NAE Chapter 6 Tables and Figures

Figure 6.1 Framework for the analysis of sustainability. Source: Adapted from Scoones, 1998, Dfid, 1999.

Framework for Sustainability Analysis

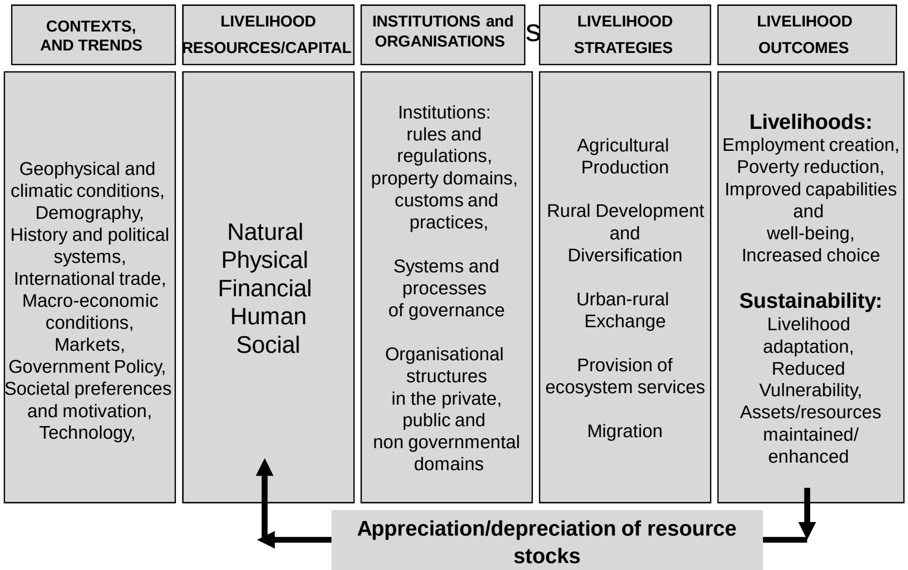

Table 6.1 Functions and objectives of multifunctional forest management

Functions	**Subcategories**	**Specific objectives**
Production	Timber products	Sawtimber, veneer, pulp and paper, panels, bark
	Bioenergy	Firewood, charcoal, biofuels
	Hunting	Game management
	Other products	Mushrooms, fruits, pharmaceutical molecules
Protection and restoration	Habitats	Naturalness as an ecological heritage (reserves) Protected habitats (http://www.natura.org) Microhabitats (ponds, peat bogs) Patches of senescent forests Deadwood material (large woody debris)
	Plant biodiversity	Endangered or rare species Ordinary biodiversity Genetic diversity
	Diversity of other taxa	Endangered or rare species Hunting and fishing Wildlife, birds, insects, etc… Microorganisms (e.g. soil microbes)
	Carbon storage	
	Water quality	Chemical (avoid nitrates, xenobiotics, raise up pH) Ecological (microbial and vertebrate diversity in streams)
	Soil protection	Chemical (maintenance of soil fertility) Textural (prevention of compaction)

		Integrity (prevention of erosion)
	Forest health	Limit sensitivity to diseases and disturbances
	Human protection	Use forest to mitigate landslides, avalanches, falling stones
Social function	Landscape quality	Meso-scale (forests in landscapes) Microscale (managing hedges for scenery) Landscape diversity (patchiness, mixtures, canopy texture)
	Naturalness as a cultural value	Forest reserves, botanical gardens, arboreta Undisturbed or low-impacted landscapes
	Tourism	Hiking, bicycle paths
	Other cultural values	Trees, flowers, fruits, animals of high cultural relevance Religious holy sites
	Educational value	Forests as support for education (ecology, environment)

Table 6.2 Agricultural research: Who pays and who delivers?

		Who Pays?		
		Government including parastatal organizations	**Nongovernmental, organizations**	**Private, commercial**
Research Objectives		Public good e.g. food security, environmental protection	Organizational Agenda, e.g. poverty alleviation, animal welfare	Private good, e.g. profits, increased utility of consumers
Who delivers?	**Government, including parastatal organizations**	Government funded research institutes	Government research institutes conducting external research contract	Government research institutes conducting external research contract
	Universities*	Govt funded research programs in Universities	University research under contract to NGOs	University research under contracts to commercial companies
	Nongovernmental, organizations	NGOs undertaking research on contract to Government	NGOs funding and operating own research programs	NGOs conducting research on contract to private companies
	Private, commercial	Commercial research organizations on contract to Government	Commercial research organizations on contract to NGOs	Market driven, research for competitive advantage, conducted ‘in house’ or contracted out

*Universities also fund their own research programs, but this usually draws indirectly on external funding sources, such as trust funds.

