BOXES FOR NAE CHAPTER 4 (OPTIONS FOR ACTION)

Box 1: Contribution of new Complex Systems Science to elucidate agricultural systems

The contribution of complex systems science appears in four ways as: (i) a better understanding of the components of the system and their interactions (ii) a better control of the development of dynamic complex socio-technical 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 which 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. AKST needs to be mobilized for:

- developing a meaningful knowledge representation and modeling of a 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 system.
- building needed infrastructures for facilitating information storage and agricultural complex systems approach.

Box 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 factors of production such as soils, water, and energy 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. Sachs (2002) suggests that 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 . 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 unregulated markets and does not see in agriculture 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 gotten rid of; 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 illusory any optimal equilibrium.
- The public goods, such as food security or protection of the biodiversity, are not recognized by the market. Consequently, the market price will not be able to guarantee these public goods.
- The General Equilibrium model cannot represent the diversity of the 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.

- Agriculture relies on complex interactions to short and long-term. Non-consideration of food security, biodiversity and environmental impact impede price signals to be socially efficient.

Box 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 indeed 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. .

Boussard *et al*. (2005) provide three main criticisms to CGE's models:

- The most *liberalized* situations depicted through these models are undoubtedly efficient and Pareto optimal[1]. But they rely on a particular income distribution, resulting from factor scarcity rents[2] which are not necessarily socially optimal. Other Pareto efficient situations, with a different income distribution, could be deemed more socially desirable.
- Only those commodities which are subject to market exchanges are accounted. Those externalities ignored by the market are also ignored in the CGE benefit / cost balances analyses.
- A CGE model assumes markets are functioning properly, *i.e.* marginal costs are equal to marginal receipts everywhere, producers and consumer adjust their plans immediately in response to observable equilibrium prices (hence the reference to "equilibrium").

The existence of price instability confounds the price signal and rendering it an economically inefficient signal. Thus it appears that these models have no connection with reality. Boussard *et al*. (2005) introduce a key point in this respect. "Apart from monopolistic competition considerations, the main immediate reason for a discrepancy between marginal costs and prices is to be found in risk considerations. The central argument is that the market by itself can endogenously create risk, and maintain it through dynamic mechanisms. In addition, such a mechanism is not general but, to a large extent, specific to agricultural commodities".

It follows from the previous considerations that there are gaps in research on the ways to adjust 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, chaotic and related 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 correct market imperfections and to deal with the difficulty to reach an optimal general equilibrium (box 2).

Box 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 which 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 labour with competitive production costs on the international markets. On the environmental level, standard operating procedures provide information on quality and a sanitary and environmental profile of each good. The dimension of the farms is such that a certain division of the labour can be carried out, with a strong specialization on certain tasks.

[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.).

In this type of agriculture the majority of the farmers gradually ceased direct marketing and processing and play a reduced role as suppliers of raw material at low prices (Bonny, 2005). The food processing chain has become more complex. It is 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 with the consumers and increases for that the contracts with the producers.

- A demand for identified products

On the other pole, agriculture is concerned by products identified by their origin, with characteristics specific to a "terroir". They are territorialized products, with strong value added thanks to marketing niches. It is traditionally around the controlled labels of origin for wine that this agriculture developed first in Western Europe.

The territorial identity results from several factors, like the identification of places, the typicity of the products etc. 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) by the marketing (fair trade, direct sales etc.).

Box 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 micro-nutrients (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;
- the development and expansion of technologies that preserve foodstuffs germ-free without refrigeration, such as novel packaging technologies, irradiation, etc.

Box 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 much 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, green house gases and global warming potential (GWP). For the most part in agriculture, they are indirect, given that most energy is tied up in 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 7: Plant and animal breeding targets to contribute to the IAASTD goals

(FAO 2004 , Agricultural biotechnology: meeting the needs of the poor; FABRE technology platform, 2006; Plants for the future technology platform, 2005)

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 less 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 micro-nutrients (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 namely under-utilized species among which medicinal and aromatic plants possessing high health and economic potential;
- 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 fishes, leading to improved disease prevention strategies, for persistent and costly diseases;
- revisit gut physiology (for improved efficiency, less pollution, less diseases), 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 non-ruminant animals and poultry);
- improve nutrition and hygiene in intensive productions to reduce pollution and to control diseases;
- 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.

Box 8: Genetic Engineering and the 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 presently 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 health and environmental risks and consumer acceptance. 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.

Development of organisms produced by 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 lead 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 entangled with many other issues, including indigenous peoples' rights, biodiversity conservation and food aid, complicating the picture. 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 not 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.

The 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, 2004), 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 the IAASTD goals must be assessed on a case-by-case basis. We can conclude with confidence that genetic engineering is positioned to help meet the IAASTD goals, and we can even say that some (future) products of genetic engineering will likely help meet the 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 socio-economic and environmental context for the use of transgenic organisms enables them to contribute to these goals.

