species and ecosystems to extinction, such as in high latitudes and in neotropical cloud montane forests, Williams et al. (2007) models mapping local climate change (see Section 5.2 above) indicate that

BOX 5.4 | Climate change impacts in the Amazon - Review of the scientific literature (WWF 2006)

The Amazon contains one of Earth's richest assortments of biodiversity with...at least 40,000 plant species, 427 mammals, 1294 birds, 378 reptiles, 427 amphibians, 3,000 fishes, and likely over a million insect species. The Amazon River is the largest single source of freshwater runoff on Earth, representing some 15 to 20% of global river flow. Subsequently, the Amazon's hydrological cycle is a key driver of global climate, and global climate is therefore sensitive to changes in the Amazon. Climate change threatens to substantially affect the Amazon region, which in turn is expected to alter global climate and increase the risk of biodiversity loss.

Empirical and modeled data suggest that the Amazon basin is at particular risk to climate change effects. Projected changes of warmer temperatures and decreased precipitation during already dry months could manifest in longer and perhaps more severe droughts and substantial changes in seasonality. Coupled with land use changes, these changes could lead to devastating impacts, including: increased erosion, degradation of freshwater systems, loss of ecologically and agriculturally valuable soils, loss of biodiversity, decreased agricultural yields, increased insect infestation, and spread of infectious diseases....

Climate change effects pose a substantial threat to Amazonian forests and the biodiversity within them. Amazonian forests contain a large portion of the world's biodiversity: at least 12% of all flowering plant are found within the Amazon [and] therefore threats to Amazon forests translate into threats to biodiversity at large. In fact, climate modeling studies have projected a warming and drying effect which, when combined with a decrease in evapotranspiration from plants, will likely lead to a substantial decrease in precipitation over much of the Amazon. These changes will likely lead to significant shifts in ecosystem types and loss of species in many parts of the Amazon. Land-use change will also interact with climate through positive feedback processes that will accelerate the loss of Amazon forests...Large-scale modeling shows widespread forest loss over most of the Amazon, accelerated by positive feedback between warming, forest dieback, and emissions of carbon from soil and vegetation. In fact, the Brazilian government has released figures suggesting that deforestation has exceeded 520,000 square km since 1978, with the second worst year of forest loss occurring in 2004. Species specific modeling suggests that 43% [of the] sampled Amazon plant species may become non-viable by the year 2095 because their potential distributions will have changed due to climatic shifts. In order for species affected by these changes to reach appropriate new bioclimatic zones, dispersal or migration would have to occur over hundreds of kilometers...

Amazon forests are also threatened by secondary effects of climate change, such as a potential increase in the frequency and perhaps in intensity of fires. It is suggested that fire poses the greatest threat to Amazon forests and numerous studies have shown a well established link between forest fires, habitat fragmentation, climate change, and extreme El Niño events in the Amazon....climate models predict that a globally warmer world may result in a permanent El Niño-like state with dramatic effects such as: droughts, fires, and increased release of carbon to the atmosphere. El Niño events...tend to dry affected areas and lead to large, intense droughts and fires. Severe droughts can also stress and potentially kill sensitive plant species, resulting in a replacement of tropical moist forests with drought-tolerant plant species. It has also been shown that there are substantial releases of carbon from the Amazon during El Niño years. Strong El Niño years bring hot, dry weather to much of the Amazon region and the ecosystems act as a source of carbon to the atmosphere instead of a sink as during non-El Niño years.

There are a number of positive feedback loops that drive the expansion of fires in the Amazon: 1) Forest fires release substantial amounts of smoke into the atmosphere which can reduce rainfall and thus promote more drought and more fires; 2) Fire-assisted conversion of forests to agriculture and pastures also promotes drought by decreasing water vapor flux (evapotranspiration) to the atmosphere, further inhibiting rainfall; and 3) Fire increases the susceptibility of forests to recurrent burning by killing trees, thereby allowing sunlight to penetrate and dry the forest interior, and increasing the fuel load on the forest floor.

such climates may entirely disappear. Species that are endemic to these climates are obviously at risk of extinction, and ecological communities likewise may desegregate or disappear. The threats to biodiversity are subsequently great: 'The areas of disappearing climates closely overlay regions identified as critical hotspots of biological diversity and endemism, including the Andes, Mesoamerica, southern and eastern Africa, Himalayas, Philippines, and Wallacea' (a group of Indonesian islands separated by deep water from the Asian and Australian continental shelves) (Ibid.).

In order to understand the full impacts of climate change on biodiversity, it is important to clarify how species respond individually and in the aggregate (on average). In the short term, phenological changes (changing in the timing of natural phenomena such as the date of leaf and flower emergence, of migrations, of egg laying or of insect maturation) are probably the first to occur, where plants are affected primarily by photo-period, temperature and, less commonly, by moisture availability (Root & Hughes 2005). In temperate zones, such changes are related to accumulated temperature, where global warming is advancing the timing of seasonal events such as budburst and delaying autumnal events such as leaf fall, giving rise to a longer growing season. Higher latitudes and higher elevations experience greater change. In the tropics, phenology is more related to precipitation, where an increase in the length of the dry season will have major consequences for plants. For example, plants may fail to flower or flowering may not be synchronised, and insect populations may be be higher during the phase of main leaf growth (Ibid.).

Insects and mammals are likewise affected, and the effects on these species in turn has major implications for plants, plant communities, and agriculture. Insects and other cold blooded animals may move faster into adulthood, potentially resulting in more generations per year; flying insects may be able to fly earlier, permitting them to find mates, disperse, evade predators and lay eggs more readily. Many animals that feed on insects may encounter greater supplies that are available earlier in the year, which may increase their own population numbers.

Drought in the Amazon region 2007.

Certain migratory species may find that their foods supplies are unavailable at the accustomed moment or in the accustomed place, which may pose a major threat to temperate species that over-winter in tropical areas (Ibid).

> *As the globe warms, animals will probably shift both their ranges and densities. Species will be able to move into regions that are warmed, and retreat from areas that become too warm...but this will be species-specific ....This differential shifting could easily cause a tearing apart of present-day communities, resulting in an uncoupling of predator-prey interactions and reequilibration of competitive interactions (Ibid.).*

This discussion of phenology highlights a subject that is of great concern to biologists and ecologists - the uneven ability of species to change their range, or distributions, in response to climate change, which many scientists think represents one of the main means that species have to adapt given that climate change is occurring too rapidly to permit many species to evolve *in situ*. If individual species are not able to change their range in response to changes in temperature or precipitation, they are likely to be lost. It also highlights a second major concern, which is the break up of species associations and communities, which will result in further extinctions and also in major ecological changes that occur as new species associations form and species richness potentially decreases (see below).

Throughout biogeographical history, climate change has continually transformed biodiversity, resulting in evolution *in situ* of individual species, changes in species distributions in time and space, and changes in associations between species with concomitant changes in species communities and in ecosystems. Species survive in what are known as environmental or climate envelopes - the temperature and moisture regimes to which they are adapted physiologically. For some species, these envelopes, and hence species' distribution ranges, are quite small, whereas for others they may be quite large. Species also have different capacities to migrate and colonise in order to keep up with movement in their climate envelopes as the climate changes: thus, the responses of different species to climate change are individualistic. Since the 1980s, scientists have been building models that use climate envelopes and data on individual species (physiology, current distribution) and ecosystems to estimate future extinction rates in different areas of the world, as well as changes in species range (actual as well as projected) (IPCC 2001, Malcolm et al 2005). Indeed, meta-analyses indicate that temperature rises in the 20th century have led to shifts in species' range toward the poles that average 6.1 km per decade (Williams et al 2007). In the past, the climate has changed rapidly and biodiversity has changed on a par with relatively few extinctions, but today habitat loss greatly constrains the capacity of species to adapt through migration (Hannah and Lovejoy 2005).

Species with high dispersal capabilities may migrate at the rate of one kilometre per year or more, so that these species, together with climatically tolerant species, are likely to dominate many of the earth's ecosystems. An example is goldenrod (*Soldago* L.), which invaded Europe at rates of close to 200 km / yr in the 1800s (Malcolm et al 2005). Other species, such as forest herbs and earthworms, may migrate at rates of less than 10 m / yr. These processes of migration, colonisation and local extinction also occur at different rates: some species may persist for a substantial amount of time in an unfavourable environment before becoming extinct, creating a substantial lag time before the full consequences are felt.

Scientists also argue that species are less able to adapt to climate warming today than at any other period in the last 10,000 years due to the faster pace of change and to human-induced ecosystem changes, especially habitat change, which limit the possibilities for species to migrate and to adapt. Thomas et al (2004) used projections of species' distributions from climate change scenarios to model risks of extinction for sample regions covering about 20% of the world's land area. They found that, as global warming causes species' ranges to shift, population numbers are reduced and the newly colonising populations exhibit lower levels of genetic variation. Further, only a subset of races or subspecies are able to change their distributions since either other subspecies have colonised first, or there are geographical barriers which prohibited this. 'Climate warming in the north temperate zone is already resulting in population-level extinctions and range retraction in the southern parts of the distributions of many species, and further expansions are taking place at many northern range boundaries. Genetically diverse populations and subspecies toward the warm margins of species range are, therefore, becoming extinct' (Ibid.). Further, many of the species that are likely to become extinct have a very limited range (e.g. many endemic species in biodiversity hotspots). Still, there are other researchers that argue that such predictions are made on the basis of too few interacting variables - this is taken up below in the discussion of species invasions.

Both biodiversity loss and changes in species range can have multiple knock on effects on ecosystems, which may be drastically altered not in large part due to changing species composition and richness, which in turns affects ecosystem functions and services (see Chapter 3.3). Many researchers emphasise the difficulties entailed in attempting to predict such changes:

> *No single analysis can capture all ecological risks associated with climate change, e.g. shifts in ecosystem distributions, changes in carbon sequestration, altered hydrological functioning, and increased fire frequency, so a variety is needed to capture the multidimensional responses of species and ecosystems to multidimensional climate change. Moreover, climate change is just one of many current ecological stressors. Interspecific differences in response time to the rapid pace of projected 21st-century climate change will also promote the formation of novel species assemblages and extinction risk. These factors, together with the projected development of novel climates and the threat that the climates particular to some biodiversity hotspots may disappear globally, create the strong likelihood that many future species associations and landscapes will lack modern analogs...* (Williams et al. 2007).

Ecologists and evolutionary biologists are developing major insights for understanding change drivers and their potential outcomes for species and ecological communities especially by examining invasive alien species. These species and their impacts provide 'experiments' across large spatial and temporal scales that allow researchers to observe ecological and evolutionary processes and rates of genetic change that are not easily observed otherwise (Sax et al. 2007), and it is also to this

Much of the world is becoming dominated by ecosystems composed of species that do not share a long evolutionary history. As globalization and climate change continue to occur, a greater number of ecosystems will be made up of exotic species assembled from multiple sources. It is currently unclear how the function of such systems will compare with those that are relatively less invaded (Sax et al. 2007).

literature that we turn in order to assess the desirability and potentials for *in situ* conservation (mitigation of change drivers) and for human adaptation through the GIAHS programme.

5.3.2 Threats: Ecological Insights from Invasive Alien Species

Invasive alien species (IAS) are considered to be a major driver of local and global extinctions and of biodiversity change in general, where the number and magnitude of invasions have increased 'by as much as 1000 times' over the past few centuries due mainly to global trade and transport, giving rise to introductions that have been both intentional and unintentional (GISP n.d.b). As the citation at the top of this page indicates, there are an increasing number of reasons for giving special attention to species invasions. First, invasions will continue to be an important driver of biodiversity and ecosystem due to the same forces that have caused them in the past. Second, invasions will increase quite dramatically through range change: most of the world's habitats are likely to experience native species loss and also to gain new species. Third, the literature on invasive species helps to understand biodiversity change from both a biological and an ecological perspective, and provides insights that help to understand if not predict the effects of global environmental change. Fourth, there is a dearth of literature on human adaptation to biodiversity change, where some of the recent literature on IAS helps to highlight some of the important implications for human welfare and adaptation.

The first problem is to define 'invasive alien species', which in the past has been difficult and today is even more problematic. 'Alien' (some scientists prefer the term 'exotic') is generally regarded as a species that has been introduced or established because of human activities. 'Invasive' generally implies that an alien species has become naturalised, that is, its populations have become self-sustaining in an area in which it has been introduced or has otherwise colonised (Sax et al 2007). The Millennium Ecosystem Assessment defined IAS as 'those species introduced outside their normal area of distribution whose establishment and spread modify ecosystems, habitats, or species, with or without economic or environmental harm' (Mace et al. 2007) (for an example, see Box 5.5).

Assessing the human and ecological impacts of invasive species is both complex and important. The insights to be derived lead to recommendations for researching the dynamics of native species decline in GIAHS sites, and ***such insights also have implications for GIAHS programme goals related to in situ conservation of agrobiodiversity*** that will be drawn out here. Sax et al. (2007) review much of the relevant literature, drawing out the implications for the understanding of native species extinctions, adaptation, and climate change impacts, among other topics.

First, they note that it is often assumed that ecological communities are full, or saturated with species, and new species cannot be added without losing existing species - a corollary is that, if areas are species rich, they will be more resistant to invasion. However, whereas studies of birds on islands do provide strong support for saturation, many other studies show that many communities are not saturated, and that the net outcome of species invasions is usually an increase in species richness. For GIAHS, this implies that ***biodiversity will not necessarily decline even when native species become locally extinct; however the direct and indirect values of biodiversity may alter substantially with changes in species and in ecosystem functions and services.***

Second, the concern with invasive species is often centred around the idea that it is competition between species that leads to native species extinctions. Recent reviews indicate, however, that exotic species are not likely to provoke global extinctions even if they do destroy local populations. On the other hand, however, there are many cases where exotic predators and pathogens have led to native species extinctions, so that it is important to include predators and diseases, in addition to abiotic factors such as facilitation (interactions between species that benefit at least one of the species and do not harm the other). What is not clear, however, is whether competition-induced extinctions are underway but are not yet evident since this may take hundreds to thousands of years.

Third, the formation of ecological communities may often occur through mechanisms other than co-evolution, based solely on ecological interactions among species. Some communities are composed mainly of exotic species and these communities can be as rich as those that are dominated by native species. It is not necessary for species to have co-evolved since 'rapid evolutionary adjustments might still have occurred over timescales of decades to centuries' (Ibid.). This highlights a fourth insight, which is the fact that genetic adaptation can occur rapidly (within a few years), as is seen in laboratory conditions and in relation to insect resistance to pesticides, as well as in natural field settings where human influence is low. They note that severe population bottlenecks do not necessarily halt rapid adaptation, and in fact cite genetic mechanisms through which population bottlenecks might promote adaptive responses. These insights are very important for conservation initiatives: researchers are increasingly questioning ***whether conservation biologists might not be impeding rapid genetic adaptation when they make deliberate attempts to maintain genetic diversity within managed populations.***

Finally, Sax et al. indicate that climate envelope approaches (as discussed above) may be inadequate to project future distributions of many species since native distribution 'results from the combined effects of abiotic environmental conditions, species interactions and dispersal limitation' but it is usually difficult to determine how such variables operate independently or interactively (see below). Climate envelope modelling might not be appropriate for estimating responses of species that have small

BOX 5.5 | Ecological and social effects of invasions by *Lantana camara*

Lantana camara is regarded as one of the world's ten worst invasive alien species, but in India it is used as a hedge plant, as a source of paper pulp, fuelwood and traditional medicine, and even as a craft material for weaving baskets and making furniture. Invasion by Lantana is known to cause significant changes in the structure and function of forests by obstructing potential succession processes, interfering with fire regimes and pollination services, and displacing native flora and fauna. However, in recent years several local communities have begun using Lantana as a craft material in place of bamboo and rattans, which have dwindled due to over-extraction. Encouraging people to use Lantana in this way not only reduces pressure on native resources, but also creates options for improving rural livelihoods. Large-scale harvesting may even help control the spread of the species, and allow native biodiversity to regenerate and recover' (GISP n.d.)

Another source reports that the species 'can become dominant understorey shrub by smothering native shrubs. The dense thickets can even transform forest into shrubland. Its allelopathic qualities can affect the growth of nearby plants. *L. camara* can stall natural forest regeneration and poses a serious threat to native endangered plant species. The plant is able to invade a wide range of environments. Its prolific all-year flowering allows rapid dispersal, and the seeds are spread fairly long distances by birds. On the Galapagos Islands, the dense thickets affect bird breeding by impeding flight. Its extensive seed production throughout the year encourages rat populations. The replacement of native pastures with *L. camara* in Kenya is threatening the habitat of the sable antelope. The shrub can interfere with agricultural harvesting and reduce the economic viability of certain crops. It can also cause loss of pasture by invading agricultural land. There are many cases of cattle and sheep poisoning due to the shrub, particularly newly introduced young animals. Unripe berries are poisonous to humans and can cause death. The dense thorny thickets produced by the plant can deter human access. The soil has a lower capacity to absorb water in dense stands of *lantana* than in grass cover, increasing run-off and therefore soil erosion. The plant may reduce erosion in mountainous areas not previously covered by grass. Thickets can be a breeding ground for malarial mosquitoes in India...' (http://www.tropical-biology.org/research/dip/species/Lantana%20camara.htm)

Another effect that *L. camara* can have is to increase the incidence of tsetse fly, which spreads the African trypanosomiases, which are diseases that can be deadly to humans (sleeping sickness) and to cattle (nagana).'In tsetse both sexes feed exclusively on the blood of vertebrates for a few minutes every 2-3 days. Tsetse flies seek cover from high temperatures to conserve energy and plants provide shelter for tsetse in all the biotopes they occupy. Recently, tsetse have taken cover in plantations and under the invasive bush *Lantana camara* that has invaded large areas of the tsetse fly belt of Africa' (Syed & Guerin 2004).

native ranges given that some such species have small native geographical distributions but large naturalised distributions, 'suggesting that they tolerate climatic conditions different from those experienced in their native ranges', and also some species with large native ranges are found 'well outside their predicted climate envelopes in their naturalized ranges' (Ibid).

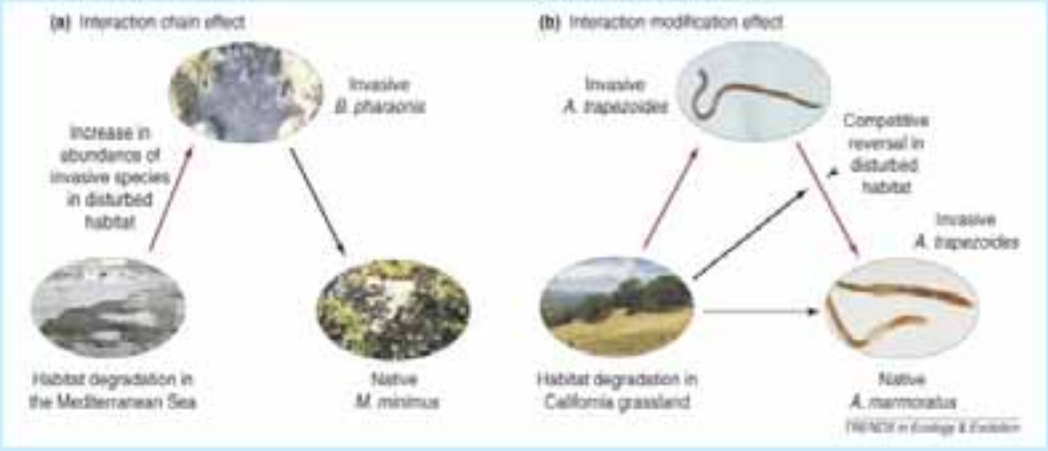
Didham et al. (2007) take this discussion further and have made an important contribution by studying two major biodiversity change drivers: habitat change and IAS. They note that these two drivers are usually studied independently, without researching the interactions between them.[6] They developed a framework to help identify and discriminate between two very different causal pathways through which such multiple drivers interact, and draw out the implications for conservation management directed toward mitigating the decline in native species. There is a strong correlation between habitat loss and invasions, which makes it difficult to understand precisely why native species decrease. It may be habitat modification that drives an increase in the area or intensity of invasion, where the impact of the invaders increases in direct numeric proportion to their abundance, or it may be that habitat modification changes the functional response of invasive species, where the total impact is not proportionate to invader abundance (a functionally moderated process). These are fundamentally different types of interaction with different consequences (Figure 5.2). The first case, where there is a per capita (numeric) effect, is what they term an ***interaction chain effect***, and it is probably very common, given that increasing the amount of habitat that is suitable for invasives generally has a direct impact on their total abundance. This can occur in a linear or a non-linear fashion, depending on the context and the species. Non-linear increases may indicate that even a small increase in habitat change may lead to a major change in invader abundance. In other words, there may be a lag time, and conservation efforts need to recognise that invaders that have not yet caused major impact may well do so in future. There are also other mechanisms through which habitat change can lead to increased invasive impacts through interaction chain effects.