Box 6.1 Contribution of new complex systems science to elucidate agricultural systems

The science of complex systems makes four main contributions:
(i) a better understanding of the components of the system and their interactions
(ii) a better control of the development of dynamic complex sociotechnical systems, e.g. new processes and materials, multi-site factory production and supply chain dynamics
(iii) a better understanding of the complex environment in which engineered systems exist, e.g. ecology, regulation, ethics, markets and
(iv) a better understanding of the design, engineering and management process that is often itself a creative, multilevel, complex human system, capable of great successes but inherently liable to spectacular failures (Bourgine and Johnson, 2005).
For these reasons a major effort is required in developing complex system science and education applied to agriculture. Specifically AKST needs to be mobilized for:

- developing a meaningful knowledge representation and modeling of an agricultural system as a whole;
- identifying and storing relevant information as well as developing methods to aggregate this information. through the establishment of meaningful indicators regarding the functioning of the whole agricultural system; and
- building infrastructure to facilitate the storage of information from complex agricultural systems approach

Box 6.2 Contrasting views on agricultural development and markets

<u>From a sustainability point of view, a society must provide for the replacement and growth of its capital, including both human reproductive capital and replenishment of natural resource capital</u>. Capacities can be constrained severely by scarcity of soils, water, and energy, among other factors, when there is growing demand for food and energy. Scarcity of renewable natural resources is contingent with their use.

Markets are necessary, but do not guarantee sustainability of public goods such as food security, conservation of natural resources, or protection and enhancement of the environment. There are incentives to produce goods with negative externalities because producers may not pay for damage caused to public goods (Stiglitz, 2006).

Agricultural production happens within complex agrarian systems whose capacities can be constrained by a lack of resources or lack of autonomy. Sustainable development should be based on the pillars of endogeneity (as opposed to mimetic growth), self-reliance and self-confidence (as opposed to dependence), be need-oriented (as opposed to market-led), in harmony with nature and open to institutional change (Sachs, 2002). Resilience, the capacity to absorb shocks, is necessary to prevent dependency. A compromise is necessary between the two extremes: autarky and completely free trade. It is necessary to imagine an optimum position that ensures viability and resilience, such as is the principle of biological systems (Tabary, 1993).

<u>This perspective contrasts with the view that puts much more emphasis on the role of less regulated markets and does not see agriculture as an activity that is different in character from other economic activities</u>. In this view, the private sector must be the engine of economic growth; inflation must be low to maintain price stability; state bureaucracies must be small; government budgets must be close to balanced; tariffs on imported goods must be lowered or eliminated; restrictions on foreign investment must be removed; industries, and stock and bond markets must be open to foreign ownership and investment; quotas and domestic monopolies must be removed; exports must increase; state-owned industries and utilities must be privatized; capital markets must be deregulated and currencies made convertible; the economy must be deregulated to promote domestic competition; government corruption, subsidies and kickbacks must be eliminated; banking and telecommunications systems must be opened to private ownership and competition; and citizens must be allowed to choose from among competing foreign and domestic pension options and mutual funds (Friedman, 1999).

<u>For a variety of reasons, the previous position has been a point of major conflict in international trade and financial negotiations over the last two decades.</u> A long-standing perspective within the field of agricultural economics contests this position with one that emphasizes the particular nature of agriculture in its social and biological context. This position argues out that in the agricultural sector the general equilibrium model of the economic theory with a unique and social optimal equilibrium price cannot, indeed, a fortiori at a world level, be simply applied, for the following reasons (Loyat, 2006):

- certain assumptions for a competitive equilibrium are not met (market failures, asymmetry of information, great differences in productivity levels between agricultures), making any optimal equilibrium illusory;
- public goods, such as food security or protection of biodiversity, are not recognized by the market. Consequently, the market price will not be able to guarantee these public goods;

- General Equilibrium model cannot represent the diversity of agricultural economics. The equilibrium price on the world market is disconnected from the real costs of production because of imperfect competition, dumping practices and the heterogeneity of resource endowments and labor productivity. This situation can be detrimental for most of local farm systems; and
- agriculture relies on complex short and long-term interactions. Non-consideration of food security, biodiversity and environmental impact impede price signals from being socially efficient.

