Global Chapter 2 Tables, Boxes and Figures

Table 2.1 Roles of agriculture (adapted from FAO-ROA project: http://www.fao.org/es/esa/roa/index_en.asp).

Role	Environmental	Social	Food Security	Economic	Cultural
Global	Ecosystem resilience Mitigation of climatic change (carbon sequestration, land cover) Biodiversity	Social stability Poverty alleviation	Food security	Growth	Cultural diversity
Regional/ National	Ecosystem resilience Soil conservation (erosion, siltation, salinization) Water retention (flood and landslide prevention) Biodiversity (agricultural, wild life) Pollution abatement/generation	Balanced migration Social stability (and sheltering effects during crisis) Unemployment prevention Poverty alleviation Gender relations	Access to food National security Food safety	Economic stability Employment Foreign exchange Tourism	Landscape Cultural heritage Cultural identity Social capital
Local	Ecosystem resilience Soils conservation Water retention Biodiversity Pollution abatement/generation	Social stability (employment, family)	Local and household food safety	Employment effects on secondary and tertiary sectors	Landscape Indigenous local knowledge Traditional technologies Cultural identity

Table 2.2 Characteristics of models of knowledge processes in relation to fitness for purpose.

Model	Model Characteristics	Fit for Purpose
ToT	Science as the source of innovation; linear communication flows through hierarchically organized linkages; farmers as passive cognitive agents serving public interests	Productivity increase on the basis of substitutable technologies, simple messages, simple practices; catalyzing Cochrane's 'treadmill' (1958) i.e. forcing farmers to adopt the latest price-cutting, yield increasing measures in order to stay competitive in the market. Not fit for promoting complicated technologies & management practices, complex behavior change, and landscape scale innovations
Farmer-Scientist Collaboration	Innovations as place dependent & multi-sourced, based on widely distributed experimental capacity; communication flows multi-sided, through networked social and organizational linkages among autonomous actors serving their own interests	Socially equitable, environmentally sustainable livelihood development at local levels, multi-stakeholder landscape management, and empowerment of self-organizing producers and groups. Not fit for rapid dissemination of simple messages, substitutable technologies, simple practices
Contractual Arrangements	Science as an on-demand service to support production to specification; communication flows framed by processors' and retailers' need to supply to known market requirements; farmers as tied agents serving company interests	Sustains yield and profit in company interests; can be environmentally sustainable but not necessarily so. Contractual arrangements can trap poor farmers in dependent, unequal relationships with the company. Crop focused, thus not fit for promoting whole system development or landscape scale innovations

Chain-linked	Science as a store of knowledge and a specialized problem-solving capacity; structured communication among product/technology development team around iterative proto-typing, continuously informed by market information; farmers sometimes as team members but primarily as market actors serving private interests	Motor of innovation in the private commercial sector in the presence of monetized markets, consumers able to articulate demand, and adequate science capacity. Increasingly, practitioners have begun to internalize within company R&D practices a range of environmental and sustainable livelihood concerns - the 'triple bottom line' - under pressure from citizens and regulation

Table 2.3 Analytic map of the main features of AKSTD paradigms.

Label	Features of Production System	Features of AKST	Direct Drivers	Indirect Drivers
Pre-modern/ Traditional	diverse products locally; "natural" systems; small-scale units; local/recycled inputs	Local knowledge generation and repositories	Biophysical: soils, local climate Resources: labor availability Social factors: mutual help, social capital Economic: local economy / food need	Policy and economic: tax systems, access to markets Social: cultural practices related to farming Cognitive: focus on meeting local needs
Industrial Agriculture in Capitalist Contexts	Mechanization; less diverse products – greater specialization; larger scale units external inputs; private sector production	Formal R&D (public and private); dissemination of knowledge	Cognitive: profit and yield maximization through science policy: subsidy for production goals Economic: agribusiness corporations Institutional: formal research institutions	Social and economic: consumer demand Trade: international trade agreements Economic: cheap energy; externalization of health and environmental costs
Industrial Agriculture in Socialist Contexts	Mechanization; larger scale units; external inputs; collective ownership of resources (labor, land); central planning	Public sector R&D, dissemination by state institutions	Policy: national food self-sufficiency Institutional: funding for research/extension	
High External Input Intensive Agriculture in South (e.g. Green Revolution; some plantation systems)	HYVs; package of external inputs; pest management and nutrient management through chemical inputs	National agric. universities and research stations; CGIAR; global transfer through aid agencies / projects; local knowledge has little influence	Cognitive: increase production to keep up with population; science provides solutions Policy: state support/subsidy Institutional: research community Technological: growth of new technologies Trade: focus on export-led growth	Economic and policy: post-colonial drive for food self-sufficiency Cognitive: faith in rational science & expert advice Globalization and trade: multinational agribusiness and agrochemical corporations; aid conditionalities Social: loss of local knowledge; perceived inefficiencies in previous production systems
Low External Input Agriculture in South (not necessarily sustainable)	Marginal land resources; low yields; low priority crops (national and trade perspective); prone to natural shocks; minimal use of synthetic inputs	Little attention from formal R&D; reliance on local knowledge and innovation	Institutional and policy: low provision of credit and technical assistance	Institutional and policy: high potential lands have been prioritized Trade: low value of output means little attention from input manufacturers and agribusiness
Organic / Low Impact / Sustainable Farming in South and North	Low use of external inputs; crop nutrition and pest management; based on natural systems; focus on maintaining/building quality of soil and water resources	South Local learning, e.g., through Farmer Field Schools; documentation and dissemination of local knowledge; Cuba's model of centers to reproduce biological	South Social: social capital, collective effort Economic: high cost of external inputs; negative impact on yields of high input agriculture. Policy: sustainability Cognitive: farmer concern with resource / ecosystem damage	South Globalization and investments: international organizations (IFOAM) Cognitive: farmer and researcher recognition of externalities of high external input agriculture North Cognitive and social: recognition of