In distinction to the interaction chain effect, there are an increasing number of studies that show that the impacts of invasive species is functionally mediated (what they term ***interaction modification effects***), and that 'cannot be explained without recourse to the moderating influence of habitat modification on the per capita interaction strength between native and invasive species' (Ibid.). Functional modifications may also occur through changes in predator-prey relations in landscapes that have been disturbed, or through spatial subsidies. It is not always the case that these functional changes lead to greater abundance of invasive species: there are cases where invasive species have moderated the effects of habitat change. Such cases may actually be quite important, given that exotic species dominate many land use systems across the globe. Finally, they note that not all interaction modification effects lead involve synergies: habitat modification may also mitigate (antagonistic effects) the effects of habitat disturbance on invasive impacts: for example, in New Zealand, when water was extracted for agricultural use, the native round-head fish *galaxiids Galaxias anomalus* was able to co-exist with the invasive brown trout *Salmo trutta* because the trout are substantially more sensitive to low water flow conditions (Ibid.).

What is important about the above discussion is that, in GIAHS sites, *there are multiple drivers of biodiversity change that will lead to increasing reconfigurations of species* (disaggregation of communities), *which can only be managed if synergies and antagonisms are relatively well understood.* For this, Didham et al. argue that *it is necessary to understand the different types of pathways, whereas current conservation approaches do not consider such interactions, even in the most advanced analysis.* The need to better understand the interactions and their dynamics is even more

FIGURE 5.2 | An interaction chain effect: mussel invasion in the Mediterranean (Didham et al. 2007, Figure 1)

The mussel Brachidontes pharaonis colonised the Mediterranean Sea via the Suez Canal in 1869, but remained rare before 1995 (Figure la) [25]. Early studies predicted that it would not become invasive because it was an inferior competitor to native Mytilaster in near-shore habitats [25]. However, a recent increase in habitat degradation led to Brachidontes dominance of offshore platforms, providing large source populations for propagules, which saturated near-shore beachrock habitats. This caused a dramatic shift from Mytilaster-dominated to Brachidontes-dominated communities on near-shore beachrock, which might otherwise have been a sink habitat for invasive species. Therefore, habitat destruction altered the population-level outcome for native species by increasing the relative importance of stochastic colonisation by invasive propagules, even in undisturbed habitats.



Empirical examples of interactive effects. (a) Interaction chain effect, in which habitat degradation in the Mediterranean Sea caused an increase in abundance of the invasive mussel B. pharaonis, displacing the native mussel M. minimus in near-shore habitats through increased propagule pressure. In this example, habitat degradation occurred on offshore platforms, so there is no direct effect of habitat change on native decline in near-shore bedrock. Photos reproduced with permission from Gil Rilov. (b) Interaction modification effect, in which grassland conversion to agriculture in California increased productivity, driving both an increase in abundance of the invasive earthworm A. trapezoides and a competitive reversal over the native earthworm A. marmoratus. In this example, native earthworms had higher growth rates in high-productivity conditions typical of disturbed habitats, so the direct effect of habitat change on native earthworms is likely to be small, and potentially positive, in the absence of invasive earthworms.

important when additional drivers are involved. However,

> *Attributing species decline to one or more drivers becomes increasingly difficult as the number of potential drivers and their interactive effects increases... Interaction chains are well known in global change research. In addition to the direct effects of CO_2 on plant physiology, elevated CO_2 can drive climatic change, which affects a great varieties of species... However, measuring the independent effects of CO_2 or climate change on native species decline will not enable prediction of the net combined effects of both drivers…One driver (CO_2) increases the extent or frequency of another driver (climate change) with the 'per unit' (e.g. degree of temperature increase) effect of the latter remaining constant..In contrast to interaction chains, the per unit effect of one driver can be modified by another in an interaction modification effect. For example, the geographical distribution of butterflies tracks climate warming, but in fragmented landscapes the movement of habitat specialists is restricted by adverse conditions...In this case, direct responses to climate change or habitat fragmentation do not change in intensity. Yet, one driver (fragmentation) increases the impact of a given change in climate on native biota'* (Ibid.).

If the pathways are well understood and the effects of one driver are proportionately related to the effects of other drivers, this then presents the possibility to mitigate negative effects through indirect means, such as by improving habitat quality or quantity, but this requires information about specific systems: 'ecologists need to routinely incorporate multiple factors into sampling designs or at least specify the environmental (global change) context in which a single factor is being addressed' (Ibid.).

There is as yet comparatively little literature that addresses how the processes mentioned here are likely to affect crop diversity, and most of the published literature addressing climate change in agriculture focuses on the world's major crops: maize, rice, and wheat. There has been far less attention thus far given to other crops and to landraces, which are the types of crops that many GIAHS communities are likely to cultivate: for example, searching on keyword 'landraces' produced 4,195 citations in CAB Abstracts, and searching on 'climate change' produced 12,022, but the combination of these two terms produced no records.[7]

5.3.3 Human Adaptations: Insights from Invasive Alien Species

While there is a large and exponentially growing body of literature on changes in biodiversity within the biological sciences, relatively little research focuses on human adaptation to biodiversity change and the consequences that such change has for human welfare, vulnerability, and resilience. There is a major gap in the literature that directly addresses how humans are adapting and may adapt in future to biodiversity change, although there is clearly more that has investigated, directly or indirectly,

how people adapt to the loss of biodiversity given, e.g. the introduction of HYVs, deforestation, desertification, other types of habitat change, migration and displacement. This literature has not yet been subjected to a meta-analysis for the purpose of gaining insights or developing conceptual frameworks, and it is not possible to review it in this context. However, the research on the economic implications of invasive species and human adaptation has been at least partially reviewed (Perrings 2006,[8] Shackleton et al. 2006) and, because of the importance of IAS to the overall analysis of global change, ecosystem change and native species loss, we rely largely on this literature to gain preliminary insights regarding human adaptation to biodiversity change.

Invasive species often requires human adaptation in the short term. It is clear from the literature that IAS bring benefits as well as costs to communities, and that these benefits and costs are not evenly distributed. Many IAS can be beneficial to some human communities at the same time that they pose costs for others, summarised in the adage 'One woman's weed is another's flower'. Nevertheless, attention has been focused on IAS for well over a century because they are considered to often wreck environmental and economic havoc, and for this reason there are currently a number of major international programmes directed toward their control or eradication.

The ecosystemic and economic effects of IAS have been documented in a large number of publications. Great efforts are expended by individuals, groups, and governments to combat invasive species (see Table 5.1 for some estimated costs), which can be very expensive and which also often have a low likelihood of success, since invasions are exceedingly difficult to reverse. The costs of invasive species are estimated to be very high and increasing: it is estimated, for example, that IAS in the United States provoke more than $138 billion per year in losses (of which an estimated US$ 21 billion is spent on control efforts), and that around 42% of the species that are listed as Threatened or Endangered are at risk due to invasive species. The global cost is estimated at US$1.4 trillion, or 5% of global GDP (Pimentel et al. 2000).

What these figures generally do not reveal, however, are the economic implications of invasive species for the livelihoods of the people most affected by them, that is, rural dwellers. Shackleton et. al. (2007) found only four published studies that rigourously examined the role of IAS in local livelihoods. Our own rapid review of CAB Abstracts[9] found 4,102 citations on 'species invasion', 3765 of which contained the keyword 'economic', and 126 of which included 'value', but only five that included 'livelihood'; a number of other studies mentioned specific uses of IAS. According to Shackleton et al. (Ibid.), economic valuations of IAS impacts focus on national or sub-national scale and primarily on ecological impacts or impacts on formal economic activities while omitting local level benefits or trade-offs.

Given this dearth of information, the Global Invasive Species Programme[10] carried out a rapid appraisal on the effects of invasive species on poor rural households and some more in-depth research was carried out in specific localities in South Africa and published in Shackleton et al (Ibid.). Such studies indicate that the effects of IAS on rural livelihoods are complex. Within communities, some households may make use of the invaders whereas others may not, or may suffer damages. As is the case with most wild species and landraces, many IAS provide multiple purpose resources used for food, medicine, fibres, construction, and other purposes, and they often generate income through sales. Many have acquired cosmological or religious significance over time, and some are thought to be beautiful. IAS may be found closer to households and thus reduce the need for labour to collect these resources compared with (possibly declining) native species. Shackleton et al. conclude from their South African study of *Ficus opuntia indica* (prickly pear) and *Acacia mearnsii* de Wild. (black wattle) that 'it is clear that the label of a 'pest' for an IAS is a culturally, socially, and economically specific judgement, and that the difference be-

TABLE 5.1 | Estimated costs of invasive alien species, selected cases (GISP n.d., p. 6)

Species	Economic variable	Economic impact	Reference
Introduced disease organisms	Annual cost to human, plant, animal health in USA	$41 billion/year	Daszak et al., 2000
Coypu/nutria (aquatic rodent)	Damages to agriculture and river banks in Italy	$2.8 million/year	Panzacchi et al., 2004
Zebra mussel	Damages to US and European industrial plants	Cumulative costs 1988-2000 = $750 million to 1 billion	National Aquatic Nuisances Species clearinghouse, 2000
Six weed species	Costs in Australia agroecosystems	$105 million/year	Watkinson, Freckleton & Dowling, 2000
Pines, hakeas and acacias	Costs on South African Floral Kingdom to restore to pristine state	$2 billion	Turpie & Heydenrych, 2000
Water hyacinth	Costs in 7 African countries	$20-50 million/year	Joffe-Cooke, 1997
Varroa mite	Economic cost to beekeeping in New Zealand	$267-602 million	Wittenberg & Cock, 2001
Comb-jelly	Lost anchovy fisheries in Black Sea	$17million/year	Knowler & Barbier, 2000
Golden apple snail	Damage to rice agriculture in Philippines	$28-45 million/year	Naylor, 1996

tween 'nuisance' and 'useful resource' is perhaps a matter of perspective and scale' (Ibid.).

Which factors seem to determine the net benefits to households and communities of IAS? Contextual factors that Shackleton et al (Ibid.) suggest influence livelihood impacts and local perceptions include 'the extent and density of infestation, availability of alternatives, costs and mechanisms of control, land tenure, current vulnerability, discount rates, and the severity of loss of ecosystem goods' (Ibid.). The case study from Timor in Box 5.6 also shows that the ecosystem services provided by IAS may be considered by rural dwellers to be beneficial (e.g. for soils) even while governments perceive them to be negative, and that ability to benefit from, or control IAS depends as well on labour constraints.

Shackleton et al. (Ibid.) developed a conceptual framework to help understand the possible impacts of IAS on rural livelihoods (Figure 5.3 and Table 5.2). The curves represent temporal trajectories that correspond to the period subsequent to a species' introduction. The first curve plots abundance of the IAS over time in the absence of controls. The second represents local livelihood benefits which are assumed to mirror the abundance curve - the greater the resource, the greater the benefits. The third is the cost curve, and includes 'all costs, such as ecological costs, aesthetic costs, harvesting costs, costs of control, etc.,' which compound as abundance increases and therefore the curve is exponential (Ibid.). The fourth curve reflects the livelihood vulnerabilities that are related to the IAS, where vulnerabilities are assumed to be high at the

BOX 5.6 | Invasive species in Timor: Livelihoods, adaptations and conflicts of interest (McWilliams 2000).

Over the course of the 20th century, *Lantana camara*, *Opuntia elatior* (prickly pear) , *Imperata cylindrica* and, most recently, *Chromolaena odorata* (siam weed) have invaded Timor with diverse effects on livelihoods that have provoked diverse adaptation strategies and responses that reveal conflicting interests in eradication.

In the early part of the century, prickly pear covered 'substantial areas of grazing and farm land', at times necessitating 'wholesale relocation of settlement sites as surrounding arable land was consumed'. It's spread was probably facilitated by the fact that 'the persistence of clan warfare and feuding meant that mountain populations usually maintained barricaded defensive strongholds against attack' where prickly pear was used as a defensive barrier. Eventually, biological control agents were introduced that led to a dieback of prickly pear and today it is found only in isolated pockets.

When *Lantana camara* invaded, it 'quickly established and reestablished itself following the clearing and burning of swidden food gardens. Apart from somewhat increased labor requirements for swidden clearing, most Timorese agriculturalists managed to incorporate *Lantana* fairly effectively into their cropping systems. Indeed, the increase in biomass and *Lantana's* soil conditioning properties tended to improve cropping conditions and to reduce the fallow period required in swidden cultivation systems' (other research indicated that fallows could be reduced from 12 to 5-6 years in the presence of *Lantana*). '*Lantana*, however, was much more of a threat to cattle owners and herders. As grasslands became smothered in the unpalatable *Lantana*, extensive areas were lost to grazing resulting in cattle losses and the disbursement of stock. It also led to increase in animal numbers in the remaining *Lantana* free areas, with consequent overgrazing and soil erosion...for reasons which remain undocumented, the general incidence of *Lantana* began to decline' and by the 1980s its capacity to threaten biodiversity was largely eliminated.

Chromolaena odorata represents the largest current threat, and it began to invade Timor sometime before 1980, with 'significant adverse implications' for livelihoods. Farmers had to 'incorporate the weed into their farming systems. Few of...[its] properties were beneficial. It grows rapidly and produces a dense mass of leaf matter that gradually shades out all other competitors...[it] seems to thrive on fire..The marked and extended dry season...creates ideal conditions for the spread and dispersal' and 'In many villages up to 60% or more of the arable land is now covered.' For rural Timorese communities, cattle represents the main store of wealth, and are a vital part of social relations. *Chromolaena* is 'unpalatable and even toxic as a cattle feed, and combined with the heavy shading habit of the plant, the expansion of Chromolaena is in direct proportion to the decline in stock feed across the rangelands of West Timor', especially depriving animals of dry season feed. 'Local management strategies..have been severely constrained by the absence of any overall coordinated industry approach. Farmer responses...tend to be very localized and opportunistic. In the absence of any programs for improving the quality and quantity of rangeland feed stocks, and present government proscriptions on the use of fire as a management tool in the rangelands, small-holder cattle owners simply have to utilize whatever palatable feed persists into the late dry season...there is increasing competition for this restricted cattle feed supply. Grazing pressure increases and cattle are forced to subsist on ever more marginal lands and adjacent forest areas. Along with uncontrolled burning of forest areas and catchment protection zones, cattle herds are major contributors to widespread soil erosion and land degradation across the highlands of West Timor'. In spite of its purported soil conditioning properties, *Chromolaena* is also reducing maize yields due to higher labor requirements for weeding in an areas where 'labor rather than land is the critical limiting resources' and due to its possibly allelopathic properties.

Imperata cylindrica, an invasive grass species, is regarded as a valuable resource, but it is being eliminated by the spread of *Chromolaena*. Young cattle are grazed on *Imperata* grass and it 'is the material of choice for thatch in house and granary construction'. To construct a house roof requires about 1000m2 of well-vegetated Imperata grassland, which can last up to 20 years with minimal maintenance. Alternative roof materials are corrugated iron, which has doubled in price recently and is too expensive for most rural dwellers; or palm leaf, the use of which is restricted by local availability and price...' Grain is also stored in structures that are thatched with *imperata*. Given the loss of *Imperata* due to *Chromolaena* invasions, 'some communities are actively cultivating *Imperata* as the resource becomes locally scarce and increases in value'.

National and local government responses to each of these species invasions has generally been contrary to the interests of local farmers. In general, 'local government responses...have been muted...this lack of response is symptomatic of the lack of attention historically accorded extensive upland agriculture in Indonesia'. In spite of political pressure, the Department of Animal Husbandry has not acted, principally because it supports intensification of production through modern technologies rather than extensive rangeland production. On the other hand, the Ministry of Forestry perceives that *Chromolaena* is beneficial since it helps in the 'stabilization of critical slopes and the fertilization of eroded soils through aeration and its properties as a soil conditioner....[it] also has the indirect benefit of reducing the impact of free range cattle grazing within forest lands. Due to its unpalatable, even toxic properties due to high nitrate levels, Cromolaena provides a kind of buffer zone against cattle incursions, thereby permitting regrowth of forest seedlings. Cattle grazing in forestry lands is a significant management issue in Timor and one that often places the Forestry Department in conflict with local cattle owners'. Australian researchers have developed a management programme through biological control with the gall fly (*Procecidochares connexa*) but to date there has not been any significant success. 'Timorese farmer responses, and to a significant degree those of the local government, tend to be reactive rather than strategic, adaptive rather than interventionist, in overcoming agricultural threats'.

FIGURE 5.3 | A conceptual framework to interpret impacts of IAS in rural livelihoods (Shackleton et al. 2007, Figure 2).

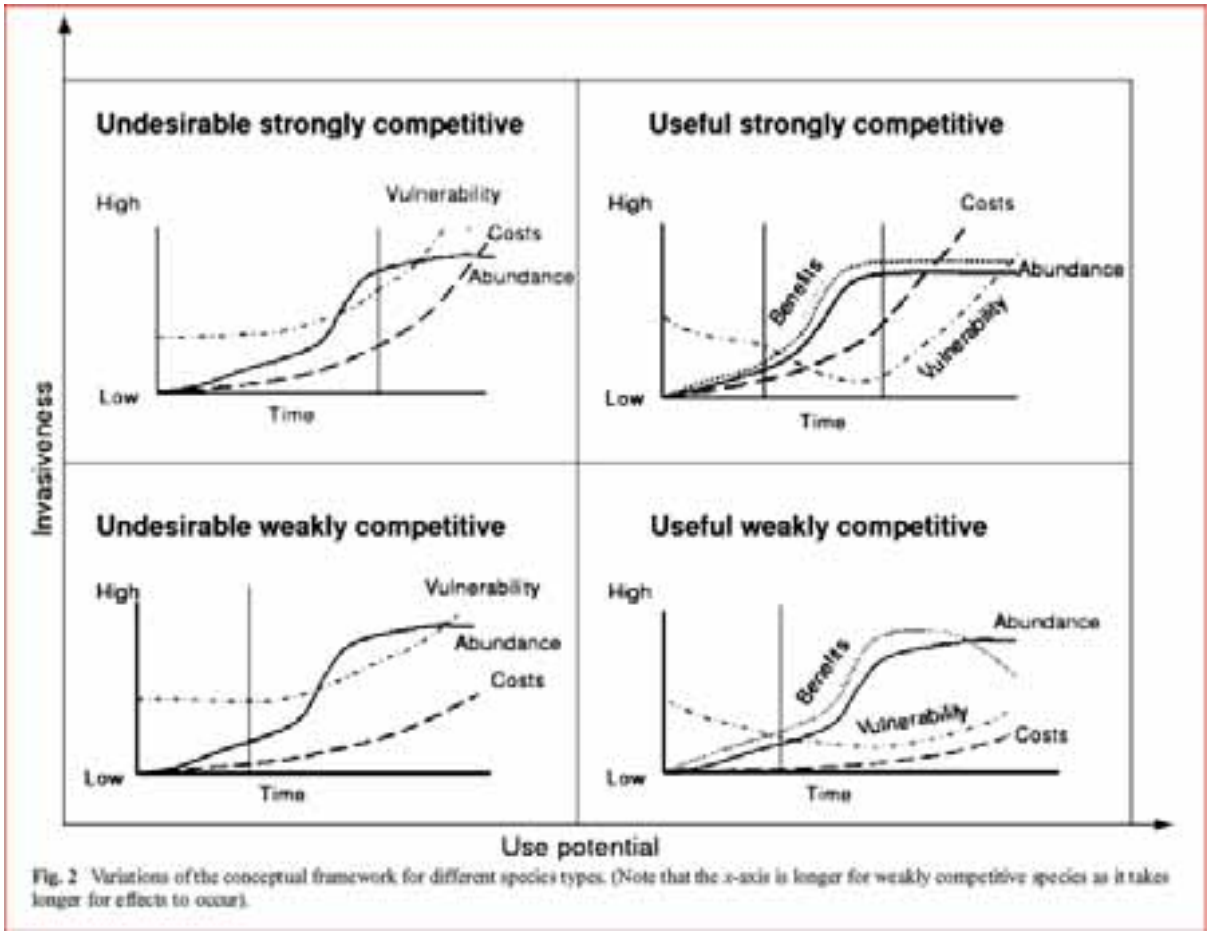


Fig. 2 Variations of the conceptual framework for different species types. (Note that the *x*-axis is longer for weakly competitive species as it takes longer for effects to occur).