Box 6.3 A specific need for agricultural research in economic modeling : the case of CGEs models

The computable general equilibrium (CGE) models have become major instruments supporting trade negotiations. These models provide quantitative estimates of benefit, as well as how benefits are shared among stakeholders. Agriculture is not treated differently than any other economic activity. The validity of this approach can be questioned.

There are three main criticisms to CGE's models:

- the most *liberalized* situations depicted through these models are theoretically efficient and Pareto optimal[1]. But they rely on a particular income distribution, resulting from rewards to factors of production such as land, labor and capital which reflect their relatively scarcity (i.e. economic rents) [2] which are themselves not necessarily socially optimal. Other Pareto efficient situations, with different income distributions, could be deemed more socially desirable;
- only those commodities which are subject to market exchanges are accounted for externalities, such as water pollution, factors that are ignored by the market are also ignored in the CGE benefit / cost balances analyses; and
- a CGE model assumes markets are functioning efficiently , *i.e.* marginal costs are equal to marginal returns everywhere, producers and consumer adjust their plans immediately in response to observable equilibrium prices (hence the reference to "equilibrium") (Boussard et al., 2005).

The existence of price instability confounds the price signal and renders it economically inefficient . Thus it appears that these models have no connection with reality. Furthermore, agricultural markets often operate imperfectly because of restrictive practices by dominant players and high levels of risks and uncertainty, especially associated with variation in supply (Boussard et al., 2005).

It follows from the previous considerations that there are gaps in research on the ways to manage supply and demand for agricultural products, knowing that, regardless of the scale: prices on agricultural markets are unstable and volatile, the supply of agricultural products is unstable, sometimes chaotic and subject to uncertainty and risks, especially for the poorest decision makers lacking in resources who are more risk averse than others. Such research may lead to specific policy considerations to improve modeling of agricultural markets and correct for market imperfections (box 2).

[1] **Pareto optimality**, is an important notion in neoclasical economics. Named after Italian sociologist and economist Vilfredo **Pareto** (1848-1923), **Pareto optimality** is a situation which exists when economic resources and output have been allocated in such a way that no-one can be made better off without sacrificing the well-being of at least one person.

[2] David Ricardo's Concept of Economic Rent on land is the value of the difference in productivity between a given piece of land and the poorest [and/or most distant], most costly piece of land producing the same goods under the same conditions (of labour, capital, technology, etc.).

Box 6.4 Bipolarisation of agricultural demand

A new profile for agriculture is taking shape, with two major poles.

- A demand for common products

The first pole corresponds to an agriculture that provides **basic common commodities**. From an economic point of view, the sustainability of this agriculture is guaranteed thanks to a combination of land, capital and labor with competitive production costs on the international markets. On environmental aspects, standard operating procedures provide information on quality and a sanitation and environmental profile of each good. Farming systems tend to be large scale, specialized with high level of division of labor into particular tasks.

In this type of agriculture the majority of the farmers gradually ceased direct marketing and processing and became suppliers of raw material at low prices (Bonny, 2005). The food processing chain is more complex, made up of players whose economic dimension and the number on each level is very variable *e.g.*: a significant number of heterogeneous consumers, farmers generally of modest economic size, a central group of players with a lot of influence on the chain (e.g. central purchasing agencies).

The agro-industries and the distribution companies capture a growing part of the added value. However, in the past few years the downstream sector has developed a strategy of differentiation of its supply and has increased contracts for such with the producers.

- A demand for identified products

On the other pole, agricultural **products are identified by their origin, with characteristics specific to a particular region or "terroir" with strong value added linked to niche markets**. The use of controlled labels of origin for wine was one of the first applications of niche marketing in Western Europe.

The territorial identity results from several factors, like the identification of places and, the types of products. It is accompanied by the organization of particular supply chains with a guarantee on the origin and the manufacturing processes, through specific qualification procedures: by the origin of products, by the production process (organic farming, certifications of conformity) and by marketing (fair trade, direct sales).

Box 6.5 AKST options to improve the quality of unprocessed plant and animal products

AKST focused on the following issues could facilitate improving the quality of unprocessed agricultural commodities:

In the plant domain:

- understanding plant metabolism and developing plants containing higher levels of important macro- and micronutrients (essential fatty acids, oils, vitamins, amino acids, antioxidants, fibers, etc.) and reduced allergen levels;
- developing the taste and quality of products, particularly fruits and vegetables, while improving the post harvest quality and storage capacity; and
- selecting plants with low input requirements to reduce the risk of residues in plant-derived food, particularly pesticide residues, nitrates and other potentially toxic elements.