Label	Features of Production System	Features of AKST	Direct Drivers	Indirect Drivers
		pest control agents North producers' organizations; independent R&D institutions networking among producers; government funding for research on organic and sustainable farming	Trade: high demand for organic / niche products in northern markets Institutional: emergence of local NGOs for dissemination of sustainable practices; increase in aid for low input agriculture North (EU) Cognitive: idea of "natural" and ecological farming popularized institutional and policy: funding, subsidy and support for conversion Economic and social: public awareness of organic products Institutional: good support structure of organizations and extension services	negative environmental effects of high input ag., and problems faced by family farms Globalization and trade: disease outbreaks leading to trade restrictions Institutional: rise of Green movements and political parties

Table 2.4 Constraints of university arrangements.

Funds	Universities have to share budgetary allocations with other public sector for agricultural research. In Latin America, e.g., expenditure per researcher diminished strongly in the 19080s, and then recovered in the nineties but without reaching the previous position.
Scientific Culture	Different knowledge paradigms and scientific culture pervade teaching, research and extension activities addressing societal problems. Most public concerns or problems are multidisciplinary, while most university departments are disciplinary. Research, especially in the agricultural colleges - produces fundamental knowledge under standards of rigor focused on "manageable" (well defined) or "technical problems," not always pertinent to social needs. Teaching follows the same disciplinary pattern, moving from simple units to complex ones in five to six or more year programs. There is little latitude for interdisciplinary or multidisciplinary work, though professional practice deals with ill-defined, complex and practical problems of agriculture which are "incapable of technical solution" and are intertwined with social and cultural patterns and ethical issues. Needs for synthesis of diverse elements, and interdisciplinary approaches. Outreach requires a different epistemology of science, because it faces real, synthetic and complex problems, and needs training in communicative competences and participatory approaches.
Promotion and Reward	Academic staff usually promoted and rewarded on the peer review system. Although this system has served certain fields of agricultural science well, it does not allow much credit for societal value or social pertinence of research contributions, and give less value to teaching and extension. It also emphasizes the big gap between basic and applied research and between wealthy and developing countries´ academic and research systems and also marginalizes basic research in industrialized countries.
Curriculum Policies	In many universities, curricula were broadened to encompass environmental sustainability, poverty alleviation, hunger elimination and gender issues. But this trend has not always been followed by specific fund allocation to programs oriented to these goals, nor have interdisciplinary courses and social sciences- sociology of organizations, cultural anthropology, IP issues, food security, and some cross-cutting subjects, such as Ethics- have not always been included. Change is sometimes cosmetic.
Enrollment and Graduation Rates	Enrollment of agricultural students is today very low compared to total university enrollment. This is a generalized trend even in countries with a high share of agricultural GDP in total GDP and a high ratio of rural to urban population, mostly in non-industrialized countries. Likewise, graduates in agricultural programs (agriculture, forestry and fishery and veterinary) have a very low percent of total graduates. In many countries where agriculture is a major source of income, employment and export earnings, and thus critical to alleviating rural poverty and safeguarding natural resources, the percent of graduates is low (UNESCO, 2005).
Gender Issues	Despite their key role in agricultural and food production and security, agricultural information and education is not reaching women and girls. Greater awareness of women's contributions to agriculture and changing discriminatory practices and attitudes are needed to foster their participation in agricultural education and extension. Not many women professionals are trained in agriculture due to factors rooted in the gendered nature of culture and society. Women's participation in higher education in agriculture is increasing, but is still lower than that of men, even in the developed countries and in Latin America and the Caribbean, where women participate in higher education in nearly equal numbers with men (UNESCO, 2005).

Table 2.5 Public-private partnerships in the CGIAR. Source: Spielman and von Grebmer, 2004.