TABLE 5.2 | Impacts on rural communities of invasive species (Shackleton et al., 2007, Table VI)

		Aggressiveness	
		Low	**High**
Beneficial traits	**Low**	**Undesirable, docile species** The species has negligible or low impact on rural people, because its invasivity is low. Hence it is easily controlled, although such control does represent a cost. It currently has no known direct or indirect use.	**Undesireable, agressive species** No or limited direct or indirect benefits to people. It invades rapidly, and is often difficult to control. The impacts on rural livelihoods will be most severe in the later phases of invasion. Communities are frequently unable to control the species without external help.
	High	**Useful, docile species** Not very invasive, the species is easy to manage. Benefits can be extracted from it, so rural people with limited livelihood options will exploit it to maximum benefit. Such exploitation will be sufficient to keep it in check in most situations.	**Useful, aggressive species** The species invades habitats rapidly, and may be difficult to control. It is useful to the invaded society and hence there is resistance to its complete removal. Harvesting by dependent communities is an inadequate control measure, so abundance and concomitant ecological costs increase with time.

beginning at the period, reducing as use of the IAS increases, and then diminishing as costs increase relative to benefits. They point out two important features related to resilience, which they define as 'a measure of the amount of change or disturbance represented by the IAS that local livelihoods could absorb without major shifts' (Ibid). First, there are thresholds inherent in each of the curves, that is, 'points at which the rate of response over time changes markedly. Additional thresholds are possible at intersections between curves' and these thresholds are what must be identified and monitored in order to predict impacts. Second, the temporal dimension must also be identified as much as possible in the field. In the early stages of invasion, benefits are generally low or indirect

and are confined to those who have introduced the species or to those who have first discovered possibilities for exploitation. In the next phase, abundance has increased and so have the number of people who are obtaining benefits, which 'may have prompted technological innovations or changes in livelihood patterns'; ecological costs may be approaching or surpassing a threshold, and management options may be considered, but livelihood vulnerability is generally reduced. It is in the third phase where costs generally exceed the benefits unless controls are exerted or important new benefits arise. 'People are now faced with either (1) controlling the invasion, or (2) living with it resulting in impaired livelihood options and increased vulnerability' (Ibid.). Of course, not all IAS are equal: some present only costs and others present principally benefits. The differences between IAS are presented in Table 5.2 as a matrix of aggressiveness and benefits, and is self-explanatory.

Siges et al.'s study (2005) on the livelihood impacts of *Piper aduncum*, a shrub or low tree, in the Finschhafen area of Papua New Guinea, indicates how adaptation has occurred as this IAS has come to dominate much of the landscape, having colonised most of the fallow land and secondary forest vegetation. One farmer described the changes with *Piper* invasion:

> *Our forefathers cut a lot of forest trees down to make gardens in the past. All the forest and its services are gone, together with the wild animals. We only see what forest is like from the pictures in the magazines or books.* Piper *has become our new environment* (cited in Siges et al., Ibid.).

Today, live *Piper* trees are used as shade for pigs, windbreaks and weed control. Mature stems are used as digging sticks, stems and branches are used to build soil retention structures that permit cultivation of crops on contours where previously only grasses and cane were grown; stems, stumps and branches are used for staking climbing crops; stems are used to make and maintain fences, for pegs, to build chicken coops, coffee and vanilla drying platforms, and handles for tools; roots make soil tillage easier (men now establish new garden sites in areas where *Piper* dominates since it is easier to remove and soils are lighter); ashes are used as pesticides and fertilisers; and is it used as a medicinal to treat cuts, tooth-ache, diarrhoea, dysentery, cough, fungal infections, insect bites, headache, scabies and stomach ache (Ibid.).

Many older residents lament the loss of native species, particularly forest species, since indigenous forest regeneration was impeded by the *Piper* invasion. They once used native trees for timber, rafters, poles and posts, which have now been replaced by *Piper*; people are no longer able to collect many wild fowl eggs, mushrooms, and rattans, and wild animals such as cassowary, pigs and other small animals no longer inhabit fallows. There has been a switch from the staple crops Chinese taro (*Xanthosoma sagittifolium)*, taro (*Colocasia esculenta*), and yam (*Dioscorea* spp) to sweet potatoes (I*pomoea batatas*), which previously was a minor crop, and that may have been at least partially due to *Piper*, since the yields of the former crops are said to have decreased and it is said that sweet potatoes yield very well after a *Piper* fallow. *Piper* may have facilitated the development of new human settlements since it makes it easier for people to clear new areas compared with well-developed secondary forests (Ibid.). People also think that *Piper* has rid the area of malicious spirits who used to live in forests.

What is clear from the above is the fact that rural subsistence producers have adapted to species invasions generally by incorporating them into their SES, even when this requires making substantial adjustments to their livelihood systems. They readily recognise new species and apparently adapt over time, utilising local knowledge which appears to be quickly gained through experience, and adapting or developing local technologies. Even in the case of *Piper*, which could be characterised as an 'useful aggressive' IAS, it is possible to question whether adaptation to IAS has caused these villages to cross a 'threshold' of one or more of the curves presented in the graphs, since (a) it appears that there have been substantial changes in their system, and (b) there have quite clearly been environmental costs but what these costs are have not been investigated, and (c) it is not clear whether the invasion has reached an intermediate phase and *Piper* abundance may continue to increase. Nor is it clear to what degree the exploitation of *Piper* is controlling, or contributing to, its abundance. It is also less clear from all of these cases how people adapt, or maladapt, to species that are of the highly aggressive, low benefit type.

Piper aduncum *in Timor*

The importance of carrying out ecological and socio-economic research in this context cannot be overstated. Perrings (2006) called attention to this when he discussed

the needs for careful cost-benefit analysis of IAS control measures:

> *to calculate the net benefit of restoration, control or eradication measures requires an evaluation not just of the damage or forgone costs of invasive species and the cost of control, but also of the benefits conferred by the invader or the activities that support the introduction or spread of the invader, and the distribution of the benefits...When those benefits are taken into account it is not always obvious that eradication or control is the optimal strategy* (Ibid.).

A limited number of other studies that have been encountered mention other ways in which people may adapt to biodiversity change that leads to native species decline. The literature on IAS emphasises species substitution (using the invasive species in place of missing or less accessible native species for particular uses). Especially the homegardening literature shows that people frequently transplant threatened or missing species into homegardens (see e.g. Johnson & Grivetti 2002, Niñez 1987) or establish or nurture them in other appropriate micro-environments (e.g. secondary vegetation), although what is successfully transplanted depends on a number of factors including transplanting success. Several others demonstrate that people establish what may we term 'human biological corridors' to obtain missing seed or species that have become locally extinct, or which they lose access to through migration or displacement, through extended social networks and/or trade (see e.g. Greenberg 2003, van Etten & de Bruin 2007, Zeven 1999). It is widely recognised that most communities continually introduce new species to agricultural fields and homegardens even when native species are not threatened, which is of course one of the sources of IAS, one of the means by which rural dwellers adapt to change and innovate, and one of the sources of species richness in managed environments.

There is as yet insufficient understanding of human adaptations to biodiversity change. The cases presented above tend to reflect contexts in which IAS have invaded over a relatively long timeframe, and where there have been few IAS that people must contend with simultaneously. Much more abrupt and dramatic changes have occurred throughout the 20th century, as with massive deforestation, desertification, drought, agricultural intensification and other forms of land use change, many of which have created very difficult situations for rural people and to which they are likely to maladapt. Depending upon the degree of disruption of livelihoods that results, some adaptations to biodiversity change will be common responses to various types of stresses (such as to drought), e.g. changing cropping and grazing patterns and practices, changing land use, liquidating capital (such as livestock and financial assets), seeking alternative sources of income, and migration. Most environmental degradation entails loss of native biodiversity, so that literature which addresses human impacts of degradation should also shed light on factors that tend to undermine, or strengthen, adaptive capacity and resilience.

Maladaptations to biodiversity change are also expected: for example, as biodiversity derived livelihood assets diminish, pressure to over-exploit remaining resources will also increase, leading to more rapid local species extinction; imperfect knowledge given new species configurations and ecological conditions will result in threats to health and safety (e.g. incorrect substitutions of species for medicine, food and animal fodder), and loss of productivity (e.g. failure to encounter appropriate grazing resources, incorrect planting dates, ineffective means to combat weeds and pests).

5.3.4 Conclusions for GIAHS and *In Situ* Conservation

What are the conclusions for the GIAHS Programme? First and foremost, there is a great need for programmes and policies such as GIAHS that will directly support traditional subsistence societies as they confront the enormous challenges presented by biodiversity change. Second, ***the goal of conserving agrobiodiversity* in situ *is laudable, but this goal should never be interpreted to mean that agrobiodiversity should be 'frozen' in time and space.*** As the authors of one major scientific review about the effects of climate change on biodiversity expressed it,

> *difficult theoretical questions will evolve, such as 'What is natural vegetation?' When climate conditions have no historic analog and species can no longer move freely into and out of areas, natural precedents may provide no ready answer to this question. Managing to maintain conditions of a historical reference point... would be trying to force vegetation to match a climate that no longer exists. Yet estimating what species would find new climates suitable and how they would interact in competition with one another is well beyond our current abilities to predict….there may be strong social pressures to retain [certain desired] elements, even when natural processes are driving transitions toward new states* (Hannah and Lovejoy 2005).

Species change will occur in all GIAHS sites: this is inevitable and there are probably fewer actions that can be taken to mitigate native species decline than there are that can help people to adapt to new species configurations and to help to ensure that ecosystem functions and services and livelihoods do not cross thresholds into undesirable states. Rather than aspiring to maintain all existing agrobiodiversity *in situ*, ***it is probably more realistic and biologically constructive for the GIAHS Programme to seek to maintain species richness and avoid the most deleterious effects of 'transforming' species that move into GIAHS SES, supporting species substitutions with ethnobotanical and agroecological knowledge from within or outside of GIAHS communities, supporting the development of social and trade networks (as discussed in Chapter 5) to permit people to access culturally and economically important species, and helping people to experiment and learning within their changing environment.***

5.4 Changes in Oil Supplies and Prices and the Food Question

There are very good reasons today for discussing world oil supplies as a global change driver the context of the GIAHS Programme. Until very recently, the world's supply of oil has not been factored in to projections about food security, human security, land use, and biodiversity over the coming century. With the emergence of global markets for agrofuels (ethanol and biodiesels), the poten-

tial for shifting land use on a massive scale away from food and toward fuel production has become very real and threatening. Even at this very early stage of growth in agrofuel crops, the impacts are indeed being felt through food prices. While the agrofuel debates rage on, one can advance the proposition that fuel prices will in future be a major determinant of land use change and of food supplies. Together, food and fuel prices will in turn be a major, if not the major, determinant of overall global economic trends. Investment in agriculture will increase but these investments are not likely to benefit the poor, and may very well represent an additional threat to their control over land, water, and other resources.

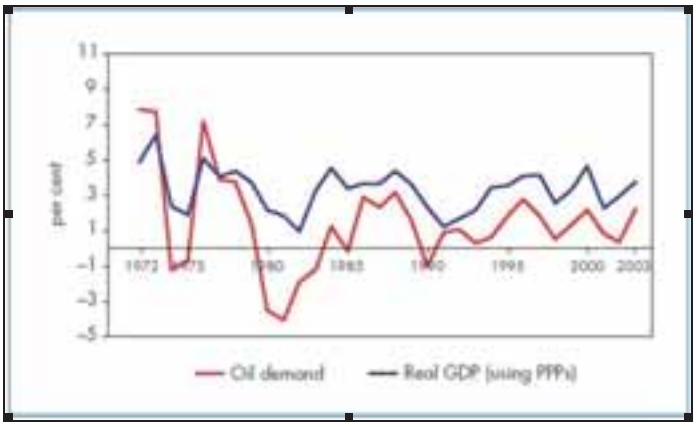
The global decline in oil supplies relative to demand has possibly already commenced, and the resultant oil shocks are major economic drivers at global and national levels starting from around 2003 and extending at least until the middle of this century. By 2008, at the time of this writing, when oil prices this was beginning to have an impact across the globe through higher fuel and food prices. In the past (such as 1973-74 and 1979-80), oil shocks (which refers to the consequences of a sharp rise in oil prices that are generally triggered by supply problems) have had serious negative consequences for the global economy and especially negative impacts for vulnerable nations, economic sectors and populations. Poor nations and the poor within nations have born the heaviest burdens. In comparison to these shocks, however, reaching peak oil, or that point when global oil supplies decline relative to demand, is likely to have far more serious and long-lasting consequences. While subsistence SES are almost by definition less vulnerable to oil shortages and the direct effects of oil shocks, to the degree that they are reliant upon external markets (for product supply or demand), oil based transport, or external investment, they may be quite vulnerable to the indirect consequences.

5.4.1 Vulnerability of the Modern Oil Economy

The modern global economy is founded upon oil: without this cheap source of energy, the economic expansion that occurred throughout much of the 20th century would have been unthinkable. In spite of gains in energy efficiency in many developed countries since the first oil shock in 1973-74, there continues to be a strict relationship between growth in oil demand and in gross domestic product (GDP) (Figure 5.3), where the correlation only weakened during the 1970s and 1980s when nuclear power plants were most widely in use. In 2001, oil comprised 37% of the world's primary energy supply. While it is used to generate electricity, it is principally destined for the transport sector which is overwhelmingly oil based (Wakeford 2006). Other sectors that are heavily oil dependent and hence vulnerable to oil shocks include tourism, industrial agriculture, manufacturing, and the military, where the latter three depend on oil both for energy and as the basis for petrochemical products.

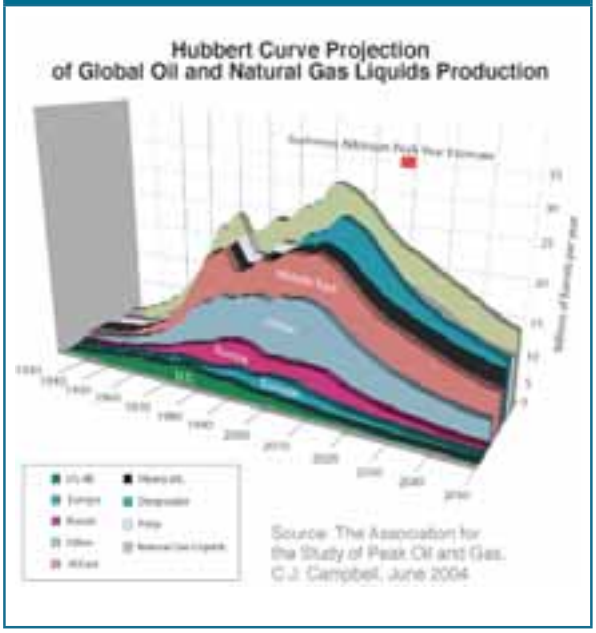
Global dependence on oil, and overall oil demand, are not expected to decline before at least 2030. The principle reasons for this are found in the relationship between energy intensity and economic growth, on the one hand, and in the lack of ready substitutes, on the other. With economic growth, modern commercial energy sources such as oil begin to replace traditional sources (fuelwood, draught power, wind, etc.), leading to an increase in commercial ***energy intensity*** (the rate of conversion of inputs to economically valuable outputs). As income continues to grow, energy requirements per unit of economic activity begin to decline, producing an inverted U. However, 'growth in productivity and intensity improvement has historically been outpaced by economic output growth. Hence, materials and energy use have risen in absolute terms over time' (MEA 2005c). In its 2007 report on the world's energy outlook, the International Energy Agency projected that, 'if governments don't change their policies, oil and gas imports, coal use and greenhouse-gas emissions are set to grow inexorably through to 2030...the world's energy needs would be well over 50% higher in 2030 than today.'[11]

FIGURE 5.4 | Relation between oil demand and GDP growth
(IEA 2004, Figure 3.1)



Oil shocks have also been a major, if not *the* major, source of economic disturbance throughout the second half of the 20th century, and they are expected not only to continue, but to increase as supplies of oil begin to decline relative to demand, that is, after peak oil (Figure 5.4) is reached. The peak in world oil discoveries seems to have occurred in the 1960s, and the peak in production is predicted by many experts to be imminent, although there is fierce debate as to precisely when it will occur. 'In nearly 50 countries...the production of crude oil has already reached its peak...[including] eight of the top oil producers in the world...Once worldwide oil production peaks, geopolitics and market economics will result in even more significant price increases and security risks' (Gupta 2008). Indeed, most agree that reaching the peak has momentous consequences: it is widely predicted to represent 'a structural break of the highest order' (Wakeford 2006). According to the World Energy Council, the subsequent decline will entail 'a discontinuity of historic proportions... The transition to decline threatens indeed to be an age of great economic and geopolitical tension'(WEC 2006); and the IEA argued that 'these trends would threaten energy security and accelerate climate change...the consequences of unfettered growth in global energy demand are alarming for all countries.'[12] The concerns expressed are not only related to supply risks and to the need to increase efficiencies and shift toward alternative fuel sources: they are ultimately related to the the risk of geopolitical conflict, and to the nature and distribution of economic consequences of the decline in oil supply,

FIGURE 5.5 | Hubbert peak oil projection (http://www.peakoil.net/uhdsg/)



which is addressed in the literature as oil shocks and as oil vulnerability.

The two important dimensions of oil shocks are their magnitude of increase and their timing, characterised as rapid and sustained, or rapid and temporary, or slow but sustained: 'The speed of a shock is important as it affects the ability of economies to adjust, which is typically very restricted in the short run' (Wakeford 2006). There have been four oil shocks to date, where oil prices at least doubled: 1973-74, 1979-80, a spike in 1990, and 2003 to present. The first two shocks had severe repercussions for many of the world's largest economies in the form of sharply rising prices coupled with an inflationary spiral and recession, which was described by coining a new term: 'stagflation' (see below). It is in part by studying the repercussions of these oil shocks that predictions are made about the current shock and about future trends (see below).

Oil vulnerability is measured as an index that is formulated on the basis of market risk and supply risk indicators (Gupta 2008; Bacon 2005) (for vulnerability indexes of countries hosting GIAHS sites, see Table 5.3). Market risk refers to the risk of macro-economic effects from price fluctuations, for which there are generally three indicators: the ratio of the cost of oil imports to total GDP, the amount of oil consumed per unit of GDP, and the share of oil in total energy supply. Supply risks are short or long term, where short-term risks are associated with hazards and local conflicts, and long-term risks are associated with political change and strategies in producing countries, international conflicts, declines in investment in production and transport facilities, market failures, and government failures. Supply risk indicators include, for example, the ratio of domestic reserves to oil consumption, net oil import dependence on specific oil supplying countries (exposure to geopolitical risk), and market liquidity (the amount of domestic demand relative to world supply, or the ability that a given country has to change suppliers).

5.4.2 Macroeconomic Effects

The macro-economic effects of oil shocks are investigated from various perspectives: of net oil exporting and net oil importing economies and the global economy; and in relation to distributional effects (between countries and between national income groups) and to effects on households and the poor. The precise effects, of course, depend on a multitude of factors, among which oil vulnerability and overall level of economic vulnerability, wealth and poverty figure importantly, and also depending upon the magnitude and duration of the shock, as mentioned above.

An increase in the price of oil has been likened to a consumption tax, where the income from the tax goes to the major oil producers and is taken away from the consumers (Vielle & Viguier 2007). Income is transferred through a shift in the terms of trade, so there are clear winners and losers: both net oil importing nations and consumers suffer a loss of real income (Park 2004). From the perspective of ***net oil exporting countries***, there is obviously an increase in national income through higher export earnings. A recent study (IEA 2004) estimated that, with a US$10 per barrel price increase, those oil exporting countries with low incomes (less than US$900 per capita) would see an increase in GDP of more than 5%, and the lowest income countries, such as Angola, would see a 30% increase. Major improvements in the ***balance of payments*** (all payments and debts to foreigners, minus all payments and credits from foreigners) mean that GDP rises and spending increases domestically, unless income is put massively into savings. Governments earn a large part of this additional revenue through royalties and taxes, and it is such governments' fiscal management of the revenues that largely determines overall domestic economic impacts and whether GDP growth will be sustainable or benefit the nation's welfare. Governments can spend more on education, health, and physical infrastructure, which should have overall positive impacts. However, if government spending is badly managed, this can lead to inflation, which is one of the effects of so-called *'Dutch Disease'*.[13] As a World Bank report warns, 'The challenge for these countries is to use the extra resources well. Incremental fiscal revenues arising from the higher oil prices need to be spent wisely or held for future generations. Transparency over receipts and expenditure becomes more important at times of such large increments in revenue' (Bacon 2005). Another consideration is that, in some oil exporting countries, rising oil prices do not lead to the an equivalent magnitude of benefit. For example, in Iran, the lack of refining capacity, coupled with rising consumption, mean that about 40 percent of the domestic gasoline consumed is imported at market prices and then is heavily subsidised (Ibid.).