In the animal domain:

- understanding the functioning of the rumen ecosystem to underpin the development of improved animal nutrition strategies and technologies for the production of healthy milk and meat;
- improving the nutritional value and human health features (e.g. the fatty acid composition of meat and milk, the nutritional quality of eggs) as well as sensory qualities such as tenderness, flavor, visual appeal, and processing characteristics;
- improving livestock resistance to spreading zoonotic diseases, for example through improved immune system function, to improve food safety; and
- selecting animals that are more robust and able to adapt easily to the production environment (e.g. feeding system, climate, housing/grazing system), to reduce the need for medicines and thus the risk of residues in animal-derived food.

In both plant and animal domains;

- the influence of genetic factors, production methods and contamination by mycotoxins and pathogenic microorganisms on the variability of raw materials and on human nutrition; and
- the development and expansion of technologies that preserve foodstuffs germ-free without refrigeration, such as novel packaging technologies, irradiation, etc.

Box 6.6 Energy efficiency in NAE food and farming systems

Energy efficiency in farming can be measured in terms of the ratio of the energy content of output to the energy content of inputs, excluding solar energy in crop photosynthesis and measured in joules or equivalent.

Energy ratios vary across the NAE region according to average yield levels (t/ha) that in turn are a function of the environmental factors and the relative scarcity of land and labor (Pimentel and Giampietro, 1994). Where population pressure is relatively high and land is relatively scarce, such as in many parts of western and northern Europe, high yielding agriculture tends to have high energy inputs per ha and per ton of product. This gives relatively low energy ratios, of about 1 or less. Where land is relatively plentiful and labor is scarce (and relatively expensive), such as in North America, farming systems are more extensive, have lower energy inputs per ha and per ton of product, but higher (almost 5 times more) energy input per farm worker.

In Eastern Europe and Russia, conditions vary considerably, but relatively low energy inputs per ha and per worker are associated with relatively low yields. In some parts of NAE, some small-scale, peasant-type farming systems can display high energy ratios, but low yields and low added-value are often associated with low incomes and poverty.

The enhanced yield performance of crop and livestock systems in the NAE has thus been based on low cost, readily accessible energy supplies. Furthermore, commonly promoted strategies for adding value to farm products and increasing farm incomes, such as quality assurance, product differentiation and on-farm processing, tend to be energy intensive. Although organic production, now finding favor amongst some consumers, uses less agrochemical energy, inputs of labor and mechanization tend to be higher and overall yields lower than conventional methods. This results in similar, if not reduced, energy efficiency compared with conventional methods.

There are also important links between energy use, greenhouse gases and global warming potential (GWP). For the most part in agriculture, they are indirect, given that most energy is associated with the use of fertilizers and machines. Nitrous oxide (N_2O) in particular and methane (CH_4) emissions (from ruminate livestock) have the greatest impact GWP, more so than CO_2 emissions. However the origin of N_2O is linked to high fertility soil so there is little difference between organic and conventional systems (Williams et al, 2006). There are also other important links with other environmental impacts, such as soil erosion and compaction, water pollution and worker and animal welfare. At the same time, however, energy intensification has helped to reduce drudgery in farm work and has improved the health and life-expectancy of farm-workers, and enhanced the skill base and rewards for farm workers, factors which are important in the recruitment and retention of people in farming.

Box 6.7 Plant and animal breeding targets to contribute to IAASTD goals

For crops AKST could contribute to the following:

- focus on characters and functions involved in plant susceptibility and resistance to pests, diseases, weeds (weed control in one of the largest input costs in agriculture) and environmental stress (expected climate changes may increase the diversity and spread of pathogens and impose additional heat, cold and drought stresses on plants);
- develop crops that require less fertilizer and other agrochemicals, and that also require fewer water resources, based on a fuller understanding of factors regulating nitrate and phosphate utilization, water-use efficiency and impact on natural resources;
- develop crops for different types of agriculture: intensive, but also extensive and organic;
- understand the genetic and physiological determinants of genetic and phenotypic "plasticity" and develop crops that have capabilities to adapt to environmental change;
- understand plant metabolism in order to develop plants containing higher levels of important macro- and micronutrients (essential fatty acids, oils, vitamins, amino acids, antioxidants, fibers, etc.) and reduced allergen levels, reduced anti-feedants; and better understand plant carbohydrate metabolism, especially control of source-sink relationships. Use this knowledge to breed healthier, better tasting crops, as well as better food, feed, and biofuel crops;
- enhance breeding efforts enabling the use of a wide range of species, particularly under-utilized species of medicinal and aromatic plants possessing high health and economic potential; and
- Ascertain how to do the above while maintaining yields at levels that will not require putting more land under the plow.