Box 9: Animal biotechnology developments and the IAASTD goals

(FABRE technology platform, 2006; Rollins, 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 the 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.
- There are many foreseen applications in the medical field: animal models, animals as bioreactors, animals for xenotransplantation *etc*.

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. A number of other concerns has been expressed and debated (Rollins B., 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 the IAASTD goals requires detailed analysis on a case-by-case basis weighing possible costs against possible benefits whatever environmental, sanitary, social and 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 10: 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 interdisciplinarity in research:

Interdisciplinarity and professional reality: Interdisciplinarity in agricultural research is essential, but here 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 organisational 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 in the main the peers chosen to evaluate research proposals 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 for such proposals in educational institutions as well as subsequent course delivery mechanisms and learner assessment procedures. In fact, many such initiatives are almost completely dependent on their promotion by a "champion" who has the vision to catalyze a team to design the program proposal, who is 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 program delivery until its (hoped-for) eventual success with the targeted learners prompts the earlier obstructionists into acquiescence or even into claiming 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 readily surmounted. There is considerable evidence that crossing institutional boundaries can be quite difficult, especially if it also involves crossing Ministerial boundaries.

Box 11: 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 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:

- 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 12: Framework for African Agricultural Productivity (FAAP)

The FAAP has been developed as a tool to help stakeholders come together to bring these political, financial, and technical resources to bear in addressing problems and strengthening Africa's capacity for agricultural innovation. The Heads of State and Government of the African Union (AU) endorsed the ‘Framework for African Agricultural Productivity (FAAP)’ at its Heads of State Summit in Banjul in June/July 2006. Specifically, the AU, “Urges regional economic communities and member states to realign their regional and national research priorities to the Framework for African Agricultural Productivity with the support of the Forum for Agricultural Research in Africa (FARA).

The FAAP, in its detailed discussion of the evolution and reform of agricultural institutions and services, has several proposals regarding the future strengthening of extension, research training and education, several of which resonate loudly with the proposals of this section:

- End-users should be actively engaged in the processes of agricultural research priority setting, planning and managing the work programs. (p. 11)
- The quality of tertiary agricultural education is critical because it determines the expertise and competencies of scientists, professionals, technicians, teachers and civil service and business leaders in all aspects of agriculture and related industries. It raises their capacities to access knowledge and adapt it to the prevailing circumstance, and to generate new knowledge and impart it to others. There is a consensus amongst recent studies, such as those by the Inter-Academy Council and the Commission for Africa, that urgent action must be taken to restore the quality of graduate and postgraduate education in Africa. (p.12)
- Establishment of national agricultural research strategies through participatory and multi-disciplinary processes - and the endorsement of these at national level through inclusion in the poverty reduction strategies. (p.12)
- Breakdown the institutional and programmatic separation between universities and NARIs which results in inefficient use of capacity and unproductive competition (p.13)
- Create synergies among institutions and curricula in education, research and extension (p.13)
- The FAAP document suggests that international contributions could be, amongst others, in the following principal areas :

1. Bringing best practices, data, knowledge and expertise from other regions of the world to bear on African issues.

2. Providing research-based, relevant information and data for training, and curricula and course development.

3. Providing specialized expertise in cutting-edge sciences including biosciences, social sciences and policy analysis.

4. Creating critical mass and building capacity through collaborative research.

5. Enabling cross-country and cross-continent replications and comparisons to inform African research and development.

Box 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 centres 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 non-renewable 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 favourable and non favourable 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
- the development of rural innovation and raising rural incomes.

Box 14: The complexity of property questions illustrated with water law reform or species and genetic resources' protection.

For various reasons, throughout Europe and North America, and much of the rest of the world, water historically has 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.

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.

Box 15: Common Property regimes

Common property regimes arise in situations where appropriators acting independently in relationship to a common-pool resource generating scarce resource units would obtain a lower total net benefit than what is achieved if they coordinate their strategies in some way, maintaining the resource system as common property instead of dividing it up into bits of private property. Common property function through complex community norms of consensus decision-making, facing the difficult task of devising rules that limit the amount, timing, and technology used to withdraw various resource units from the resource system. Setting the limits too high would lead to overuse and eventually to the destruction of the core resource, while setting the limits too low would unnecessarily reduce the benefits obtained by the users. In common property regimes there is no free access to the resource and common-pool resources are not public goods. While there is relatively free but monitored access to the resource system for community members, there are mechanisms in place, which allow the community to exclude outsiders from using its resource. Thus, in a common property regime, a common-pool resource has the appearance of a private good from the outside and that of a common good from the point of view of an insider.