While the benefits of rising oil prices may or may not translate into long-term sustainable growth or welfare in net oil exporting countries, the overall consensus is that higher oil prices have strongly negative macro-economic effects depending on the oil vulnerability of the ***net oil importing countries***. Much literature models such effects which in general are characterised as '***stagflation***': the rate of economic growth slows and output may decline (stagnation), at the same time that prices increase (inflation). Stagflation across oil importing countries translates into global economic downturn. Specific macro-economic effects of oil shocks that have been described in the litera-

TABLE 5.3 | Data on energy, oil and GDP for GIAHS pilot and other selected countries (adapted from Appendix Table, Bacon 2005)

Country	% change in GDP from a US$10 increase in oil prices	GDP per capita	Oil vulner-ability	Energy intensity - BTU per 1995 US$ of GDP	Net oil exports as % of GDP
Algeria	8.0	1711	-6.15	23290	18.9
Tanzania	-0.9	268	1.00	9683	-2.1
Kenya	-1.3	347	1.00	15360	-3.0
Philippines	-1.6	976	0.98	12560	-3.8
Morocco	-1.2	1190	0.98	10564	-2.8
Peru	-0.3	2032	0.40	8862	-0.7
Tunisia	0.0	2103	0.17	13408	0.0
Chile	-1.1	4715	0.92	11498	-2.5
US	-0.4	34292	0.54	10575	-0.9
China	-0.4	858	0.30	35764	-0.8
Russia	5.3	1749	-1.62	72162	12.5

ture covered here (Bacon 2005, IEA 2004, Park 2004, Vielle & Viguier 2007, Wakeford 2006) can be as follows:

- Oil imports cost more, which usually requires that the total demand for foreign goods must decrease by reducing imports. This occurs in part as export earnings from oil-intensive export goods and services (especially tourism) decrease. The balance of payments deteriorates (imports become more expensive and exports become cheaper), causing a decline in real national income.
- There is downward pressure on exchange rates as importing country currencies decrease in value with respect to strong international currencies in which oil is traded.
- A rise in oil prices reduces industry outputs through higher production costs. Higher prices for fuels and petrochemicals lead to higher prices for transported commodities and especially food. Reduced demand caused by higher prices, together with lower real income, further depress domestic demand, leading to higher unemployment. Wage earners can also seek wage increases, which further feeds into higher production costs, and is then passed on to consumers. All of this leads to inflation and wage-price spirals extending beyond the initial shock
- Falling tax revenues and increases in the government's budget deficit drives up interest rates; inflation also leads monetary authorities to increase interest rates, which leads to decreased consumption of imports, which leads to lower demand for exports.
- The higher cost of imports, plus possible decrease in exports, plus the possible increase in interest rates, lead to a decrease in GDP.
- 'Furthermore, oil shocks can be expected to generate increased uncertainty about inflation, interest rates, exports and the exchange rate, and therefore will have a general dampening effect on consumption and investment' (Wakeford 2006). Increased economic uncertainty leads to reduced foreign direct investment or even capital flight which compounds the negative balance of payments and may lead to currency devaluation, which exacerbates inflationary impacts by raising the price of oil and other imports.

According to the World Bank (Bacon 2005), the degree of damage that occurs to a net oil importing economy that doesn't have large foreign reserves, is in general determined by the magnitude of the net oil import bill relative to GDP, which determines the the size of the domestic adjustment needed to restore the balance of payments equilibrium. The number of policies that can address such oil shocks in the short term are 'severely limited': 'At a macro-economic level... governments have little alternative but to deflate the economy in order to adjust the balance of payments. Short term borrowing or reserve reduction may be an option for some countries, but for many this is not possible, and in any case it is not a sustainable response to a permanent shift in oil prices'.

The effects of oil price increases are essentially internationally ***redistributive***, and it is the poorest countries that bear the heaviest burden. First, they bear a disproportionate burden in terms of GDP adjustment to price increases. The IEA (2004) reported that the poorest countries (per capita income below US$300) would lose 1.5% GDP with a US$10/barrel price increase, and even the wealthiest oil importers (above US$9000 per capita) would lose .44% in GDP; on the other hand, as mentioned above, the poorest net oil exporters also stand to gain proportionately more growth in GDP but, for the period 1999-2001, there was only one oil exporter that fell into this poorest group (Bacon 2005). Second, the poorest net oil importing countries countries lack foreign exchange reserves that can be used to buy time to allow adjustments to occur. Third, price elasticity of demand in these countries also tends to be very low, so that the economy must contract (Bacon Ibid), and fourth, these economies tend to be the most energy intensive, so their industries become the least competitive.

Which countries and regions of the world are the most affected? First, net oil importers far out-number net oil exporters: in 2004, of the 204 countries that did not belong to OPEC,173 (85%) were net importers.[14] Three regions - North America, Asia-Pacific and Europe - held about 10% of world oil reserves and yet consumed 78.6% of global oil, whereas the Middle East, the former Soviet Union, and Africa together represented 81.3% of reserves and only 15.5% of total demand in 2005. Over 60% of world reserves are in the Middle East, while OPEC has 75.2% of the reserves and controls about 42% of world production (Gupta 2008). In Bacon's study, 34 countries had negative oil vulnerability indices whereas 94 were positive, 77 of which were between .8 and 1.0 (high vulnerability). The monetary impacts of a US$10 increase on oil prices on GDP were greater than -2% in 13 countries,[15] between -1 and -2% in 36 countries, and between 0.5 and .99% in 26 countries. Table 5.3 provides data for GIAHS pilot sites and selected comparison countries, where it is clear that, with the exceptions of Algeria and Tunisia and, to a lesser extent, Peru, these countries indeed suffer substantially from oil shocks.

5.4.3 Household and Poverty Effects

The effects of oil shocks and peak oil on households and particularly on the poor have been studied in the past for shocks of limited duration and magnitude. The World Bank recently reviewed the effects (Bacon 2005), which it classified into three types: (1) the direct effects of oil price increases; (2) the indirect effects of oil product price increases, and (3) the indirect effects through reduced GDP. Regarding the direct effects of price increases, households directly consume oil products, especially gasoline, kerosene and LPG. A study in Yemen, for example, showed that a price increase of US$15 per barrel of oil would increase the direct costs to the poor by 14.4%, whereas it would increase the cost to the rich by half this percentage. Many governments attempt to control prices for these products and may decide not to pass all or some of the direct price increases onto consumers, but this may create other serious difficulties. For example,

> *In Yemen, the government has been trying to phase-out subsidies on oil derivatives for at least seven years. A first rise in gasoline of 40 percent in 1998 led to riots and a death toll of 50. In July 2005, the government raised the price of diesel and oil as well as kerosene and cooking gas significantly: pump prices for diesel jumped from YR17/litre (8 US cents/liter) to YR45/ litre, while those for oil almost doubled. These price hikes were combined this time with pro-poor supportive measures such as sales tax cut, production and consumption taxes cancellation, and 200,000 additional individual covered under the Social Care System. However, despite safety measures, riots led to 13 dead and the government withdrew part of the price hike: new prices were cut by 20-30% and oil prices remain at around half their market rate* (Bacon 2005).

It is clear that, if governments do not pass price increases on to consumers, then their fiscal positions will worsen, which will result in less government spending than what would otherwise occur. Some of this spending might also have directly benefited the poor (e.g. through education and health care), or indirectly benefited them through higher GDP.

Less is know about the indirect effects of oil prices on the prices of other goods, and their respective poverty and welfare impacts, since this requires additional data which is not usually available (for a study on Pakistan, see Box 5.7). Households purchase products that are transported, transport entails oil consumption, and thus these products are also subject to price increases (e.g. food, bus and taxi services). Many basic consumption goods for which demand is relatively inelastic are affected, and these goods account for a larger percentage of total household expenditures in the budgets of the poor compared to wealthier classes. 'This type of effect needs to be calculated for each fuel and each final product in order to calculate the aggregate impact of the price shock on household expenditure' (Bacon Ibid).

To the extent that higher GDP benefits the poor (e.g. through employment, through government expenditure), then decreases in GDP will also have negative poverty implications. Another recent World Bank study reported on the estimated poverty impact for countries in the Middle East and North Africa (World Bank/MENA 2006), where three 'resource poor' economies were found to be highly negatively affected by a US$10/barrel increase in oil prices: Djibouti, Jordan and Lebanon. 'In Djibouti and Jordan, the impact was especially large, estimated as a 4.7 percent rise in the poverty headcount, and in Lebanon, the increase in the poverty headcount was estimated at approximately 2.6 percent. Irrespective of this relationship between GDP and poverty overall (poverty may also rise as GDP increases), reductions in public spending are highly likely given the negative effects of oil shocks. In the longer term, this is likely to affect physical and social infrastructure (and especially spending on the poor), causing both a direct and an indirect loss of welfare , where the indirect loss stems from the 'loss of output and employment in the economy caused by the reduction in aggregate demand made necessary by the oil price rise'

BOX 5.7 | Impacts of oil price increases on households in Pakistan (reported in Bacon 2005)

A study for Pakistan investigated a scenario in which the average price of gasoline and diesel was increased by 33 percent, while the prices of other petroleum products remained constant. The impacts came through changes in the cost of transportation, both direct and indirect, and are shown below.

Estimated Percentage Changes in Household Expenditure for Quartile Groups in Pakistan as a Result of an Average Transport Fuel Cost Increase of 33%

	Urban	Rural
Quartile 1	1.9	1.9
Quartile 2	1.8	1.7
Quartile 3	1.7	1.5
Quartile 4	1.2	1.0

This table shows that even for transport fuels, where the poorest households certainly do not own their own vehicle, the impact of the fuel price increase is, in percentage terms, most burdensome for the poorest quartiles. This is most marked for the rural households, whose total household expenditure for each quartile is around 25 percent lower than for the corresponding urban quartile. These results are for cash expenditures, so although non market activities may add to the welfare of rural households, and so reduce the proportionate welfare loss to some extent, the relative impact on cash expenditures will remain unchanged, with the poorest group of household being proportionately affected almost twice as much as the highest quartile group. Given that the actual price increase analyzed was 33 percent, and it excluded changes in prices for both kerosene and LPG, it is clear that the total effects of current product price increases would be several times greater.'

(Bacon Ibid). Indeed, according to another study, 'Globally, high oil prices have the effect of reducing the welfare by around 2% in 2015 compared to the original baseline scenario...high oil prices impose a significant welfare cost in oil-dependent regions like India, Asia or Europe (-6%, -5%, -4%, respectively) whereas oil exporting countries (Middle East = +10%) gain a lot' (Vielle & Viguier 2007). In an era when the Millennium Development Goals seek to reduce poverty, it is clear that oil shocks and the advent of peak oil will increase it.

5.4.4 Implications of Peak Oil for GIAHS

The impacts reviewed are related to oil shocks of limited magnitude and duration. The perspectives mentioned above for post-peak oil are that the effects will be drastically compounded:

Peak oil is thus likely to entail the worst combination of oil shock types: sharp, sustained, repeated and cumulative. The probable effect of this on the global economy will be a severe bout of stagflation, particularly as central banks are primed to raise interest rates in an attempt to curb inflation and inflationary expectations...Viewed simply, the down-slope of the oil production curve implies a series of supply-side oil shocks spanning decades. Conservative estimates of the post-peak depletion rate are around three per cent per annum. Considering that prices trebled in 1979-80 after a mere five per cent reduction in output... the potential for runaway oil prices becomes evident. Thus, we can reasonably expect an upward oil price trend (due to cumulative shocks) along with greater volatility (as a result of economic adjustments and demand destruction) (Wakeford 2006).

Adjustments to post-peak oil are likely to be very difficult. As oil prices increase and the global economy slides into recession or depression, oil prices may tend to fall temporarily. The possibilities to conserve or increase efficiency of course exist, but it is generally agreed that technology replacement and substitution will be costly and will take decades to achieve. In the past, when higher income countries, which have access to the necessary financial means and technology, also suffered the negative effects of oil shocks but did not decrease their oil import dependency (Bacon 2005). 'Moreover, there can be little doubt that investment conditions will be far less favourable in an era of declining oil production, since less (and more costly) energy will be available to underpin economic activity, interest rates may be much higher, and levels of uncertainty and risk will be far more acute' (Wakeford 2006).

This is essentially what experts are warning: global economic downturn, recession or even collapse will likely result due to oil vulnerability and peak oil, if countries do not change their energy policies radically and rapidly to realise the investments that are necessary while such investments are still possible. Poor countries are much more limited in their capacities to make such investments and to reduce oil vulnerability. Certain countries will in general benefit from high oil revenues, but these countries are also vulnerable to global economic recession; many are politically unstable and their reserves are currently, or are likely to be in future, the focus of future geopolitical or local conflict (e.g. Sudan, Nigeria).

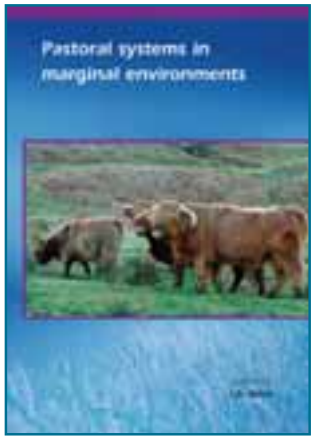
The transmission of oil shocks to GIAHS SES is likely to occur through (a) higher prices for food and transport, (b) depressed domestic and international demand for GIAHS SES products; (c) the decline of the tourism industry; (d) pressures on land for biofuel production, and (e) limits on global and national capacities to invest in social and economic infrastructure and in research and development to counteract the negative effects of this and other drivers. All of these can have major implications for vulnerable people and for adaptive capacity within such SES. Further, conflicts and social unrest are likely to emerge from competition over energy resources and from the repercussions of oil shocks, which are likely to compound or be compounded by other environmental conflicts (WBGU 2008). ***While it is the synergistic effects of peak oil and other drivers that are of greatest concern (see Section 5.6), the GIAHS Programme has the capacity to foresee and respond only to a limited set of impacts, such as by avoiding over-dependence on vulnerable markets (e.g. for food and other goods and services such as tourism that depend on long-distance transport, for agricultural inputs based on petrochemicals), by generating or reinforcing certain forms of self-sufficiency (especially in energy, such as sustainable fuelwood production) and trade (e.g. local trade, trade not as subject to inflation such as barter), and finally by avoiding long-term dependence on government or international investments and transfers.*** Adaptive capacity in GIAHS SES definitely means the capacity to be shielded from, and adapt to, major external economic shocks.

5.5 Cultural Change

Global environmental change, whether it be climate change, land use change, biodiversity change, or depletion of natural resources such as fuel are themselves currently driven by anthropomorphic (human created) drivers, which are economic and cultural in origin. Globalisation is a phenomena driven above all by markets, and by the concomitant increases in demands on the part of consumers whose cultures are changing largely due to market forces that tend to homogenise wants and needs. Increases in consumption of fossil fuels, of automobiles, meat, electronics and all of the other trappings of 'modern society' are changing people's perceptions about social status and social relations in ways that generally devalue traditional lifeways.

The characterisation of traditional SES and of the people who are their stewards as uniformly 'poor', their cultural practices as 'backwards', and their production systems as unsustainable (destructive) or poor yielding, all of which are therefore in need of massive transformation, has been a primary driver of their dissolution from at least the colonial period right up to the present. This devalorisation and discrimination, based on irrational assumptions about the superiority of other (particularly, but certainly not only) Western values, knowledge, technology, status systems and social relations, has strongly contributed to the erosion of many traditional SES.

It can be argued that, even as Western scientists begin to extol the benefits of traditional SES for agrobiodiversity conservation, some of the language continues to reflect past attitudes. Many assume, for example, that agrobiodiverse SES are present in 'marginal' environments. The term 'marginal' has diverse definitions, e.g. irrelevant (not of central importance or relevance); on the fringe (of a group or movement); very low (at or close to the lowest acceptable or viable limit); barely covering costs; or difficult to cultivate. Most biophysical scientists would consider that the latter is the most important: traditional SES exist because the conditions for their transformation into intensive, high productivity systems do not exist; for example, it is often found that, because of agroecological conditions such as highly variable rainfall or poor soils, local crop diversity outperforms modern varieties, or the use of chemical fertilisers or other industrial inputs does not increase productivity. Certainly, many traditional SES are found in environments that have posed major challenges for the people who inhabit them, where cultures have had to evolve knowledge and means of subsistence that are quite specialised, and that are also conducive to periodic or episodic difficulties, e.g. related to hunger or drought.



Marginal, however, does not, in this sense, imply a lack of resilience, or a lack of a capacity to provide essential ecosystem goods and services. There are simply too many examples of traditional SES that are located even in 'extreme' (or what IFAD calls 'harsh') environments that have been stable over long periods, principally because cultures have evolved political, social, technological and cultural (productive, reproductive and consumptive) means to deal with such conditions. Scientists have turned their attention to these systems in part because they have realised that technologies developed for agroecological environments where agrochemicals and modern varieties are effective in increasing yields are often less effective or ineffective, and confer greater risk, in such areas. They have discovered that local knowledge, technologies and practices are indeed better adapted, and that these societies can also be highly innovative: this discovery has coincided with scientists' increasing interest in conserving agrobiodiversity *in situ*.

As the FAO indicates, certainly mainstream science and technology developers and disseminators have not generally been oriented toward productivity improvements in such environments; national research and extension services have strongly promoted exotic crops and modern varieties; and the private sector has not provided many options (see for example Nederlof 2006). Why might this be the case? This can be discussed by referring to some of the other definitions of 'marginal' that could be applied. First, marginal may mean small. If SES are not very extensive and require investments in specific technologies or knowledge to increase productivity (e.g. to generate economic growth), such investments may be seen as unprofitable, both on the part of economic actors and on the part of governments and research institutions, largely because the impact of such investments is also small-scale and local. Second, with regard to markets, transaction costs may be very high (e.g. due to lack of transport or infrastructure), local populations may lack effective demand (ability to pay) or cultural demand for marketed goods and services, and profits may be impossible, since marginal returns on investments in technology or services are low or negative, or risks are high. Often, when markets do develop, they are for specific products (e.g. raw materials such as timber, rattan, rubber, minerals, etc.) found within these SES which stimulates investments in extraction technology, infrastructure and knowledge, but this does not mean that 'development takes off'. Very often it has been found in such contexts the local populations benefit little if at all from such exploitation since they do not perceive the profits, and reinvestment of capital derived from such enterprises does not occur locally, but are invested elsewhere. It also often leads to resource depletion, since those who exploit the resources represent mobile capital: once the resource is depleted, capital is simply invested elsewhere. This has much to do with who controls the technical and financial means to exploit such natural resources on a commercial scale.

Third, local agrobiodiversity is often assigned little or no value outside of the SES in which it has been developed or occurs, and social stigma is increasingly attached to the use and knowledge of these resources. This has many implications. One is that, if such agrobiodiversity is seen by powerful agents (governments, commercial interests) to be valueless, it may simply be eliminated through activities that pursue other forms of value: for example, when native tree species and wild plants are eliminated as forests are clear cut for timber or for cattle ranching, when aquatic species are destroyed as a result of pollution from agrochemicals, or when local landraces are lost or traded-off for modern varieties. This is a major reason for valuation efforts in environmental economics: the loss of agrobiodiversity is seen to be an externality.

Devalorisation of local agrobiodiversity is not a phenomenon confined to globalising interests. Another implication that is barely recognised but of great concern, is the fact that demand for agrobiodiversity *within* traditional SES is also decreasing. Several studies report that the consumption of indigenous crops and wild plant foods in many developing countries is decreasing due to the fact that these foods are accorded lower status in comparison with exotic foods. For example, Astone (1996) noted that, among the Fulbe peoples in Fuuta Jalon, Guinea, 'Women who can afford condiments such as oil, maggi, peanuts, and meat will ignore volunteer and low-prestige crops such as the boroboro leaf and small tomato' and they purchase the ingredients to replace the traditional vegetables which are now considered to be ingredients for 'poor woman's sauce'. Maundu et al. (1999) also report that, in Kenya, in relation to indigenous vegetables, 'little knowledge is being passed from the knowledgeable to the less knowledgeable…consumption of traditional species is despised by modern people. The result of this is loss of knowledge (of names, uses, etc.), genetic erosion and in some instances loss of species.' Daniggelis (2003) also found in eastern Nepal that wild food resources are increasingly viewed as easily accessible and 'free' and they are stigmatised as 'poor man's food' and 'famine food'. Thaman (1995) found that migrants to urban areas in the Pacific increasingly face the 'deterioration of the diet as a result of a shift from the consumption of nutritious traditional foodstuffs to convenience or 'junk' foods of inferior nutritional status.' Ogle and Grivetti (1985) reported that people in Swaziland, in Southern Africa, have decreased their use of wild foods, indicating their preferences for the taste of cultivated species and beliefs that eating wild species is 'old fashioned'. In general there was an appreciation and high level of use of wild foods, but as well there was an attitude that their consumption was a reflection of poverty.

These phenomena are related to many other primary drivers, such as food aid and food 'dumping' (e.g. of US wheat throughout Latin America), as well as to the deliberate diffusion of Western dietary standards through commercial and political mechanisms which are in large part responsible for the dramatic increase in consumer demand for meat products, sugar, and refined carbohydrates. In China, for example, dairy products were not part of the traditional diet except in the North, and consequently lactose intolerance is a widespread phenomenon. The recent increase in consumption of dairy products is contributing to serious health problems (including the

Chinese milk advertisement for the Olympic Games.

substitution of breast milk by powdered infant formulas),[16] and environmental stress. It has been promoted by dumping of powdered milk and other dairy products, the transmission of Western (now superseded) dietary recommendations, advertisements, and government school food programmes (Goodland 2001). The rise in demand for such food items is often aired in policy circles as 'inevitable,' a 'natural' outcome of rising prosperity, rather than clearly the result of strategies of firms and decision makers whose policies are geared toward promoting the interests of lobbying groups and their own national exports. These drivers, as Goodland (Ibid.) confirms, also mean that people are substituting goods that are not only nutritionally inferior with respect to traditional diets, but also much more expensive, thus contributing strongly to poverty, nutritional and other health problems, and environmental deterioration as grains that have been principally destined to feed human populations are now being used to feed cattle and other livestock. Such a phenomenon has global environmental and nutritional implications since China has become a major importer of grain.