For livestock, to improve the efficiency and sustainability of production in terms of food quality and safety, the environment, zoonoses and animal welfare concerns, AKST should contribute to the following:

- identify genes and gene networks that control immuno-resistance in livestock, including pigs, poultry and fish, leading to improved disease prevention strategies for persistent and costly diseases;
- revisit gut physiology (for improved efficiency and decreased pollution and disease), understand the functioning of the rumen ecosystem to underpin the development of improved animal nutrition strategies and technologies for the production of health-enhancing milk and meat, and the reduction of gaseous emissions, especially methane production by cattle;
- identify genes and gene networks relevant for fertility in all species and reduce the growing infertility problem of high-yield dairy cows;
- adapt animals to less intensive production systems (plant-based feed and saline water for fish, high digestibility cereal grains for nonruminant animals and poultry);
- improve nutrition and hygiene in intensive productions to reduce pollution and to control diseases; and
- Improve animal welfare: upgrade existing minimum standards; promote research and alternative approaches to animal testing; introduce standardized animal welfare indicators; develop new tools enabling breeders to handle welfare traits more objectively than at present (new biological insights into brain function, the genetics of behavior and physiological indicators of stress and wellbeing); develop efficient information management systems for health monitoring, health detection etc; inform animal handlers and the general public on animal welfare issues; support international initiatives for the protection of animals (FAO 2004b; FABRE, 2006; Plants for the future, 2005).

Box 6.8 Genetic engineering and IAASTD Goals

Genetic engineering is distinguished from conventional plant breeding by its reliance on molecular methods (i.e., not including sexual reproduction) to introduce genetic variation into the cells of a target population. In agricultural applications, transgenesis is currently the most common kind of genetic engineering. Transgenesis uses a vector to introduce segments of DNA isolated from one or more organisms into the cells of another organism where it is integrated into the genome. Transgenic annual crop plants are used widely in the United States, Canada, Argentina, Brazil, India and China, and many farmers using them have benefited; the number of farmers planting transgenic crops continues to grow in the NAE and elsewhere. Many new transgenic plants and animals are being developed for use in agriculture. In addition to transgenesis, several other molecular methods are being used to introduce significant genetic variability into agriculturally important species directed evolution and site-specific mutagenesis. In the future it is likely that these and other, yet to be developed methods, will become more common.

However, transgenic organisms have engendered controversy as they have been developed and used. The controversies have revolved around three interlinked issues: policy priorities, self-determination and ownership, and risk and consumer acceptance (NAFTA-CEC, 2004; Andow and Zwahlen, 2006). These controversies have themselves affected the organization of AKST in the NAE. It is likely that the many controversies will not be resolved in the next 5-10 years.

The policy divide, recently reflected by the WTO dispute between the United States, Canada and Argentina versus the European Commission, has resulted in policy instability that has delayed the development and implementation of agricultural genetic engineering. This divide not only occurs between countries in the NAE, but between the NAE and other parts of the world. There is a need to stabilize the policy environment, beginning with clarification of the differences.

Genetic engineering has sharpened some tensions between ownership rights and the rights of farmers and individuals in general. Biological patents remain controversial in many parts of the world, but in the NAE they have accelerated the commercialization of biological products in many fields outside of agriculture as well as in agriculture. These patents have helped stimulate the fusion of molecular biology with plant and animal breeding, which has led to new areas of investigation in the plant sciences. At the same time, they have contributed to a weakening of public sector capacity to conduct innovative research in agricultural biotechnology, and have contributed to the concentration of ownership of the seed industry. The rights of peoples to determine how transgenic organisms enter nations has been a subject of much international negotiation (e.g., under the Cartagena Protocol on Biosafety) and the terms under which they enter into individuals' lives is still a matter of much discussion. These controversies have become more complicated as they have entangled with many other issues, including indigenous peoples' rights, biodiversity conservation and food aid. The consequences of these and related changes need to be understood for the NAE and the rest of the world, to better assess the need for mitigation measures, and if needed, what measures would be appropriate.