Analyzing the design of long-enduring Common Property Regimes institutions, Ostrom (1990) identified eight design principles that are prerequisites for a stable CPR arrangement:

- Clearly defined boundaries
- Congruence between appropriation and provision rules and local conditions
- Collective-choice arrangements allowing for the participation of most of the appropriators in the decision making process
- Effective monitoring by monitors who are part of or accountable to the appropriators
- Graduated sanctions for appropriators who do not respect community rules
- Conflict-resolution mechanisms that are cheap and easy to access
- Minimal recognition of rights to organize (e.g., by the government)
- In case of larger CPRs: Organization in the form of multiple layers of nested enterprises, with small, local CPRs at their bases.

Box 16:Efforts Towards Collective Management of Public Intellectual Property for Agricultural Biotechnologies

The CAMBIA initiative (www.cambia.org**)**:

CAMBIA is an international, independent non-profit research institute. For more than a decade, CAMBIA has been creating new tools to foster innovation and a spirit of collaboration in agricultural biotechnology by independently developing new and patentable transformation technologies, expression vectors and cassettes, as well as isolated genes for use in agricultural genetic engineering that are outside of others' patents. These tools are aimed at enabling people in disadvantaged communities and developing countries to choose their own methods, to help themselves meet their own challenges in food security, health, and natural resource management.
CAMBIA's mission is achieved through four interconnected work products outlined below:
Patent Lens: Patents were intended to foster innovation, but they can also form a barrier to innovation. The Patent Lens provides tools to make the world of patents and patent landscapes more transparent, to help focus paths leading to freedom to (co)operate.
BiOS (Biological Open Source) Initiative: The BiOS Framework communicates and advocates for the development and sharing of life sciences technology through its BiOS licenses, an open source form of collaborative agreement suitable for patented technology.
BioForge: BioForge is a prototype portal to a dynamic group of protected enabling technologies, available to everyone who agrees to maintain them available to share for improvement and to use in new innovations, whether for research, commercial use, or humanitarian use.
CAMBIA's Materials: CAMBIA has designed, developed and delivered molecular enabling technologies with a focus on their use by disadvantaged communities, for example in international agriculture and public health.

PIPRA initiative (ott.web.arizona.edu/**PIPRA**_Activities.php)

PIPRA is working with the University of California Berkeley to further develop and maintain a database of agricultural technologies owned by PIPRA member institutions. The database contains over 4,500 records consisting of utility patents, plant patents and patent applications owned by members. A distinctive feature of the database is the licensing information that informs users about technologies that are exclusively licensed and those that might be available for use. Current PIPRA members claim to control almost 40% of all US public sector agricultural intellectual property. Almost 75% of the technologies in the database are unlicensed, non-exclusively licensed and have limited option agreements and therefore potentially available for use by researchers.

PIPRA staff and researchers pool complimentary technologies from the database to develop research tools and products that are made available to member institutions on a non-exclusive basis. Patent pools have been used by industry when multiple proprietary patents block the development of a key technology that can benefit the public or developing countries, as illustrated by the "Golden Rice" case. The patent pooling strategy has been effective in expediting the development of more than 70 technologies with significant societal impact for agricultural researchers and small subsistence farmers in developing countries.

In an effort to resolve problems of IP inaccessibility, PIPRA is in the process of developing alternative core technologies. Currently PIPRA researchers are exploring new promoters comparable to those licensed to the private sector that will efficiently control gene expression. Through its collaborations with the USDA, PIPRA hopes to identify constitutive, tissue specific, inducible and synthetic promoters. PIPRA will make these innovations available to researchers at member institutions through a non-exclusive license with no transaction costs. Non-exclusive licenses will also be available to private industry; however PIPRA will charge appropriate fees to reimburse its research and patent costs.

EPIPAGRI initiative (www.international.inra.fr/partnerships/)

The European "EPIPAGRI" project (specific support action) aims to set up a collective network for the management of patents and other exploitable assets (know-how, software, etc.) held by European public research organizations in the field of agricultural biotechnologies.
EPIPAGRI is being funded for a period of two years, during which the following actions will be implemented: establishment of an information exchange system concerning intellectual assets (including patents, emerging technologies and know-how) owned by EPIPAGRI members and other public research organizations, evaluation of this system through the building of patent bundles, evaluation initially on a scientific basis and then from an economic point of view, identification of IP which restricts freedom to operate, detection of emerging projects with high potential, proposing patent bundles to private partners for non exclusive licensing., proposing consensual solutions for European organizations and institutions aimed at improving the management of public intellectual property in agricultural biotechnologies.

EPIPAGRI involves eleven European organisations representative of the sector: Biopolisz (Hungary), FLM

(Portugal), GI GmBH (Germany), INRA and its subsidiary INRA Transfert, FIST subsidiary of the CNRS (France), IRTA (Spain), PBL (UK), SLU (Sweden) TEAGASC (Ireland), and VIB (Belgium).