Another important factor in the management and loss of agrobiodiversity is related to the fact that production, procurement and post-harvest processes in traditional SES are often very labour-intensive, and particularly the need to generate cash income is drawing labour away from these activities. Malaza's research (2003) in Swaziland showed time constraints play an important role in the loss of agrobiodiversity: preparing most traditional foods is very time consuming, and rural women no longer grow certain indigenous food crops such as legumes because of a shortage of labour. In urban areas, female wage employment is negatively correlated with the consumption of indigenous legumes and traditional vegetables, which are most difficult to process and prepare, and more difficult and time-consuming to procure. Zimmerer (1991) reported that, in the Peruvian Andes, 'despite time-saving measures, sufficient economic and social pressures sometimes overcome agriculturalists' culinary preference for native cultivars and force the substitution of improved varieties' and, with male out-migration for wage labour, women have less family labour available, and thus less time to maintain traditional varieties, which is a major reason that both genetic diversity and men's knowledge of such diversity are eroding.

The foregoing should make it clear that the utility of plant biodiversity for humans depends upon not only the demand for these resources that is related to culture and culinary traditions, but as well on the availability of labour, of knowledge of the properties of plants, and of the skills and technology for processing, preserving, preparing, and storing plant materials. If for any reason these are lost, the use and knowledge of the plants and animals and their production and procurement is also likely to be lost which, in turn, can threaten species that depend for their existence upon human interventions, and it can also threaten ecosystems that have been managed over centuries to provide these species. The major reasons cited for the erosion of plant biodiversity are usually not related to culture, the kitchen, or the domestic sphere, but rather to factors related to production and the environment (Howard 2004). However, it is increasingly recognised that changing food habits that are related to migration, urbanisation, globalisation of food habits, and expanding food commodity markets result in a decrease in the management and use of local biodiversity (Johns & Sthapit 2004). The awareness that gender relations are also intimately involved must also be increased.

It is thus clear that, historically and contemporarily, it is not global markets that have created and sustained the world's biologically rich SES. Rather, these markets tend to render them valueless (leading to neglect or destruction) because they are not recognised as useful or desirable resources outside of their specific cultural and environmental context (for example, when clearing forests for commercial timber, wild food resources of local peoples are 'inadvertently' destroyed). When these resources do become commodities, the threat of their neglect or destruction may also increase due to over-exploitation. Modern 'industrial' agriculture seeks to maximise yields and minimise direct costs in the context of global market

Cattle Feedlot in the USA

Intensive Glasshouse Horticulture in the Netherlands

competition, where production is divorced as far as is technologically possible from natural processes, local environments, and local cultures ('de-naturalising' and 'de-culturalising' agriculture). Globalisation (or 'de-localisation'), when coupled with a focus on maximising yields, leads to the standardisation and specialisation required for mass commodity production for global trade, which undermines both cultural and biological diversity. The future sustainability and productive capacity of these integral social-ecological depends upon the nature of demand itself, which clearly cannot be a function of an infinitely expanding set of needs determined by an unmitigated drive toward accumulation either on the part of internal or external actors; nor should the demand on the part of external actors be for goods and services that are not locally available and renewable. This was not the nature of consumption throughout most of human history, which was largely determined by local resource availability that shaped culture and hence consumption itself. The loss of biodiversity is not only related to the expansion of industrial agriculture: it is as well related to the loss of local cultures and languages and the associated changes in culinary habits and the homogenisation of diets that have accompanied the expansion of the global agrofood system.

The devalorisation of traditional culinary habits and indigenous foodstuffs is part and parcel of a more general trend, where the use of traditional crops and wild plant resources is devalorised by dominant cultures. Formal educational systems teach children to abandon their native languages, agricultural, culinary, and medicinal customs, knowledge and practices, which has often led to a decrease in traditional people's social status. For example, in the Venezuelan Amazons, Hoffmann (2003) showed that, since their first contact with colonial explorers, Arawakans have adapted to outside influences and yet, to a great extent, have maintained their traditional subsistence patterns. Within the last 35-40 years, the government has increased its efforts to integrate Amazonia into the national economy. Education has been encouraged, and Arawakans have had to migrate to larger population centres to ensure that children attend school. Besides disrupting traditional subsistence patterns, the educational system devalorises traditional subsistence practices by teaching children that they are 'backward', and that European-style practices, knowledge, food, clothing, culture and other habits are superior. These and other factors have caused a decline in the region's subsistence system, particularly in crop and cultivar diversity and in the detailed knowledge required in order to guarantee a steady and reliable food supply. Turner (2003) also cites the devalorisation of traditional subsistence practices and cultural knowledge by dominant cultures as major reasons for the erosion of local plant-related knowledge and practices in the Pacific Northwest of the USA and Canada, where formal education systems pertaining to the dominant cultures are implicated and traditional sources of status erode. Traditional peoples' capacities to negotiate these changes in ways that are favourable to them are often compromised by the fact that they do not have the political power to confront dominant cultures.

Loss of plant biodiversity ensues as traditional and indigenous rights regimes break down (see e.g. Acharya 1990, Aggarwal 2001, Bakhit & Hayati 1995, Cunningham 2001, Lu 1999, Yeh 2000), since these have regulated access to and management of agrobiodiversity with the result that such resources and ecosystems have proven to be resilient (see e.g. Acharya, 1990, Aggarwal 2001, Bakhit & Hayati 1995, Irvine 1987, Robbins 1996). Several of these studies attest to the positive welfare implications of such rights regimes since they are also oriented toward ensuring equitable access at least to subsistence resources, and of the deterioration in welfare (particularly food security, health and income) of the respective populations as plant rights regimes fail, and they also attest to the concomitant erosion in traditional botanical knowledge. Securing traditional rights to agrobiodiversity is clearly only part of the solution: other primary and proximate drivers cited earlier clearly need to be addressed, but the neglect to even recognise existing rights regimes around agrobiodiversity in Intellectual Property Rights and Common Property Rights discussions and debates practically ensures that well-intentioned but misguided interventions and legal changes can fuel negative trends.

5.6 Some Indirect Drivers of Social-ecological System Resilience

It is less common that scientific literature focuses on the underlying drivers of traditional social-ecological system's resilience (but see Dove et al. 2005), which is partly due to the fact that this question only recently emerged, given the fact that much of Western science was, until the 1960s, concerned with promoting 'modernisation' of such systems, and tended to characterise what now might be termed underlying drivers of maintenance as 'obstacles' to such modernisation. Anthropologists have tended to be more concerned about the continuity of such systems, although for diverse motives (see e.g. Ellen 1982).

Understanding drivers that lead to SES resilience is emerging as a very important area of academic research and theory building, as was discussed earlier. Globally, this is driven by increasing awareness of numerous highly negative drivers that are interacting (environmental degradation, biodiversity loss, collapse of ecosystems, impending crises around water and energy, climate change, poverty, disappearance of languages, cultures and entire peoples, cultural conflicts and religious tensions related to increasing inequality and marginalisation, over-consumption, obesity, epidemics, food safety, etc.) All of this has given rise to innumerable initiatives on the part of a very wide range of stakeholders, from grass-roots to the corporate and political elite, from indigenous peoples to movie stars, agitating for organic and sustainable agriculture, traceability, fair trade, ecotourism, responsible consumption, conservation, respect for traditional knowledge and traditional cultures, participatory resource management in a multitude of forms, slow and healthy food, of cultural heritage and cultural landscapes, and conservation that benefits local people, etc. All of the above are underlying drivers that, at different levels, are intended to counter negative drivers and promote positive change.

Some of the important underlying drivers that tend to maintain traditional SES take the form of barriers to markets and political interference, some of which are mentioned above. These include political barriers that reinforce local autonomy (e.g. the existence of weak states), physical isolation or remoteness and lack of infrastructure, and financial and technical barriers to profitability (see Berkes & Folke 1998).

An explicit goal of global change research is to better predict and manage human impact on biodiversity, ecosystem functioning and, ultimately, human welfare. Meeting this objective will demand more than the current focus on the independent effects of land-use change, atmospheric CO_2 increase, climate change, anthropogenic nitrogen deposition and increasing biotic exchange. It is becoming clear that the impact of one global change driver…can be strongly dependent on the effects of other drivers acting in concert. There is growing recognition that we lack even a basic understanding of how the interactive effects of global change drivers might mitigate or exacerbate total ecosystem effects in the future (Didham et al., 2007).

Many of the drivers that reinforce SES resilience are discussed in Chapter 3, and include cultural cohesion, maintenance of cultural identity and boundaries to group membership, maintenance of territory and defence of resources, including through enforceable access rules regarding natural resource management. Further, many systems demonstrate an ongoing capacity for self provisioning, where goods and services provided within the SES are non-substitutable due to the cultural and technical inappropriateness of external technologies, animal and plant varieties, and knowledge, and because of the multiple purpose values of social-ecosystem components (e.g., specific plant species and landscapes that fulfil spiritual, material, and cultural and economic needs). Equitable access to major subsistence resources and perceptions of fairness and social justice reinforce social-ecosystem resilience and people's willingness and ability to co-operate and to comply with institutional norms. Strong mechanisms for cultural knowledge transmission accompany such phenomena, as do opportunities for learning.

Many positive, proximate or direct causes also include certain forms of external support, including for population planning, health (particularly epidemiological), programmes to eradicate pests and diseases affecting major biological resources, labour markets and remittances, political support and movements for autonomy, etc. (see Chapter 4.5). Within the conservation community there is also increasing support for direct payments for set-aside areas and community participation in monitoring and protecting them, reforestation and nurseries to provide seedlings of locally occurring species, ethnobotanical and school gardens to both preserve *in situ* agrobiodiversity and provide a means for transmitting ethnobotanical knowledge and experience to school children. In the interior of Indonesian Borneo, formal schooling hours and school holidays are scheduled around the subsistence activities of the community, which take priority so that children can participate, learn and develop the skills they need to maintain their communities (Puri 2005).

5.7 Synergies and Adaptive Capacity

Synergies in this context refer to the interactions between two or more drivers so that their combined effect is greater than the sum of their individual effects. Efforts to understand synergies and relate these to adaptive capacity, thresholds, and resilience are increasingly the order of the day in both modelling efforts and in policy making. It is especially in the field of scenario building, such as has been done for the Intergovernmental Panel on Climate Change, where scientists and policy makers together attempt to inter-relate ecological, social, and economic drivers (IPCC-WGIII 2000).

Nevertheless, it is important to note that such scenarios and models have not predicted the current food crisis or the current oil shock, and in fact these largely took most of the scientific community by surprise. When reviewing the drivers that have been discussed herein, it becomes apparent that the current shocks are indeed not surprising. What this indicates is not so much the presence of uncertainty, which most scientists highlight as an essential feature of ecosystem change, thresholds and attempts to forecast the future. Rather, what it most clearly reflects is the under-development of synergistic models and conceptual frameworks that seriously consider the interactions between real economic drivers and environmental change drivers.

In spite of the fact that the globe was already experiencing the oil shock that began in 2003, the Millennium Ecosystem Assessment, for example, did not refer to fossil fuels or peak oil in the chapter on drivers, nor did it take it into account when discussing synergies. The CGIAR system institute responsible for 'Sustainable solutions for ending hunger and poverty,' the International Food Policy Research Institute, first mentioned the problem of fossil fuels only in April of 2008.[17] Further, the studies and forecasts made by scientists regarding global change and food or crops over the 21st century (which in general are fairly optimistic about the ability of the planet to feed itself), also have failed to take into account synergies between fossil fuel prices and the limited availability of, and skyrocketing global demand for, other essential natural resources. One such resource is phosphorus (phosphate rock), for which the United States Geological Survey says there are no substitutes in agriculture,[18] which is projected to last only for the next 50-100 years,[19] and the price of which has risen by 700% over the past few years. Such projections also do not take into account competition between food and agrofuel production, changes in biodiversity and ecosystem services, or the possibilities for generalised economic recession or depression, which would obviously constrain the possibilities that governments and the private sector have to invest in technological improvements (such as plant breeding), which at least until very recently have been generally assumed to either increase over time and lead to increases in agricultural productivity (in the global North), or to mitigate many of the effects of climate change (in the South).

Part of this problem is ideological: contemporary economic science is dominated by neoliberal thinking that presumes that market mechanisms will resolve global problems through technological innovation and investment, given the correct signals. The current credit crisis highlights the fact that economists have been largely blind to underlying structural features that can lead to massive economic disturbance (only a few economists warned some years ago that something was amiss). Another part of the problem is that those scientists and economists who are dealing with different aspects of global change processes do not attempt to inter-relate their domains of work. There are still few attempts to assess interactions between synergies to be expected between climate change, biodi-

versity change, peak oil, cultural change and other stressors that haven't been discussed here but that are treated in depth elsewhere (e.g. land use change, soil degradation, nitrogen deposition, demographic change, change in resource tenure and competition over natural resources and water, conflict).

The effects of global drivers and synergies on traditional subsistence SES will be different in comparison with their effects on other types of agricultural systems. Some traditional SES may be less vulnerable compared with many intensive agricultural systems in developed and developing countries that are fully dependent on markets, external inputs, and already degraded ecosystems, and traditional subsistence SES may have greater adaptive capacity due to rapid recognition of ecosystem changes and rapid response to such changes, as well as higher levels of biodiversity. However, traditional SES also have lower buffer capacity, e.g. in terms of greater dependence on biological resources that may disappear, and their lack of financial resources and transferable skills that might permit people to gain access to alternative sources of income to support adaptation, or if their ecosystems pass thresholds into undesirable states.

For GIAHS SES, there have been major concerns raised in this chapter about the implications of global change drivers for biodiversity, ecosystem functions and services, cultural change and continuity, and livelihoods and food security. Types of responses to such changes on the part of subsistence societies have been illustrated in the sections on climate change and on biodiversity change, where it has been demonstrated that the type of response depends in large part on the severity of the impacts, which also depends on the degree to which subsistence societies are experiencing multiple interacting stressors.

The implications for the GIAHS Programme are clear. First, it is essential that the types of research that have been discussed throughout this chapter, and in other chapters, be carried out in GIAHS sites, with the fullest possible participation of GIAHS communities. Biophysical research needs to focus on drivers of change and actual change in ecosystems, biodiversity, and agrobiodiversity. A recent review (Groffman et al. 2006) of concepts and methods that can be used in adaptive co-management noted that

> *In adaptive management, solutions to problems are proposed and implemented, but prescriptions are constantly re-evaluated based on actual ecosystem response to management...Understanding the conditions under which thresholds are likely to be crossed and what mechanisms underlie thresholds behavior is critical...[which] requires monitoring a broad series of variables and their spatial distribution to provide a more comprehensive indication.*

This needs to be closely linked with social-economic research that can identify the indirect drivers of change that are cultural, demographic, economic, and governance related. Second, the GIAHS Programme must be very cautious about introducing changes that may increase, rather than decrease, uncertainties and risks by changing dependencies of GIAHS communities on external resources, whether these be markets for goods and services (such as ecotourism and niche markets for GIAHS products) or transfer payments (subsidies, donor funding, etc.) that may, in case of economic disturbances or depression, simply disappear. Rather, the GIAHS Programme should seek to change those negative drivers that are possible to change (e.g. resource insecurity, policy-induced or market-induced reductions in biodiversity, factors that fuel population growth, erode cultures and cultural institutions) to enhance adaptive capacity and resilience, particularly those factors that constrain people in their capacities to respond to change through the generation of new knowledge and innovation. In this, ***the identification of knowledge resources and technologies, and of means to enhance social relations that contribute to adaptive capacity and resilience, e.g. by (re)building social networks and institutions and enhancing equity, count among the most important contributions that the GIAHS Programme can make to attempting to secure the future of GIAHS SES.*** All such actions should be derived not from global formulas, but rather from context-specific research of the type that has been suggested herein.

There are further implications for the GIAHS Programme presented by synergies between change drivers that are very important to highlight here. The first and foremost is that the GIAHS Programme should not seek to 'freeze' agrobiodiversity because it could limit the capacity of both people and species to adapt to a possibly radically changing environment, jeopardizing both livelihoods and possibly biodiversity and the functions that it plays in ecosystems. Human adaptive capacity must also be encouraged, and people will respond to changes by experimenting with many different strategies. Such strategies in subsistence SES typically include agricultural intensification, greater use of natural resources such as forests, abandonment of certain livelihood activities in favour of others, migration and resettlement, etc. (see Petschel-Held et al. 2005). It is clearly the mandate of the GIAHS Programme to enhance, rather than undermine, actions that promote biodiversity and ecosystem resilience, as well as cultural and socio-economic resilience, and hence such strategies need to be actively assessed and monitored, and those that are clearly a threat to SES adaptive capacity and resilience should be discouraged by promoting those that do not ***GIAHS Principle 15***).

Adaptive co-management of GIAHS requires, above all, flexibility: the GIAHS Programme will have to track and monitor a moving target, and it will move in part due to GIAHS interventions. The functions and dynamics of the SES system need to be understood as well as possible, as do the management practices and their implications, as well as the knowledge system and the institutions that underpin these.

The review of change drivers in this chapter may lead many readers to question: Can the GIAHS Programme possibly deal with all of these stressors and can GIAHS

GIAHS Principle 15

Given the major global and local drivers of environmental change, the GIAHS Programme should not seek to 'freeze' agrobiodiversity in GIAHS sites since this could limit people's capacity to adapt to possibly radically changing environments, and it may also limit the capacity of species to adapt to environmental change. GIAHS societies will clearly have to experiment with many different strategies and responses to major change drivers. The GIAHS Programme should enhance, rather than undermine, actions that promote biodiversity and ecosystem resilience, as well as cultural and socio-economic resilience, and hence such strategies need to be actively assessed and monitored, and those that are clearly a threat to adaptive capacity and resilience should be discouraged by promoting those that do not.

SES possibly adapt to these changes in the 21st century and beyond? These are legitimate questions, and at this point they have no answer. They are precisely equivalent to other questions, such as, 'Can the world's governance systems reduce CO_2 emissions to avoid the worst possible scenarios of the 21st century? Can the Amazon forests be saved? Can the world's population be fed?' There are no answers to these questions at this time, but it is absolutely clear that they are the most important questions that humanity faces. The fact that they are being raised at all is the main justification for taking action. Every attempt must be made now to ensure that the world's most resilient social-ecological systems continue to exist and evolve. The challenges are real and may appear to be overwhelming, but it is because humanity has been capable of developing such ingenious, ecologically and socially resilient systems and adapting them over time, that there is reason as well for optimism.

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[1]A useful overview and set of links for such assessments is available at http://earthwatch.unep.net/; however, it does not cover all assessments, some of which are carried out by private institutions and NGOs.

[2]In fact, a new area of multidisciplinary research, global environmental change, has arisen to tackle these questions, with its own journals, conferences, policy wing and intergovernmental panels. Social scientists have participated in programmes on the Human Dimensions of Global Environmental Change, looking at both the human causes and human responses to climate change, natural disasters, land degradation, the threat of pandemics, and pollution, among others (Moran 2000).

[3]See, for example, the US Environmental Protection Agency's opinions about biofuels as a 'Smart Way to Grow and Go' at http://www.epa.gov/smartway/growandgo/documents/faq.htm#i_05

[4]For example, Biofuel Watch (http://www.biofuelwatch.org.uk), Oliomap (ttp://www.oliomap.com/about-us-en.php), Worldwatch Institute (http://www.worldwatch.org/taxonomy/term/445)

[5]See Sunday Telegraph, 1-7-2007, 'Floods are judgement on society, say bishops. Online at: http://www.telegraph.co.uk/news/main.jhtml?xml=/news/2007/07/01/nflood201.xml [accessed 2-4-2008]

[6]'Of 11 588 studies on land-use change ('habitat loss' or 'habitat fragmentation' or 'land use') and 3528 studies on species invasion...published between 2002 and 2007...only 178 (1.2%) investigated both land-use change and species invasion simultaneously, and only 4 (0.03%) also used the term 'interaction'' (Ibid.).

[7]Search performed on 26 June 2008.

[8]Perrings, C. 2006. Pests, pathogens and poverty: biological invasions and agricultural dependence. Discussion Paper, Arizona State University. Online: http://www.public.asu.edu/~cperring

[9]Commonwealth Agricultural Bureau International publishes CAB Abstracts, generally considered to be one of the most comprehensive abstracts database covering agriculture, plant sciences, and evironmental sciences. See http://www.cabi.org/

[10] A joint initiative of the IUCN, CAB International, the Nature Conservancy and the South African National Biodiversity Institute. See http://www.gisp.org

[11]IEA, 07 November 2007, London. Press release. 'The Next 10 Years are Critical - the World Energy Outlook Makes the Case for Stepping up Co-operation with China and India to Address Global Energy Challenges' Press release. http://www.iea.org/textbase/press/pressdetail.asp? PRESS_REL_ID=239

[12]See footnote 5 for source.