The development of transgenic crops has focused attention on risk and consumer preference. Risk assessment has focused on human health and environmental risks, which has led to renewed examination of the methods of risk assessment and agricultural technology assessment, particularly concerning benefits, opportunity costs, long term adverse effects, and the distribution of benefits and risks in society (Snow et al. 2005). Consumer preferences increasingly influence the development of nearly all agricultural technologies, including transgenic crops. These preferences have contributed to the stratification of commodity markets (corn is no longer just "corn"), and have thus undercut, not without some tension, the traditional supply-side approach involving undifferentiated commodity streams throughout the supply chain. The increased attention on risk and technology assessment, and the increasing strength of consumers to influence the development of agricultural technology will be important touchstones for NAE AKST in the coming decades.

IAASTD goals include elimination of hunger and malnutrition by 2050. To accomplish this will require making greater quantities and more nutritious food available to the poor (Sen, 1981), which will require improving access to, increasing production of and decreasing losses of global food supplies. Several reports of international bodies suggest that transgenic organisms will help meet this goal (e.g., FAO, 2004b), while others are less sanguine (e.g., UNECA, 2002). Unlike the Green Revolution, genetic engineering is not a single technology package, so its potential to contribute to IAASTD goals must be assessed on a case-by-case basis. We can conclude with confidence that genetic engineering is positioned to help meet IAASTD goals, and we can even say that some (future) products of genetic engineering will likely help meet IAASTD goals. However, each case must be examined on its own merits. This is the challenge for the future. There is no simple path for the use of genetic engineering that will assure that its products will contribute to meeting IAASTD goals. Likewise, there is nothing about the technology itself that is inimical to the attainment of those goals. Like other agricultural technologies, we will need to understand better how the socioeconomic and environmental context for the use of transgenic organisms enables them to contribute to these goals.

Box 6.9 Animal biotechnology developments and IAASTD goals (FABRE, 2006; Rollin, 1995).
There is considerable potential associated with the use of animal biotechnology.

- future research on animal cell differentiation may open the way to the production of gametes from stem cells. Coupled with predictive biology and statistical techniques such as genome-wide selection, these approaches could make it possible to produce and select multiple generations in the Petri dish;
- the use of nuclear transfer (”cloned”) animals for breeding could allow the rapid and wide dissemination of important genes contributing to the realization of IAASTD goals;
- genetic modification could be powerful, particularly when considering its potential to immunize animals against specific viral diseases. For example, RNA interference technology could be used to make chickens resistant to avian influenza and reduce the risk of a human flu pandemic; and
- there are many foreseen applications in the medical field: animal models, animals as bioreactors, and animals for xenotransplantation.

Although genetic technology is often claimed to be precise in targeting specific genes, possible broader effects may not be easy to predict and unintended consequences need to be better anticipated and assessed (Straughan, 1999). A number of other concerns have been expressed and debated (Rollins, 1995) including: (1) the speed with which animal biotechnology can effect changes in animals, (2) the possibility that intensive use of biotechnology might narrow the gene pool and reduce genetic diversity through the wide use of specific transgenes and intensive cloning of elite animals, (3) that the accidental or deliberate release of genetically engineered animals might be akin to the introduction of alien species, which has been known sometimes to cause serious ecological harm.

As is the case for plant genetic engineering (see box 8), animal biotechnology is not a single technology package and its potential to contribute to IAASTD goals requires detailed analysis on a case-by-case basis weighing possible costs against possible benefits whether environmental, sanitary, social or economic. Trying to decide in any area what level of risk-taking is ethically justifiable is an important societal decision, even if it is rather difficult to assess; with animal biotechnology, however, the issue becomes even more complex and controversial, because the costs and benefits will be experienced by two different groups with different interests - human beings and animals.

Box 6.10 Organic agriculture

Although it only represents a small percentage of the total utilized agricultural area, organic farming has developed into one of the most dynamic agricultural subsectors. Organic production has been encouraged by policies to promote sustainable food and farming in many NAE countries. Organic production has potential to reduce environmental risks associated with use of agrochemicals,market advantage for producers. (EU, 2007; OACC, 2007; USDA, 2007).

In view of the growing production and expanding market due to increasing consumer demand for organic foods, the Codex Alimentarius Commission has developed Guidelines for the Production, Processing, Marketing and Labeling of Organically Produced Foods in order to provide a clear description of the "organic" claim and thereby ensure fair trade practices in this area. The Guidelines are a dynamic text that can be amended as new proposals are put forward in view of the experience gained by member countries as the organic sector develops (Padel and Midmore, 2005; FAO/WHO, 2006; Stolze et al., 2000).

The main factors and activities to be considered in order to promote organic agriculture are:

- to ensure that all stages of production, preparation, storage, transport and marketing are subject to inspection and comply with the guidelines;
- to develop and promote AKST for new techniques for the production and processing of organic products, including skills and training to support adoption; and
- to develop consumer awareness and marketing systems for organic produce as part of a strategies for sustainable food and farming.

The contribution of organic agriculture to food security is open to debate and subject to divergent views, especially as information is scattered and sometimes speculative. This is a topic worthy of further research, especially given the potential for organic farming to support livelihoods amongst relatively resource poor farmers and rural communities, as well as ‘reconnecting’ consumers with farming through locally or regionally produced organic foods.

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Box 6.11 Systemic barriers to interdisciplinarity

The rhetoric of interdisciplinarity has not yet been matched by the reality. In Europe, for example, the President of EURAGRI, at their 2002 Conference on "Placing Agricultural Research at the Heart of Society," identified some key systemic barriers to interdisciplinary work in research:

Interdisciplinary work and professional reality: Interdisciplinary agricultural research is essential, but there are major obstacles. First, the organization, funding and evaluation of research are biased towards work in specific disciplines. Second, co-operative research is time-consuming. In order to climb the career ladder and to receive peer recognition and funding for their research, scientists are often forced to "publish or perish" and to focus their activities on a relatively narrow field. To overcome these obstacles, it is important to address issues such as language, culture, values, and also the methods and traditions of scientific disciplines. It is also essential to remove legal and organizational constraints that hinder EU-scale co-operation.

Innovative research and research funding: Breakthroughs in science occur more often at the edge of disciplines than in the centre, and the scientists most willing to question traditional approaches and theories are often quite young. Unfortunately in some areas of NAE, their research proposals are rarely ranked high enough to receive funding, because the peers chosen to evaluate research proposals mainly represent the mainstream. This is an obstacle to innovative, more risky research and in the long-term it may undermine economic competitiveness. We therefore need to examine how to correct these inbuilt shortcomings within the system.

Analogous difficulties exist in relation to interdisciplinary course design and course approval processes in educational institutions as well as subsequent course delivery mechanisms and learner assessment procedures. Promotion of many such initiatives is almost completely dependent on a "champion" who has the vision to catalyze a team to design the program proposal. The "champion" is usually sufficiently senior or influential to "guide" the proposal through the approval/funding processes and who is sufficiently well placed to "protect" the delivery team during the early cycles of the program until its (hoped-for) success. Earlier obstructionists who later acquiesce sometimes even claim that the success was due to the rigorous assessment procedures through which they had forced the original program proposal to pass! The sustainability of such initiatives (no matter how successful in the minds of the beneficiaries) after the well placed champion moves on or retires is often quite doubtful, in the absence of a pro-active institutional culture oriented to the fostering and "active mainstreaming" of such initiatives. Where multiple institutions are involved, the problems and difficulties are greater, often more than proportionately. For younger staff, the personal risks are often high relative to the potential for career advancement. This problem could be rectified as was demonstrated in cases of successful collaboration where the young researcher gets his/her name on far more papers than he/she would otherwise, and is typically lead author on the papers where he/she did the most work. Many leading journals now list the contribution of each author to a paper, which facilitates faculty advancement boards. This practice could be broadened to encourage more such collaborations.

Similar situations exist in the areas of extension/outreach/development activities, where the successful promotion of interdisciplinary teamwork, especially involving personnel from different agencies, is often due to the commitment and dedication of mid-level personnel at local level with the courage to act without formal approval from the top levels of their agencies.

It is clear, therefore, that a significantly greater level of level of institutional capacity development is necessary whereby AKST institutions acquire/develop an organizational ethos that facilitates/encourages/promotes various networking developments and encourages active participation of its personnel in such networks, as part of "mainstream" institutional activity attracting parity of esteem for professional recognition and career progression prospects. The "transactions costs" involved in establishing, operating and evaluating partnerships need to be kept reasonable, so that the barriers/obstacles to desirable co-operation can be reasonably surmounted. There is considerable evidence that crossing institutional boundaries can be quite difficult, especially if it also involves crossing Ministerial boundaries.