[13]''Dutch disease' is an economic concept that tries to explain the seeming relationship between the exploitation of natural resources and a decline in the manufacturing sector. The theory is that an increase in revenues from natural resources will deindustrialise a nation's economy by raising the exchange rate, which makes the manufacturing sector less competitive. However, it is extremely difficult to definitively say that Dutch disease is the cause of the decreasing manufacturing sector, since there are many other factors at play in the economy. While it most often refers to natural resource discovery, it can also refer to 'any development that results in a large inflow of foreign currency, including a sharp surge in natural resource prices, foreign assistance, and foreign direct investment' (Wikipedia, citing IMF, http://en.wikipedia.org/wiki/Dutch_disease#_note-0) accessed 31 March 2008.

[14]See the website of the United States Energy Information Administration, http://www.eia.doe.gov/emeu/cabs/nonopec.html.

[15]These were are follows: Malawi (-2.2%), Mozambique (-2.2%), Mali (-2.3%), Jordan (-2.3%), Ukraine (-2.5%), Jamaica (-2.8%), Moldova (-3.2%), Nicaragua (-3.0%), Honduras (-3.4%), Ghana (-3.7%), Swaziland (-4.4%), Togo (-4.6%), and Lesotho (-4.9%).

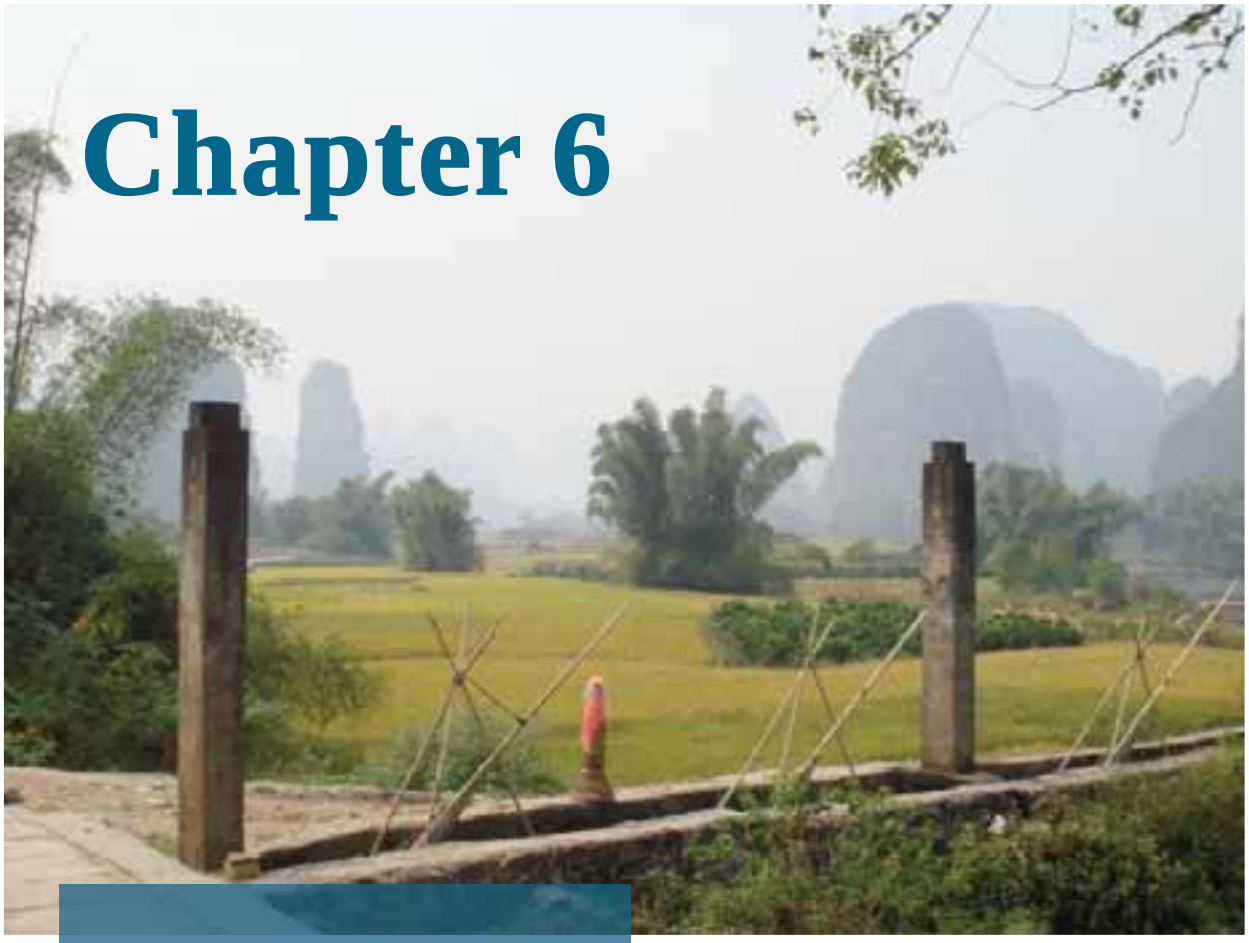
[16]See e.g. UNICEF at http://www.unicef.org/china/media_927.html

[17]Based on a search of the online publications database at IFPRI using the terms 'fossil fuel' and 'food' on 30 June 2008.

[18]See http://minerals.usgs.gov/minerals/pubs/commodity/phosphate_rock/phospmcs05.pdf

[19]This was predicted as early as 1993 (see Herring & Fantel 1993) and was recently reported in http://business.timesonline.co.uk/tol/business/industry_sectors/natural_resources/article4193017.ece (accessed 27-6-08). See also Cordell, D. 2006. *Urine diversion and reuse in Australia.* Masters thesis. Dept. of Water & Environmental Studies, Linkoping University (Sweden).

Chapter 6



Defining and Understanding GIAHS Heritage

6.1 Introduction

The GIAHS Programme recalls the process of human and biological evolution in the world's contemporary traditional social-ecological systems. These systems are globally important because they are the product of hundreds, if not thousands, of years of cultural evolution. The planet abounds with such globally important systems: it is the continued fortune of humankind that they are still quite pervasive. Such systems are even more regionally and locally important because they represent

the only viable way that humans have today of achieving human and ecological well-being in specific contexts. As a concept, then, 'globally important' cannot serve to select certain systems.

This said, the concept of heritage is also crucial to the GIAHS Programme. In the last decade, scientists and policy makers have been rethinking the ideas and assumptions behind the idea of heritage. Traditional and indigenous peoples, whose ideas of heritage are often radically different from Western perceptions, have helped to inspire this rethinking. However, what has tended to emerge from this process are two distinct ideas or definitions of heritage. The first, which is the dominant idea in the West, emphasises the material and global value of heritage. The second stresses intangible heritage, which is valued for its local or regional significance, and is often associated with indigenous and other traditional peoples. These two concepts or definitions of heritage are represented respectively by UNESCO's World Heritage Convention, and by UNESCO's more recent Convention for the Safeguarding of the Intangible Cultural Heritage (2003). These two concepts of heritage need to be merged and further developed to help formulate a more useful conceptual framework for GIAHS.

Whichever definition of heritage scientists or policy makers use, it is nonetheless agreed that heritage is concerned with the representation of cultural identity. As such, this concept is important to developing frameworks for understanding the GIAHS Programme, and to consider its potential impact on cultural expression and diversity. Ideas of heritage are also important for linking the material, or environmental, with social and cultural processes and expression. Here we discuss some of the dominant Western assumptions about the nature of heritage, and we indicate how they may hinder the development of a conceptual framework for GIAHS. It then goes on to examine some of the impacts indigenous peoples have had on ideas of heritage, and the cultural conflicts that occur between Western and indigenous peoples with respect to concepts of heritage and heritage programmes. A range of important issues relevant to the development of a conceptual framework for GIAHS emerges from these conflicts.

6.2 Dominant Western Perceptions of 'Heritage'

The dominant concept of heritage in the West emphasises its materiality. Heritage is normally considered to be an object, building, site, place, or even a landscape that is valued for its ability to represent or symbolise cultural and/or national identity. In the West, it is especially valued for its ability to represent national identity and history. Indeed, the more that heritage is seen to be representative of the entire nation, the more it tends to be valued and considered important (Lowenthal 1998, Wright 1985). This value, or the ability of an object of heritage to represent culture or national identity, is often assumed to be built into, or intrinsic to, that object. Many scholars who have analysed the history of this term in the West believe that privileging the intrinsic value of heritage has led to an over-emphasis on its material aspects. Further, it has ensured that the preservation of the fabric (e.g. original building materials, furnishings, old trees and other plant-

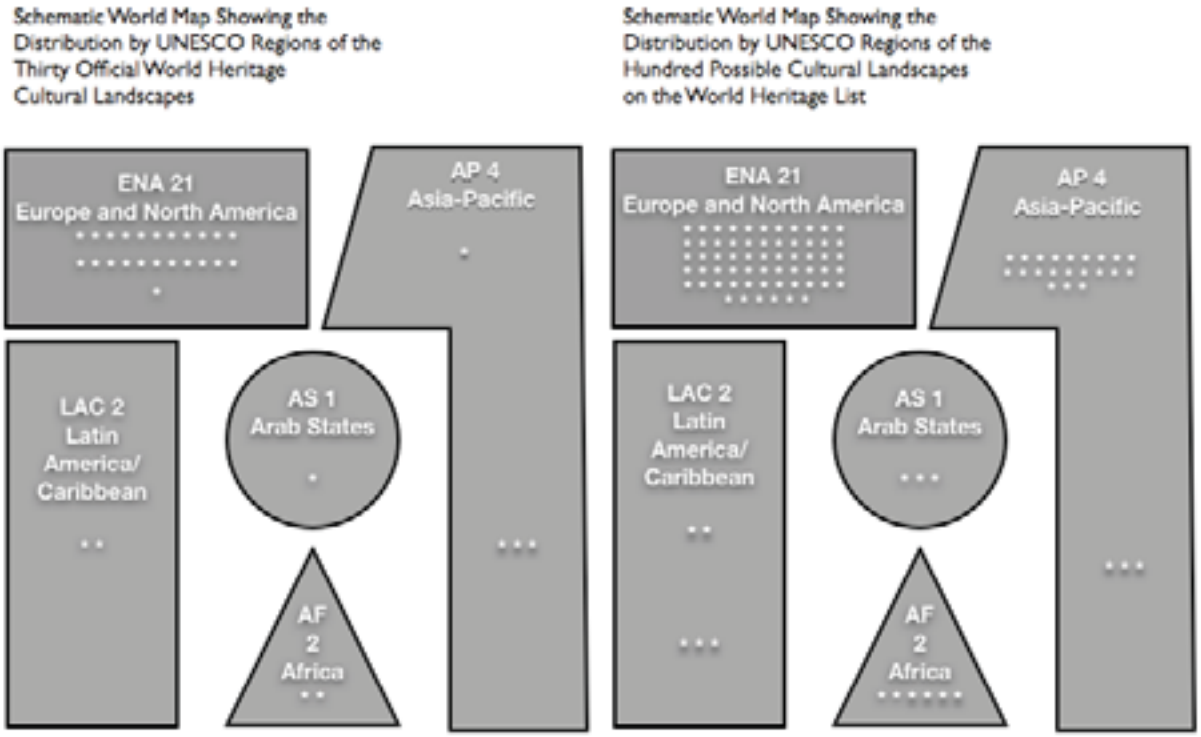
ings, and so forth) of a site or place is the first concern of the management and conservation process (Graham et al. 2000, Lowenthal 1998, Smith 2006). Tied to the emphasis on materiality, and assumptions about the nationalist worth of heritage, is a regard for the grand, beautiful, and monumental (Choay 2001).

Heritage is also defined as inheritable, something that must be passed to future generations so that they may be educated about the past, to ensure that a common sense of identity with the past may be maintained. This sense of inheritance, together with the emphasis on the innate value of the material, fosters a strong conservation ethic that requires that the present pass on heritage objects and sites unchanged to the future. As a number of scholars have demonstrated, one of the dominant assumptions underlying the idea of heritage in the West is that heritage is unchanging and unchangeable (Emerick 2003, Lowenthal 1998, Smith 2006). It is a record of cultural identity and expression that must be preserved unchanged, since to allow change is to run the risk of 'losing' an important cultural asset or expression.

This idea of heritage underwrites cultural heritage or cultural resource legislation in the Western world. The management and preservation of heritage is about the protection of material places and properties (see Cleere 1989, King 1998, Cookson 2000). These ideas also underpin the World Heritage Convention that identifies sites of universal or global value and significance.[1] As many policy makers and scientists now recognise, the degree to which the World Heritage Convention has been dominated by, and in turn reinforced, Western assumptions about the nature and meaning of heritage, has worked to ensure that these values and assumptions have themselves been universalised (Byrne 1991, Cleere 2001, Munjeri 2004). This dominance presents a problem for incorporating indigenous ideas of heritage into the GIAHS framework.

Many of the criticisms levelled at both the dominant Western assumptions about heritage, and the World Heritage Convention itself, have centred on the idea of 'universal' or global value. Of all of those things that any particular group may identify as heritage, very little can be perceived as being of universal or global significance. The assumption of the universal or national value of heritage compromises the possibility of cultural diversity. There is no site that can, or will be, valued by all cultures. It is not possible, as Lowenthal (1998) points out, for heritage to be all things to all people: the idea of universal or global value is not logically sustainable. Yet, being accepted as having either national or universal value before it can be recognised as heritage on the international stage has

FIGURE 6.1 | UNESCO World Heritage Cultural Landscape sites by Region (official and possible) (Fowler 2003)



meant that traditional or sub-national forms of heritage and identity tend to be obscured or devalued. This is a point that is strongly demonstrated by the dominance of European heritage sites on the World Heritage List and the corresponding under-representation of Africa, Asian and indigenous sites (Cleere 2001) (see Figure 6.1).

Scientists who have studied the effects of globalisation show that traditional and indigenous peoples are becoming increasingly assertive in their demands for global recognition and acceptance of their cultural identity and heritage (Berking 2003, Castells 2004, Chang et al. 1996, Escobar 2001). However, this recognition is made difficult by the dominant idea of heritage that tends to devalorise, or not recognise, the legitimacy of traditional or sub-national identities. Numerous social commentators, academics, and community activists have drawn attention to the degree to which Western perceptions of heritage, and the national and international legal and policy instruments that reproduce those assumptions have alienated, for example, ethnic and other sub-national community groups (Hayden 1997, Littler & Naidoo 2004 and 2005, Shackel 2001), indigenous communities (Smith 2004, Watkins 2003), women's heritage (Dubrow & Goodman 2003, Smith et al. 2003), and working class and labour history (Dicks 2000, Hayden 1997).

Two moves have been made by UNESCO in the last decade to address some of these criticisms. The first was to incorporate the idea of heritage landscapes within the World Heritage Convention, in an attempt to offer a more holistic approach to understanding the heritage values of particular regions or localities. However, 'landscape' has often been viewed in heritage agencies as inherently 'natural' (Titchen 1996, Waterton 2005). Lowenthal (2005) has argued that there is a marked sense within UNESCO policy documents that nature is more important than culture in dealing with heritage landscapes, and that 'nature is perfect and culture a nuisance'. Certainly, the divide between Nature and Culture in Western thought is well documented, and was noted previously in this paper as a problem for GIAHS (see Chapter 1). However, in relation to heritage issues, it is important to emphasise what is discussed throughout this paper and especially in Section 3.5.1, that people derive a sense of place or identity from landscapes, without making divisions between 'nature' and 'culture' as Westerners generally do. The idea that people also interact both materially and culturally with the 'natural' aspects of their landscape or biophysical environment in a way that underpins or informs their sense of self and cultural belonging, has often been ignored or obscured by the way Western ideas of heritage, and more specifically heritage landscapes, has been developed.

The second response to criticism of the World Heritage Convention has been the development of a range of programmes dealing with intangible heritage, culminating in the 2003 Convention for the Safeguarding of the Intangible Cultural Heritage. This convention attempts to address issues of cultural diversity and to acknowledge the legitimacy of traditional concepts of heritage. The idea of intangible heritage is important to the development of conceptual frameworks for GIAHS. Although the 2003 convention has been criticised for providing a list of heritage that is only complementary to that of the World Heritage List (Kirshenblatt-Gimblett 2004), it is nonetheless important for recognising that identity, beliefs, knowledge, and skills (all intangibles) are as much heritage as the material or tangible. More importantly, it draws our attention to the fact that all heritage is in fact intangible.

For example, as Munjerie (2004) wrote, 'the tangible can only be understood and interpreted through the intangible': in other words, heritage is only heritage because it people value it as such, not because it has inherent physical value. A child will not understand a particular building or grove of trees as 'cultural heritage' unless it is taught that this is the way to understand such a building or grove, and indeed comes to see it as part of their identity. It may therefore be argued that the focal point of heritage should be cultural values, and the meanings and cultural messages that people draw from those values (see GIAHS Principle 14). Further, the 2003 UNESCO Convention recognises that not all intangible heritage will or can be of universal value. It is crucial to understand that defining heritage values as 'globally' significant, or of national, regional or local significance, is less important than the fact that communities and individuals use these values in the construction and transmission of cultural knowledge. The importance of the idea of intangibility will be returned to below but, before this is discussed further, it is necessary to look at general traditional and indigenous heritage issues.[2]

6.3 Conflicts Over Heritage

Heritage is often a key issue in indigenous and traditional people's politics for cultural recognition. Arguments about the repatriation of indigenous human remains and artefacts have dominated heritage debates for decades. These debates, which are often discussed under the banner of 'who owns the past', frequently and incorrectly assume that indigenous and traditional peoples' concerns are solely about the possession of the material items. However, as numerous indigenous and traditional authors and scientists have commented, it is not simply the material that is important, but rather how the material interrelates with contemporary cultural knowledge, belief systems, and cultural practices. The focus is less on the past, as it is in dominant Western definitions of heritage, and more on cultural continuity in and for the present, and for the roles it plays in contemporary belief systems (Nicholas 2005; see also Deloria 1973 and 1997, Smith & Wobst 2005, Watkins 2000, 2003). As Zimmerman observes about the concerns of archaeologists for the past as heritage, 'The past of archaeologists is wrapped up in the material, the artefacts they find, and the places in which they find them. For many tradition-orientated Indians, for example, there is a very different past from that of archaeologists. It is not about objects, but people' (1998).

The protection and management of indigenous and traditional heritage is often not about 'conservation' and 'preservation' of material items, as is normally understood in Western definitions of heritage management. Rather, management is often about using items of heritage to continually reaffirm or even remake the cultural values and meanings they represent. In short, heritage may not be about possessing, but about using items or places of heritage. This may seem a to be a rather trivial difference between Western and indigenous perspectives, but it is a highly significant one. The concern for preserving material so that its fabric is not altered or changed is a key concept in Western definitions of heritage. However, for some indigenous and traditional communities, preserving objects or sites unchanged may not be as important as the act of using those sites and objects, and thereby allowing for the possibility of change. For instance, the repainting of Australian Kimberley rock art sites containing Wandjina figures by their indigenous owners in 1987 caused international debate. Many Western scientists considered that the heritage values of the painting had been destroyed since the paintings had been changed in the repainting process, particularly as so-called 'non-traditional' repainting techniques had been used (Bowlder 1988). However, the traditional owners countered that what was important for their community was the act of repainting: by means of this act, cultural knowl-

edge and practice was renewed and remembered, and this was the important issue. How the repainting was done was simply not as significant as the fact that it was done (Mowljarlai & Peck 1987).

Also tied up in the conflicts over heritage between indigenous and traditional peoples and Western heritage managers is the very strong desire that indigenous and traditional peoples have to control their own heritage. If heritage is about remembering and renewing cultural values and meanings, then how heritage is used becomes highly important. Who controls how heritage is used is also a significant issue for indigenous and traditional peoples. Control over heritage is about controlling the expression and development of cultural value and identity. It is also a statement about the legitimacy and recognition of indigenous identity: a statement that indigenous people have their own identity outside of those assigned by colonising cultures and/or the West generally. As a Tasmanian Aboriginal woman, Ros Langford, pointed out, if 'we Aborigines cannot control our own heritage, what the hell can we control?' (1983, original emphasis) (***GIAHS Principle 13***).

GIAHS Principle 13

While the global and national communities have their own concepts of heritage and reasons for supporting the GIAHS Programme, the focal point of heritage in GIAHS should be cultural values, and the meanings and cultural messages that people draw from those values. Heritage is about cultural continuity: the continued development of cultures, cultural knowledge and identity. Control over heritage means controlling the expression and development of cultural value and identity, and it is also a statement about the legitimacy and recognition of identity, outside of that which is assigned by outsiders. The stewards of GIAHS have the need and the right to define and control their own heritage if it is to make any sense at all within GIAHS SES.