Box 6.12 An example of innovative education and research model: BIFS
Innovative models can range from informally organized “farmer circles”, (which invite academic and/or extension personnel as resource persons), to a variety of more formally organized and funded programs such as the Biologically Integrated Farming Systems (BIFS) Program in California, whose projects involve farmers, University of California Cooperative Extension researchers, federally funded research staff, conservation organization staff, and private sector consultants. Originally begun to attempt to solve some of the seemingly intractable problems of heavy pesticide dependence in some orchard crops, the program has been extended to a wide variety of other crops, including row crops, ranging from cotton to melons. The program has developed innovative solutions that have reduced dependence on pesticides and synthetic fertilizers, reduced environmental impacts, and improved farm profitability. It has also revitalized the relationship among farmers and research and extension staff and has improved positive interactions among farmers themselves. Projects have been successful among both small and large-scale producers.
Key elements of the BIFS approach include, in the slightly abbreviated words of BIFS evaluators (Mitchell et al., 2001):

- experienced farmers who voluntarily share information about their production systems with other farmer participants, consultants, and researchers;
- on-farm side-by-side demonstration evaluations of conventional and alternative management practices;
- a small management team that provides technical assistance and project leadership made up of farmers, consultants, and academic researchers;
- customized information support to facilitate evaluation of alternative production practices; and
- an emphasis on providing opportunities for “co-learning” environments in which farmers, researchers, and consultants share insights.

Box 6.13 The new Challenge Programs in the CGIAR
Recently the CGIAR (Consultative Group in International Agricultural Research) system has launched challenge programs (CPs), with a double objective of encouraging the centers to work better together and mobilizing other research institutions around common development objectives. Four pilot CPs have been started. Although the networking role of this approach has already proved extremely successful, these programs are still too young to show any real impact on resource-poor farmers in developing countries. CPs have significantly increased the overall budget of the CGIAR and mobilized scientists and institutions that were not previously working on development issues. The CPs were criticized for not being sufficiently inclusive of national programs and development stakeholders. Additional CPs, or similar types of collective actions, could be launched, involving partners from NAE and developing countries together. Oriented towards farmers and building practical solutions, these new collective actions may address:

- the forecasted impact of climate change on crop and animal productions in poor countries;
- the forecasted reduction of renewable and nonrenewable resources, mostly water and fossil energy, and the potential of diversity and diversification;
- the relation between new, emerging illness in poor countries and agricultural development;
- the growing urbanization and the role for agricultural intensification in favorable and non favorable environments;
- the potential conflicts in land use arising, for example, between biofuels and food, between exports and domestic consumption;- the development of stronger food supply chains and more efficiently functioning marketing arrangements; and
- the development of rural innovation and raising rural incomes.

Box 6.14 The complexity of property questions illustrated with water law reform or species and genetic resource protection

For various reasons, throughout Europe and North America, and much of the rest of the world, water has historically been to a large degree considered a public good to be owned and traded outside the market, and/or with strong restrictions on market transactions. There are arguments that promote the creation of water markets. It has been shown that in many circumstances water markets can be created that provide efficiencies so convincing that difficulties can be overcome while meeting reasonable concerns for quality, access, and equity. But the creation of water markets raises other important questions such as the ownership claims (is a water right held by a landowner or by the legally constituted water district of which the landowner is a member?), varied and complicated market rules (different legal and geographic conditions prevailing in the different regions) etc. (Roth et al., 2005).
Property rules and policy with regard to such fundamental resources as water can have critical impacts on such clearly nonmarket issues as the survival of endangered species. The effort to protect species has already created highly charged conflicts regarding private and public claims on land and resources. These conflicts involve matters that clearly cannot be addressed simply through market mechanisms; they are in fact claims that are based on a universal human interest in the protection of species in conflict with private property interests (Fairfax and Guenzler, 2001).

Box 6.15 Enablers of AKST

Policy drivers providing high level commitment to multi-functional agriculture within the broader context of sustainable development
A knowledge and science culture at all levels of governance in society, supported by an informed science and society discourse, including aspects of welfare and ethics.
Incentives, rewards and risk sharing using an appropriate balance of public and private involvement.
Institutional frameworks governing the rules, regulations and ways of doings things, including regulation of intellectual property rights, patents, and fair trading.
Stakeholder engagement and exchange amongst providers, brokers and users of AKST, including joint and collaborative working.
Experimentation, testing and demonstration of new forms of AKST in real world conditions as a precursor to adoption and diffusion.
Funding and delivery mechanisms suited to the wide range AKST products and services, including public, private and joint public-private partnerships