An important point becomes apparent in the conflicts that occur between a range of indigenous and traditional cultures and Western concerns and definitions of heritage. Indigenous and traditional peoples' heritage, as the 2003 UNESCO Convention recognises, is often intangible. However, its intangibility does not simply rest on the recognition that knowledge, skills, rituals and so forth may be understood as heritage: it also rests on the fact that even when heritage takes material form, it is tied into active processes of making meaning. Heritage is not only about the past: it is also about how the past is linked to the present and future: heritage is a process in which cultural values and meanings are continually reaffirmed and remembered, and also remade. Heritage is therefore about cultural continuity, not in the sense that cultural forms and practices are continually rehearsed and rendered static, but 'continuity' as the continued development of cultures, cultural knowledge and identity (see ***GIAHS Principle 14***).

6.4 Lessons from Joint Management of Heritage Programmes

Recognition of the legitimacy of indigenous and traditional perspectives and values about heritage has led to changes in the way government heritage managers in many regions manage indigenous and traditional heritage. Joint management programmes now occur throughout the world (Birckhead et al. 1992, Bray 2001, Dongoske et al. 2000, Stapp & Burney 2002, Swidler et al. 1997). A number of significant issues have become apparent in these efforts to promote meaningful and useful programmes. Some of the key issues that must be considered when developing joint management programmes are the diversity of indigenous and traditional peoples' understandings and uses of heritage, which means that there can be no single recipe or process for establishing and implementing management programmes (see GIAHS Principle 15). Another issue is the diversity of knowledge and values within certain communities and cultures. For instance, it is common that men and women have different understandings, values, and uses of heritage (Smith et al. 2003). Perhaps the most significant issue to emerge from these programmes is the institutional recognition of the legitimacy of the cultural differences between scientists and indigenous peoples. Many scientists and other researchers working with indigenous and traditional groups on heritage issues find this to be difficult, since it requires that scientists, policy makers and other development agents not only be humble about their own beliefs and opinions, but also that they develop a long-term relationship of trust and respect with the people with whom they work (Carter 1997, Smith 2004, Watkins 2000, Zimmerman 2005), which is true for all aspects of GIAHS joint management.

Another issue that arises is the degree to which identifying 'heritage' through formal management programmes has drawn the attention of tourists and tourist operators. Cultural and natural heritage in all its forms has been demonstrated to be a significant tourist resource, and the growth of ecotourism has significant implications for GIAHS (MacCannell 1999, Prentice 1993, 2005) (see also Chapter 4.3). A further lesson from joint management programmes is that tourist interests and development must explicitly be part of joint management agreements, in which indigenous and traditional peoples control the extent to which they allow or encourage tourism growth, and control the return and use of profits into the community (Altman & Finlayson 2003, Silverman 2006).

6.5 Heritage as Experience

A number of issues are raised above have immediate relevance to GIAHS (see ***GIAHS Principle 14***). These issues may be summarised as:

- The need to recognise the diversity of knowledge and uses that heritage may be put to within and between indigenous and traditional cultures;
- That heritage values are relative, and that global, regional or local values of heritage are less significant that the way heritage is used and by whom and for what purposes;
- To ensure indigenous and traditional communities have real power to control and direct the use and management of heritage within their own cultural and legal frameworks;
- To recognise the inter-relationship between material and intangible heritage and contemporary cultural expression and identity;
- To understand and accept that ideas of heritage are not simply about the past, but are integral and ongoing aspects of indigenous and traditional cultures.
- The consequences of labelling a place or practice 'heritage' in light of both the World Heritage Convention and the Convention on Intangible Cultural Heritage;

What must also be acknowledged is the degree to which Western ideas of heritage may present barriers to achieving the above. While the 2003 UNESCO Convention for the Safeguarding of Intangible Cultural Heritage recognises the possibility that cultural beliefs, knowledge, and skills may constitute heritage, there is still a sense, recognised by a range of commentators on the new Convention, that such beliefs, knowledge, and skills can only be identified as heritage if these are endangered, rare or in some other way exceptional (Kirshenblatt-Gimblett 2004, Munjeri 2004, Nas 2002). In defining intangible heritage, there is a desire to 'collect' or identify aspects of cultural knowledge or practice that can be assigned clear boundaries so that it may be put on a heritage list. However, this tends to define heritage as a bounded entity, whether it is in material or intangible form, that can be singled out and separated from its contemporary cultural context. What this act of classification may miss is the inter-relationship between heritage and cultural development and expression, which is itself an inherent part of GIAHS SES.

To overcome this conceptual difficulty it is more useful for the GIAHS Programme to perceive heritage not as a 'thing', or an intangible 'event' or set of beliefs, values, knowledge or skills, but as an integral part of cultural identity and expression: indeed as a cultural process in itself. Heritage may be more usefully defined as an experience (Smith 2006) or a cultural process or way of thinking and communicating that is about the negotiation of cultural development and change. In order words, 'heritage' is something that is done at tangible heritage places and/or landscapes, or within intangible heritage events and performances, that is not only about remembering and commemorating past cultural values and meanings, but also renegotiating or, where relevant, reworking those values for contemporary consumption. Heritage is a way of thinking, talking about and identifying the cultural and social values and meanings that communities wish to consider, reflect upon and then rework. It is not necessarily about social and cultural stasis, or for that matter necessarily about cultural change, but it is a process in which decisions are made about cultural expression, identity and development. In terms of GIAHS, understanding heritage as a way of thinking and talking about cultural identity and expression may leave conceptual space for acknowledging and incorporating indigenous knowledge and experiences into the management process.

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[1]These values also underpin a range of other UNESCO Conventions and ICOMOS Charters, such as the highly influential International Charter for the Conservation and Restoration of Monuments and Sites (the Venice Charter), 1964.

[2]Note that the following discussion is generalised. Indigenous and traditional values and definitions of 'heritage' vary considerably, and the discussion here cannot do justice to the variety of cultural knowledge and ideas about heritage that exists within and between indigenous cultures and communities.

GIAHS Strategic Principles Derived from the Scientific Framework

Chapter 7

Principle: 1 a fundamental truth or proposition serving as the foundation for belief or action. 2 a rule or belief governing one's personal behaviour. 3 morally correct behaviour and attitudes. 4 a general scientific theorem or natural law. 5 a fundamental source or basis of something.

— ORIGIN Latin principium 'source', from princeps 'first, chief'.

The most important contribution that the GIAHS Programme can make globally is as a platform for awareness raising and an exercise in policy making and development practice that initiate a fundamentally new approach to human development and environmental sustainability in the 21st century. The GIAHS Programme is positioned to herald in the necessary paradigm shifts, if nothing else because it creates conditions for revalorising traditional social-ecological systems and for bringing all relevant stakeholders together in an effort to ensure their integrity, adaptive capacity and resilience both for current and for future generations living within such systems.

8.1 The Definition and Uses of Principles

The overall aim of this paper is to generate knowledge on which to base appropriate action within the GIAHS programme, and within this, the aim of the principles is to condense the findings into a more manageable set of propositions, or principles. The definition of principles referred to herein corresponds in part to definition (1) above, insofar as it is a proposition that serves as the foundation for action, and partly to definition (4), insofar as it represents a scientific theorem. Rather than referring to ethical positions, the principles put forth represent summary statements that describe, as closely and succinctly as is possible, what is known about GIAHS-type SES, about how they function with respect to drivers of change, and how they might respond to interventions. These principles can be incorporated into frameworks and guidelines that will serve policy makers, development agencies, and communities. The principles should also serve as a focus for discussion in relation to the conceptual framework and to SES complexities, as well as their relations with proposed action, in a social learning / adaptive management approach.

8.2 GIAHS Principles

PRINCIPLE 1. The stewards of GIAHS are those people who have developed these systems and who continue to depend upon them for their livelihoods and cultural integrity. The maintenance of the resilience of such systems and the in situ management of agrobiodiversity cannot be done without ensuring the well-being of their stewards, where well-being is defined not only according to biophysical absolutes, but as well according to the cultural values that are inseparable from these multifaceted systems and their landscapes. The direct benefits of the GIAHS Programme must accrue principally to those who develop and sustain such systems.

PRINCIPLE 2. The central objective of the GIAHS Programme is to maintain adaptive capacity and resilience within GIAHS so that they are able to continue to provide the products and services that are crucial to their inhabitants, regions and nations, and to the globe.

PRINCIPLE 3. The forces that are driving the disruption of GIAHS by eroding their cultures and the capacities of these systems to provide for human and environmental well-being must, to the extent possible, be addressed by the GIAHS Programme. Human and biological diversity are under threat and concerted global action is necessary to change awareness, redirect policies, address negative drivers, and support the adaptive capacity and resilience of these systems and their stewards.

PRINCIPLE 4. It is essential that GIAHS stewards be able to continue with their own inbuilt processes of adaptation. Traditional GIAHS institutions have generally served to manage and regulate social and material relations over long periods of time, and have been proven to be adaptive and resilient, so the Programme must reinforce such institutions or, where such institutions are deemed by their stewards to be inadequate, replicate, restore, or set in motion new processes that mimic the natural adaptive management strategies that have been developed by GIAHS stewards.

PRINCIPLE 5. While respecting Principle 4, a fully inclusive and participatory social learning process is necessary that focuses on meeting local needs and longer-term priorities, including the heritage priorities, of GIAHS stewards and on eliminating or attenuating the impacts of negative change drivers and mediating contextual factors, which requires that an environment be established that is conducive to fluid and mutually respectful exchange between indigenous inhabitants and external actors.

PRINCIPLE 6. Collectively understanding the social-ecological system is essential to identifying potential strategies to enhance well-being, adaptive capacity and resilience. Given that even local communities may be unaware of emergent properties, of slow moving state variables, of scale effects, and of all the potential implications of introduced changes, and given that major drivers of local change are often external to GIAHS sites, the GIAHS Programme must include scientific research at multiple scales which is conducive to social learning, and it must include provisions for carefully monitoring GIAHS, as unexpected consequences are expected. Monitoring must be part of the social learning process and therefore should be participatory and involve decision-makers at all levels.

PRINCIPLE 7. An emphasis on agrobiodiversity within GIAHS is necessary and strongly justified insofar as it represents three cornerstones of GIAHS-type SES: it both underpins and drives most ecosystems services, it is the principle source of livelihoods and hence determinant of human well-being, and it is the future provider of capacity of GIAHS communities to adapt to rapid change, particularly to the major change drivers of the 21st century.

PRINCIPLE 8. The most important values of agrobiodiversity for GIAHS are local values, since these are crucially related to well-being, SES resilience and adaptive capacity. It is also local values that provide incentives for GIAHS stewards to develop and maintain such biodiversity. It is therefore crucial to assess local values of agrobiodiversity, agrobiodiversity as livelihood assets, the increasing or decreasing values of its components given drivers of change, the flexibility with which people can substitute, complement, and transfer or procure these assets, the changing conditions of access (e.g. rights, terms of trade), and the influence of markets and non-market institutions on these incentives.

PRINCIPLE 9. There must be a concerted effort to counter the loss of traditional ecological knowledge, which nearly everywhere is occurring rapidly, and which coincides with the loss of motivations and capacities to maintain GIAHS. Formal education and training must be oriented toward the realities of GIAHS stewards, presented in their own languages, and respect their ways of life, modes of production, knowledge and beliefs.

PRINCIPLE 10. GIAHS communities must be empowered to regulate and control property rights in ways that enhance resilience and maintain agrobiodiversity, in accordance with their norms, values and beliefs; to negotiate for changes in rules to enable this to happen, and to recur to mechanisms where absolutely necessary to resolve conflicts within communities, and between communities and other instances and agents that have opposing claims.

PRINCIPLE 11. Economic rationality will need to be carefully balanced with cultural rationalities when promoting change in resource use and values, and also will need to be assessed using a precautionary approach to creating new dependencies on external revenues and resources, when these will be increasingly influenced by global resource constraints, such as those presented by peak oil. The introduction of new forms of exchange in the form of new markets that entail increasing monetisation of GIAHS can have a substantial effect on the flow of goods and services in and out of SES, substantial implications for traditional social relations, and may be unsustainable due to rising oil prices and decreasing purchasing capacity on the part of consumers. New markets therefore certainly imply trade-offs, and such trade-offs will need to be factored in as risks into decision making.

PRINCIPLE 12. Well-being is both tangible and intangible and it is context-specific. What needs to improve, why, and how are major questions, where answers should not be provided beforehand, but rather consensus should be sought about needs for improvement in particular dimensions of well-being, the causes of a lack of well-being still remain, and the means to address the causes, where multiple entry points are certain to emerge, of which some are potentially more and some potentially less consequential for overall adaptive capacity and SES resilience. There are a very substantial number of options for enhancing well-being and security that build upon, rather than potentially undermine, traditional forms of collective organisation, rationality and cultural notions of well-being that are based on 'good social relations' and that provide forms of security that governments and markets are generally unable to provide.

PRINCIPLE 13. While the global and national communities have their own concepts of heritage and reasons for supporting the GIAHS Programme, the focal point of heritage in GIAHS should be cultural values, and the meanings and cultural messages that people draw from those values. Heritage is about cultural continuity: the continued development of cultures, cultural knowledge and identity. Control over heritage means controlling the expression and development of cultural value and identity, and it is also a statement about the legitimacy and recognition of identity, outside of that which is assigned by outsiders. The stewards of GIAHS have the need and the right to define and control their own heritage if it is to make any sense at all within GIAHS SES.

PRINCIPLE 14. There are no standard interventions or recipes for implementing GIAHS goals since, although GIAHS are everywhere influenced by multiple external relations and drivers, their cultural, institutional, environmental contexts and development paths are always unique. The introduction of new tools and methods, technologies, concepts, information, institutions and social relations, must be in conformance with the wishes of GIAHS stewards, and be understood as adaptable experiments through which social learning can occur.

PRINCIPLE 15. Given the major global and local drivers of environmental change, the GIAHS Programme should not seek to 'freeze' agrobiodiversity in GIAHS sites since this could limit people's capacity to adapt to possibly radically changing environments, and it may also limit the capacity of species to adapt to environmental change. GIAHS societies will clearly have to experiment with many different strategies and responses to major change drivers. The GIAHS Programme should enhance, rather than undermine, actions that promote biodiversity and ecosystem resilience, as well as cultural and socio-economic resilience, and hence such strategies need to be actively assessed and monitored, and those that are clearly a threat to adaptive capacity and resilience should be discouraged by promoting those that do not.

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Appendix

Culture, Food, and Agrobiodiversity in Subsistence Social-ecological Systems

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Traditional farming and hunter-gatherer societies typically draw on a defined suite of resources within a local environment in a manner that is both self-sufficient and nutritionally balanced…the globalization of culture and commerce fosters a Westernization of food systems and diets (Johns & Eyzaguirre 2006).

Which of the thousands of wild, semi-domesticated and domesticated species of plants, animals, insects, fungi, etc. that people generally have at their disposal are used for food in subsistence social-ecological systems? How are these resources combined in order to fulfil human nutritional requirements (carbohydrates, fat, protein, fibres, vitamins and minerals) of different groups of people (infants, weaning, adults, pregnant women, aged, ill or infirm) throughout the year? How are the raw materials selected and converted into food? How does the conversion process affect nutritional content, digestibility, palatability, storability, toxicity, and culinary traditions? How are these resources, and the technologies and Traditional Ecological Knowledge (TEK) required to manage them, distributed among people to ensure that everyone, whether generalist or specialist producers, surplus, subsistence or below subsistence producers, or non-producers, get access to an adequate diet? What does all this have to do with the development and maintenance of agrobiodiversity, and to the maintenance of social relations? The answers to these questions are both global, that is, common to the human race (whose nutritional needs and predilections have changed little over the past 40,000 years), and local, since food systems are specific to particular cultures and locations. Crucial questions for GI-AHS are whether the traditional social-ecological systems that have evolved over time to meet the physiologically and culturally defined food needs of their respective peoples are able to continue to provide food security in its multiple dimensions, and how especially the rapid 'Westernization' of the diet, as well as other underlying drivers, affect such traditional social-ecological systems and the welfare of the people who depend largely upon them.

1. Agrobiodiversity, Nutrition, and Food Security in Social-Ecological Systems

Much is now known about the evolution of human physiology and chemistry, and human dietary adaptation. There are relatively few differences among human populations in terms of nutritional physiologies across the globe: those that are recognised are related to lactose and wheat flour tolerance, sucrose (among Inuit and Amerindians of Northern Canada), protein synthesis (enzyme polymorphisms), sensitivity to ethanol, and differences in kidney functions that are related to sodium, all of which appear to be related to specific dietary patterns. There are other differences whose adaptive function is not clear (Johns 1990, Stinson 1992). In general, humans seek nutritionally dense foods that are efficient to procure and process in terms of energy expenditure. Taste and odour preferences and avoidances, and preferences for variation as well as for nutritionally dense foods, probably have evolutionary bases and tend to be universal. However, learned behaviour, and the accumulation of knowledge about food and techniques of food processing, storage and preparation (that is, culture), can change some of these preferences.

In certain extreme environments, where very little biodiversity is present, humans have very little choice about what to eat: this is, for example, the case in Arctic regions, where meat and fish must make up the majority of the diet. The definition of 'edible' is, of course, indeterminate, since compounds that especially plants produce that are toxic can at times be eliminated through processing or can be consumed in spite of their potential toxicity. The latter is evident in the fact that many of these compounds are also useful to people as medicine where, in traditional societies, the line between medicine and food is very difficult to draw (Johns 1990).

Human food requirements (nutrition, taste, palatability, digestibility, and potential or actual toxicity) are entailed in both cultural evolution and the evolution of species, since they figure into intentional manipulation of both 'wild' resources and of plant populations that lead to domestication and even speciation (Johns Ibid.). Within traditional societies, cultural mechanisms ensure not only the transmission of accumulated knowledge and practices related to toxicity and detoxification, but as well about nutritional well-being and about the range of resources and means to manipulate them that results in nutritional well-being, which result in patterns of food procurement and consumption that may be termed traditional food systems. A well-known example of a nutritionally balanced cropping and processing system can be found in the so-called 'milpa triad' of squash, beans, and maize in Mayan societies in Mesoamerica, which provides a balance of amino acids in a diet that is dominated by grains. Processing maize with alkali has been another essential innovation, since it 'is an effective way of making niacin in the maize available and improving the amino acid content of the digestible protein fraction' (Ibid). A very high diversity of plant species within traditional Mayan homegardens completes the equation, providing the full range of necessary micronutrients (see e.g. Murray 2001).

2. Wild and Indigenous Cultivated Food

The FAO, IPGRI, and the CBD Secretariat have also joined forces to promote the use of agrobiodiversity in programme oriented toward improving food security and nutrition.[1] Much of the current focus on the relation between agrobiodiversity and nutrition related to indigenous and wild foods, where it is now well established that such foods are essential to adequate dietary intake and food security in most traditional societies, whose diets until recently have been diverse and nutritionally appropriate (Box A.1) (Dignan et al. 2004, Johns & Staphit 2004, Johns & Eyzaguirre 2006). The contribution to the diet of most indigenous and wild foodstuffs 'is ignored in dietary surveys, composition analyses, Food and Agriculture Organization food balance sheets, and policy and decision-making [but these]…unquestionably make essential con-

BOX A.1 | The Importance of Wild Food Species in Traditional Diets

Wild species not only provide food in times of shortage and famine: a vast amount of literature shows that culinary traditions throughout the world include the use of wild plants, animals, and insect species (Ogle 2001). For example, among the Hausa in Niger, 84 wild dietary staples were identified, 93% of which are regularly collected for consumption. Thirty-nine of these were eaten regularly by over half of all households, and 19% of the households also sold wild plants for income.

Among the Sigaw Karen, the largest minority group in Northern Thailand who practice upland rice cultivation, wild food plants serve food security in three ways: as year round supplies of food, as hungry season supplies, and as micronutrients for the diet which is dominated by rice. They provide very substantial contributions to food supply, which is even more important among poor families, and represent 'substantial economic savings' (Johnson and Grivetti 2002). Over 100 wild edible species are collected from forested areas and are used frequently, whereas and 'weeds' from paddy fields provided up to 50% of the rainy season diet (dry season consumption is also high).

A study done on the relationship between foraging and household food security in Salavan Province, Laos, also indicated that gathered foods are more important than cultivated crops as a supplement to the rice diet, and serve as emergency foods during times of rice shortage (Denes 1998). Sales of collected products or barter of wild foods for rice also supports local livelihoods. Women and children are primarily responsible for gathering vegetables, tubers, shrimps, frogs, snails, bamboo shoots, mushrooms, koy and insects, whereas men are responsible for hunting. Both men and women collect frogs and fish which are essential protein components of the diet.

Even in drought and famine stricken highlands of Ethiopia where devegetation is severe, a study found that all villagers consume wild food plants as part of the regular diet, where five species were commonly consumed, and another 28 species were consumed less frequently (Howard and Smith 2006).

tributions to dietary adequacy' (Johns & Sthapit 2004). It is now recognised that wild foods are important in the full range of agricultural systems in all parts of the world, that many thousands of species are utilised and are harvested from a wide range of habitats, that they are actively managed in these habitats as well as transplanted to homegardens and agricultural fields, and that they provide important micronutrients throughout the year as well as major sources of calories for certain foraging or forager-farming based societies. Wild foods and indigenous crops and livestock have been largely neglected since the number of species is large, many are very localised (grown or collected in small patches in homegardens, boundary lands, or between crops), and they are mainly managed by women (Chewya & Eyzaguirre 1999, Howard 2003a). Many indigenous foods whose nutritional content has been analysed have been found to have high nutritional value. In rural areas, they are usually cheaper and more accessible than exotic food. They are ecologically well-adapted and are also embedded in the tastes, preferences, and knowledge of local people. There is as yet a dearth of food composition analysis for indigenous foods, but currently national, regional and international many relevant organisations are prioritising it, which is expected to have 'positive impacts on health, agriculture, fisheries, biodiversity and the economies' of the countries and regions that develop this knowledge (Dignan et al. 2004, Burlingame Pers. Comm. 2006).

It is clear that not all food is obtained from field crop production. Field crops generally provide mainly carbohydrates and vegetable proteins (legumes), or 'dietary staples', whereas fruits, vegetables, and other 'minor' foods are often produced on a smaller scale in homegardens, or are gathered wild. Homegardens play a vital role in food security and agrobiodiversity management. It is well established that they are the most pervasive land use system across the globe, and function as sites of experimentation, domestication, and in situ conservation of agrobiodiversity (see e.g. Eyzaguirre & Linares 2004, Kumar & Nair 2006). In tropical areas, they provide foodstuffs throughout the year (especially fruits and vegetables, spices and condiments) that are not economically produced on a larger scale; they serve as a backstop in case of food shortage, and provide foodstuffs that can be exchanged with others through social networks, or that are marketed on a small scale, often providing a crucial source of income, especially for women (Howard 2006). Across Sub-Saharan Africa, a large number of domesticated indigenous species are cultivated and gathered to provide the sauces, relishes, and soups that make the bland carbohydrate staples consumed in the region palatable and the diet nutritious. These preparations involve a great diversity of wild plant species and indigenous vegetables that must be produced or gathered on a very substantial scale (Akoroda 1990, Chweya & Eyzaguirre 1999). The significance of these 'accompaniments' for the maintenance of agrobiodiversity is only now being recognised. For example, with respect to multi-purpose species such as cowpea, coco yams, sweet potatoes, cassava and pumpkins, selection occurs partly on the basis of the leaf as the primary character, for its use in sauces and relishes (Ibid.).

3. Traditional Food Processing, Preservation and Storage

The neglect of indigenous and wild foods has been paralleled by a neglect of the importance of traditional food processing, preservation, and storage knowledge and technologies for the development and maintenance of agrobiodiversity, and for meeting nutritional and other cultural needs. There is as yet little scientific literature or knowledge available about such technologies or about the local knowledge, skills, and cultural values that sustain them. However, the Economic Commission for Africa argues that

> *indigenous technologies provide the foundation for socio-economic progress. Owing to the influence of the training that had often been acquired in industrialized countries, policies in most African countries have tended to systematically attach greater importance to imported technologies and less attention to indigenous technologies in general and to those used almost exclusively by women in particular…There is no doubt that selective and intelligent borrowing of modern foreign technology can help. But…many modern technologies are either hard to acquire for economic or financial reasons or are unsuitable to the socio-cultural African context. Moreover, foreign technologies simply do not exist for either solving some of the specific problems or meeting the whole spectrum of technological needs… indigenous knowledge and technologies…[are] therefore an important part of any real solution to the problem of food security* (ECA 2001).

Johns & Kubo (1988) and Johns (1990) provide a comprehensive, if not exhaustive, list of traditional methods for detoxifying 137 genera and 216 species from 65 families of plants that are used across the globe, as well as a detailed classification of detoxification methods, including the use of heat, solution, fermentation, adsorption, drying, physical processing and pH change. By these means 'cultural innovations have made plant foods more available to humans'. It is clear that the bulk of foods consumed in most countries are processed and preserved using indigenous food technologies, so post-harvest technologies must play a significant role. The Crop Post-Harvest Programme of DFID (Azam-Ali & Battock 2001) gave as reasons for emphasising the importance of traditional food products and related post-harvest technologies, which 'have received very little or no research attention and are absent from most policies'. Indigenous technologies

Traditional freeze dried potatoes in Bolivia

- 'represent a 'vast treasury of knowledge'
- emerge from, and are adapted to, 'local resources and social and environmental conditions'
- have the potential to contribute to poverty alleviation through employment opportunities, household food security, improved diets, and cultural identity
- add nutrients and variety to the diet (including e.g. 'probiotics', 'nutraceuticals')
- have a strong cultural identity and are associated with traditional customs and beliefs
- increase food safety through the removal of anti-nutritional components
- increase the range of raw materials from which edible foods can be produced (increasing food access)
- are perceived to have many medicinal properties which may be scientifically valid (e.g., weaning foods with antimicrobial activity against diarrhoeal pathogens) (Ibid).'

To these must be added the fact that agrobiodiversity development and maintenance depends organically on post-harvest processing, preservation, storage, and culinary considerations, and on the technology, knowledge, labour, and fuel available for these, as can be seen below.

Food processing, preservation, storage, and preparation activities are inter-related in terms of labour and time (often representing a series of steps carried out sequentially by the same persons), and techniques (the way that meat, fish and plants are processed influences the way they can be stored and consumed). They are also conditioned by other factors such as humidity and the incidence of pests and diseases. The knowledge and skills required to develop, maintain, and innovate in this post-harvest food chain are complex, dynamic, and vital, and can take over a third of a lifetime to accrue. While much research investigates the ways in which plants are consumed as foodstuffs, there is little research that investigates the specialised TEK and related skills underpinning domestic practices, or how these are transmitted and under what influences they change.

The essential relationship between eating, food processing, and plant knowledge is most clearly seen in traditional societies where many plants that are consumed must be made edible through detoxification, which requires in-depth knowledge of plant characteristics, as can be seen in the case of communities in the Upper Arun Valley of Eastern Nepal (Box A.2). Food processing is not only required to make plants edible: it is also related to food storage, which requires its own in-depth TEK. A study in the Western Division of the Gambia (Madge

BOX A.2 | Wild Plant Detoxification in Nepal

The extensive...knowledge of Rai and Sherpa women is evident not only in women's ability to identify useful wild plants and plant parts and their growing environments, but as well in the elaborate processing techniques used…to remove the toxic compounds … An example is the phi to (*Arisaema flavum*), a wild root that contains the same toxin (cyanogenic glycosides) that is found in bitter cassava (*Manihot escuelenta*). Practices passed down by women over generations are used to detoxify the phi to and convert inulin, a complex carbohydrate, to fructose and glucose, making it digestible…First, phi to roots are washed and then cooked in boiling water an entire night without a cover. Open boiling hydrolyses cyanogenic glycosides into hydrogen cyanide and sugar. The hydrogen cyanide evaporates with the vapor. The cooked phi to is then peeled, beaten on top of a rock, and rolled into long strips. The detoxified phi to is made into bread, added to soup, or used to make raksi (distilled alcohol) (Daniggelis 2003).

1994) illustrates these points. Water in which fish has been cooked is saved and used to make a sauce because 'the water contains the goodness,' that is, water-soluble B complex vitamins. During cooking, 'acid fruits reduce bacterial growth and shortens cooking time; this probably explains why velvet tamarind (bujaala), *Dialium guineense* is sometimes added to cooking water'. Fermentation simultaneously makes food palatable, preserves it, and increases its nutritional content. In fermentation, women stress the importance of heat, which also reflects the degree of bacterial and enzymatic activity. Each household stores between three and five wild plant and animal species, some in large quantities, even during periods of abundance. Sun drying is the most commonly used food preservation method: 'Strict weight and colour controls are used to ensure through drying and successful preservation'. Smoking and salting are two other preservation methods used, and herbal preservatives are sometimes added to repel insects. TEK is also clear in the choice of storage sites: 'African locust beans (bukombong), *Parkia biglobosa*…are stored in the kitchen on the bench above a fire since constant smoking ensures that the food is protected from insect pest attack. Bush teas are not stored in the house rice store because they attract termites which will eat the rice'.

The integrity of these processes is essential to health and family well-being: not only do culinary traditions and TEK directly affect household nutrition: storage and preservation also lengthen the 'shelf-life' of both gathered and cultivated food and are therefore essential to ensuring food security. For example, historical research showed that indigenous groups in the Northwest Pacific Coast of the United States seasoned and processed wild food plants using methods that required special techniques as well as storage (Norton 1985). When harvested and stored in quantity, plant foods were dependable, all season staples. 'The edible portions of plants have a truly limited season of harvest and without processing and storage vegetable foods would have been unavailable during a large part of the year…The primary relevance of plant foods (whether staple or supplemental) to Native peoples lay not in their environmental distribution patterns but in their ability to meet quantitative and qualitative nutritional requirements year-round' (Ibid.).

4. Culinary Traditions, Post-harvest Technologies, and Crop Diversity

Culinary traditions and preferences, as well as the culinary arts that are required in order to provide edible and culturally acceptable food, have a marked influence on knowledge, selection, use, and maintenance of agrobiodiversity, and those factors that are changing culinary traditions are also undermining agrobiodiversity use and hence maintenance. Culinary traditions are one of the most important elements of cultural identity. While men may have a major ritual function in food exchanges, women are generally considered as the 'gatekeepers' of food flows in and out of the household. Culinary traditions are perpetuated by the careful transmission of knowledge and skills, particularly from mother to daughter (see e.g. Counihan & Kaplan 1998).

Culinary traditions, and food processing and storage methods, have been found to be primary stimuli for developing an apparent plethora of folk varieties. From an agroecological standpoint, most of the folk varieties developed by local populations are redundant. This is illustrated well by the case of the Andes, the cradle of the world's potato diversity. Many researchers have sought to understand why it is that farmers maintain a tremendous number of potato and maize varieties on their farms, and have sought the answer in the need to adapt plants to fit diverse environments and agronomic conditions. However, Zimmerer (1991, 1996) showed that these factors alone cannot explain the great diversity of potato and maize varieties produced. Rather, specific varieties are cultivated in order to meet precise culinary requirements and post harvest processing and storage needs: 'groups of species correspond to different uses, such as freeze-

drying, soup-making, and boiling.' This is also true of the large number of maize varieties that are maintained. '… different preparations rely on groups of cultivars. Agriculturists utilise culinary distinctions as the basis for planting separate fields in different ecological habitats'. Maize is secondary in the diet to potatoes, but this does 'not preclude extensive genetic diversity, complicated folk taxonomic classification, and elaborate ritual significance'. Besides parching and boiling maize, women make hominy, crushed maize, popcorn, mush, corn-on-the-cob, soup thickener, pudding and tamales.

A riddle that researchers have tried to solve for decades is related to why so many people across Africa and Latin America seem to prefer to grow so-called 'bitter' (toxic) varieties of cassava (*Manihot esculenta*) rather than 'sweet' (non-toxic) varieties. A very substantial amount of labour is required to remove the cyanide from the bitter varieties, most of which could be avoided if only sweet varieties were grown. Wilson (1997) researched the Tukanoan peoples of the Colombian Amazon. Only women produce cassava, which is the principle staple crop. He researched cassava crop performance and women's varietal preferences to learn why women plant more bitter varieties. Wilson concluded that: 'while yield and damage suffered by the plant may be factors which influence cultivar selection, it is the foods which can be made from each cultivar which is the most important consideration'. Descola (1994) carried out research on a similar theme: why the Achuar peoples living in Amazonian Ecuador have not developed maize cultivation as a substitute for cassava, since maize contains far more protein than cassava and requires less labour. He argued that, while two varieties of maize are cultivated by the Achuar, cultural modes of consumption have a large hand in cultivation: cassava is 'regarded as the food (mama, manioc, is often used as synonym for yurumak, food in general),' and manioc beer is an intrinsic component of social and domestic life.

The inter-relationship and, at times, indivisibility between knowledge in the kitchen and in plant production is further illustrated by research carried out in Rwanda on food quality and fuelwood conservation characteristics of bean (*Phaseolus vulgaris* L.) cultivars and landraces (Shellie 1990). Rwanda boasts the greatest genetic diversity in beans in the world (over 600 varieties are grown), and beans are a 'woman's crop'. Shellies' purpose was to identify ways in which formal plant breeding could reduce bean cooking time and conserve fuelwood. It was discovered that, over time, women farmers had successfully selected bean varieties that lacked hard seed coatings that increase cooking time, as was evident in the low amount of genetic variability for this trait. Further, 'the range in cooking time among landraces…suggested that some farmers had selected cultivars based upon their cooking performance and were developing fast cooking landraces'. Other research on farmers' plant varietal selection criteria demonstrates the same link between genetic selection and diversity and the food processing sphere (see e.g. Ashby & Herpen 1991, Defoer et al. 1997, Ferguson & Mkandawire 1990, Lope Alzina 2006). Madge (1994) wrote that, in the Gambia, this also extends to recipes employing wild foods that are related to labour and fuelwood

Making cassava bread. Painting by Benjamin Nicolas, Belize

constraints: 'The recipes used for cooking collected foodstuffs are mostly to make sauces…cooked especially during labour bottlenecks in the farming calendar…since wild leaf sauces require less cooking time and, therefore, need less fuelwood than sauce recipes which use cultivated species'.

A recent study (Lope Alzina 2006) investigated the interrelationship not only between the post harvest chain and varietal maintenance, but as well between different production spaces where maize and squash crop diversity are maintained (agricultural fields and homegardens), relating these to men's and women's cultivar diversity management and decision making among Mayan households in the Yucatan Peninsula. The case succinctly illustrates how even field crop diversity must be understood within the context of an integrated social-ecological system. The post harvest chain for maize that was encountered is presented in Figure 1. Homegardens are more related with women, and agricultural fields ('milpas') are more related to men, due to the gender division of labour and gender-specific knowledge. These production spaces have different cropping patterns and contain different varieties. Men are exclusively responsible for cultivating staple crops in milpas, where women are not allowed to go without men being present: women participate in field labour only when additional labour is needed, such as for harvest. On the other hand, women perform most of the labour and make most of the decisions in homegardens and can work in them alone. It is, however, difficult to characterise maize or squash as either a men's or a women's crop: rather, it was found that agricultural fields and homegardens are interdependent in terms of varietal selection and maintenance, and that this interdependence is an outcome of the different reasons that men and women have for cultivating a given landrace in a given production space. Women also influence the selection of maize varieties produced in men's agricultural fields given that they are responsible for most of the post-harvest sphere and know which characteristics and amounts of different land races are required. While men maintain many squash varieties in agricultural fields, women maintain different squash varieties in homegardens for their culinary and ritualistic values, and because they wish to have them near home for daily consumption. Men maintain certain maize landraces in homegardens that they do not sew in agricultural fields in order to maintain their purity and to permit their wives to give them special agronomic attention.

Food choice and food security, and their relationship with local agrobiodiversity, are inseparable from food culture. The selection of what to cultivate or harvest, hunt, glean, or fish is closely related with cultural identity (including concepts of nutrition, well-being, aesthetics and spirituality), and cultural identity in turn is strongly influenced by local food resources. Food culture is a reflection of local social-ecological relations, but it is much more.[2] Specific types of food are essential parts of many religious observances, rituals and ceremonies and, at times, food is considered to be sacred. 'Ritual meals…also perform critical social functions….Rituals and beliefs surrounding food can also powerfully reinforce religious and ethnic boundaries' (Mintz & Du Bois 2002). Food taboos are very often associated with religious and spiritual beliefs, as is true for nearly all religions, some of which affect who maintains what type of agrobiodiversity (Box A.3).

BOX A.3 | Food Taboos and Ese Eja Crop Diversity

The Ese Eja have a view of the cosmos that is internally organised in the same way as the Esa Eja themselves, and 'which is inhabited by plants, animals and anthropomorphic beings who subsist by hunting, fishing and agriculture...All plants and animals have eshawa [soul-spirit], or rather, are manifestations of eshawa. Food, as a remnant of living organisms, is still a manifestation of eshawa, and can interact with human beings. Human infants' and children's eshawa are vulnerable to attack and contamination by other eshawa, 'including those of plants with which the parents interact, either through physical proximity or, more importantly, through ingestion. Pregnancy and lactation mark periods of great vulnerability, where a broad range of dietary and behavioral restrictions serve to protect the vulnerable eshawa of the developing fetus and child.' This leads not only to a series of neonatal and childhood food taboos. Women are the main agriculturalists but, since many cultigens are considered to be polluting and dangerous for pregnant women, younger households frequently plant a lower diversity of crops. Older couples have larger and more diverse fields, as they dedicate greater amounts of time to agriculture and are not bound by the dietary restriction that younger people confront (Alexiades 1999).

5. Food Exchange and Social Organisation

Aside from breathing, food is human's most important continuous need, and the place of food in human production and reproduction is reflected equally in the symbolic meaning attributed to food, as well as its importance in the organisation of economies and social relations. Food therefore is and has been a central focus of anthropological and archaeological studies of human societies throughout history: to understand 'foodways' or 'food paths' of traditional and indigenous peoples is to understand much about their ways of life. Food is a principle medium of hospitality, reciprocity and exchange - a basic cementer of social relations within households, among kin groups, and across communities and regions. Entitlements to food in traditional, largely non-monetised social-ecological systems are based on social relations, and do not depend exclusively on access to the means to produce or procure food. There is a vast body of scientific literature about how food exchanges lie at the heart of traditional economies, power relations, status, prestige and religious beliefs. As was discussed in Chapter 2, in kinship based societies, the objects of exchange tend to assume the form of gifts, and different types of kinship organisation are associated with different forms of production and exchange of gifts. Usually 'what a gift transactor desires is the personal relationships that the exchange of gifts creates, and not the things themselves' (Gregory 1982). But food exchanges do at times serve to redistribute wealth, to provide food to those who do not have the capacity to produce sufficient amounts, and to obtain goods that one does not have the capacity to produce or can only produce uneconomically. Food exchanges are often at the heart of non-monetised exchange systems, although barter (non-monetised market type exchange) and market exchange can also be crucial, especially to obtain food items that are not found within a particular society's production system (see Box 3). Within food exchange systems, some exchanges are immediate (e.g. when food is highly perishable – such as meat) and some are delayed, when items are either not perishable or improve over time

(e.g. of stored tubers, wine). The distribution of food occurs within social and political networks that include kin, friends, and allies: as discussed in Chapter 2, it is also often the key 'currency' of political power, where exchanges occur in large festivals or ceremonies. Belief systems such as that described for the Esa Eja also affect what foods are exchanged with whom and when.

6. Food Culture and Agrobiodiversity Loss

The foregoing discussion should make it clear that the utility of agrobiodiversity for humans depends upon not only the demand for these resources that is related to culture and culinary traditions, but as well on the knowledge of the properties of plants and the skills and technology available for processing, preserving, preparing and storing plant materials, and the role of specific types of agrobiodiversity in the overall social order, e.g. of specific foods. If for any reason these values, motivations and utilities are lost, the use and knowledge of the agrobiodiversity concerned is also likely to be lost which, in turn, can threaten species and varieties that depend for their production upon human interventions and intentionality. In this context, the nutrition transition is a key phenomenon. This phrase is used to characterise the replacement of traditional food cultures and dietary intake with the consumption of the products of large-scale agriculture, leading to the simplification of diets and, among others, to the global obesity epidemic that is related to a decrease in the consumption of fibres, fruits and vegetables, which are substituted by refined carbohydrates (especially wheat, rice, and sugars) and edible oils (Wood et al. 2005, Johns & Sthapit 2004). The major factors that have contributed to the abandonment of traditional diets are cited as urbanisation, rising incomes and the consumption of more 'culturally prestigious' foods, marketing and food-aid programmes targeting the poor that change food preferences, declining local traditional knowledge about food production or procurement, food processing, storage and preparation. Globalisation and the Westernisation of diets lead to dietary homogenisation, which is associated with loss of cultural and agrobiological diversity as well as the growing crisis of obesity (Ibid., Howard 2003b). All of these phenomena are discussed in Chapter 5.

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[1]The objective of this effort is to contribute to the United Nations Millennium Development Goals, particularly to reducing by one-half the proportion of hungry people in the world by 2015. See http://ipgri-pa.grinfo.net/index.php?itemid= 1158&catid=28 (accessed 30-9-06).

[2]An excellent overview of much scientific research on food culture is found at 'World Food Habits: English-Language Resources for the Anthropology of Food and Nutrition' http://lilt.ilstu.edu/rtdirks (accessed 28-9-06).