Partnership Approach Research Topic	CGIAR Center(s)	Private Sector Partners	Other Partners
Collaborative Research-Global Programs			
Apomixis	CIMMYT	Pioneer Hi-bed (US) Syngenta (Switzerland) Limagrain (France)	L'Institut de Recherche pour le Développement (France)
Golden Rice Humanitarium	IRRI	Syngenta	Rockefeller Foundation (US), Swiss Federal Institute of Technology, and others
HarvestPlus	CIAT, IFPRI	Monsanto (US)	
Wheat Improvement[e]	CIMMYT		Grains Research & Development Corp.(Aus)
Collaborative Research – Local/Regional Programs			
Sorghum and Millet Research[e]	ICRISAT	Consortium of private seed companies incl. Monsanto (India), others	
Forage Seed Improvement	CIAT	Grupo Papalotla (Mexico)	
Insect Resistant Maize for Africa[e]	CIMMYT		Kenyan Agricultural Research Institute, Syngenta Foundation (Switzerland)
Technology Transfers			
Potato/Sweet Potato Transformation	CIP	Plant Genetic Systems[a] (US), Axis Genetics[b] (UK), Monsanto	
Genomics for Livestock Vaccine Research[e]	ILRI	The Institute for Genomic Research (US)	
Bt Genes for Rice Transformation	IRRI	(Switzerland), Plantech [d] (Japan)	Consortium of other public research institutions
Positive Selection Technology for Cassava Transformation	CIAT	Novartis [c]	

[a] Now Bayer CropScience, [b] Insolvent as of 1999, [c] Now Syngenta, [d] subsidiary of Mitsubishi
[e] The definition of a public-private partnership is extended here to include a collaboration between a CGIAR center and a philanthropic organization established by a commercial entity, or an organization established to represent industry interests, on the other.

Table 2.6 Health implcations of agricultural and food revolutions. Source: Hawkes and Ruel, 2006

Era/Revolution	Date	Changes in Farming	Implications for Food-related Health
Settled Agriculture	From 8500 BCE on	Decline of hunter-gathering greater control over food supply but new skills needed	Risk of crop failures dependent on local conditions and cultivation and storage skills; diet entirely local and subject to self-reliance; food safety subject to herbal skills
Iron Age	5000-6000 BCE	Tougher implements (plows, saws)	New techniques for preparing food for domestic consumption (pots and pans); food still overwhelmingly local, but trade in some preservable foods (e.g., oil spices)
Feudal and Peasant Agriculture in Some Regions	Variable, by region/continent	Common land parceled up by private landowners; use of animals as motive power; marginalization of nomadism	Food insecurity subject to climate, wars, location; peasant uprisings against oppression and hunger
Industrial and Agricultural Revolution in Europe and U.S.	Mid -18th century	Land enclosure; rotation systems; rural labor leaves for towns; emergence of mechanization	Transport and energy revolutions dramatically raise output and spread foods; improved range of foods available to more people; emergence of commodity trading on significant scale; emergence of industrial working-class diets
Chemical Revolution	From 19th century on	Fertilizers; pesticides; emergence of fortified foods	Significant increases in food production; beginning of modern nutrition; identification of importance of protein; beginnings of modern food legislation affecting trade; opportunities for systematic adulteration grow; scandals over food safety result
Mendelian Genetics	1860s; applied in early 20th century	Plant breeding gives new varieties with “hybrid vigor”	Plant availability extends beyond original “Vavilov” area; increased potential for variety in the diet increases chances of diet providing all essential nutrients for a healthy life.
The Oil Era	Mid - 20th century	Animal traction replaced by tractors; spread of intensive farming techniques; emergence of large-scale food processors and supermarkets	Less land used to grow feed for animals as motive power; excess calorie intakes lead to diet-related chronic diseases; discovery of vitamins stresses importance of micronutrients; increase in food trade gives wider food choice
Green Revolution in Developing Countries	1960s and after	Plant breeding programs on key regional crops to raise yields; more commercialized agriculture	Transition from underproduction to global surplus with continued unequal distribution; over-consumption continues to rise
Modern Livestock Revolution	1980s and after	Growth of meat consumption creates “pull” in agriculture; increased use of cereals to produce meat	Rise in meat consumption; global evidence of simultaneous under-, over-, and mal-consumption
Biotechnology	End of 20th century	New generation of industrial crops; emergence of “biological era”: crop protection, genetic modification	Uncertain as yet; debates about safety and human health impacts and whether biotechnology will deliver food security gains to whole populations; investment in technical solutions to degenerative diseases (e.g., nutrigenomics)

Figure 2.1 Multiple outputs produced from farm inputs. Source: Adapted from OECD, 2001; Verhaegen et al., 2002; Wustenberghs et al., 2004, 2005.

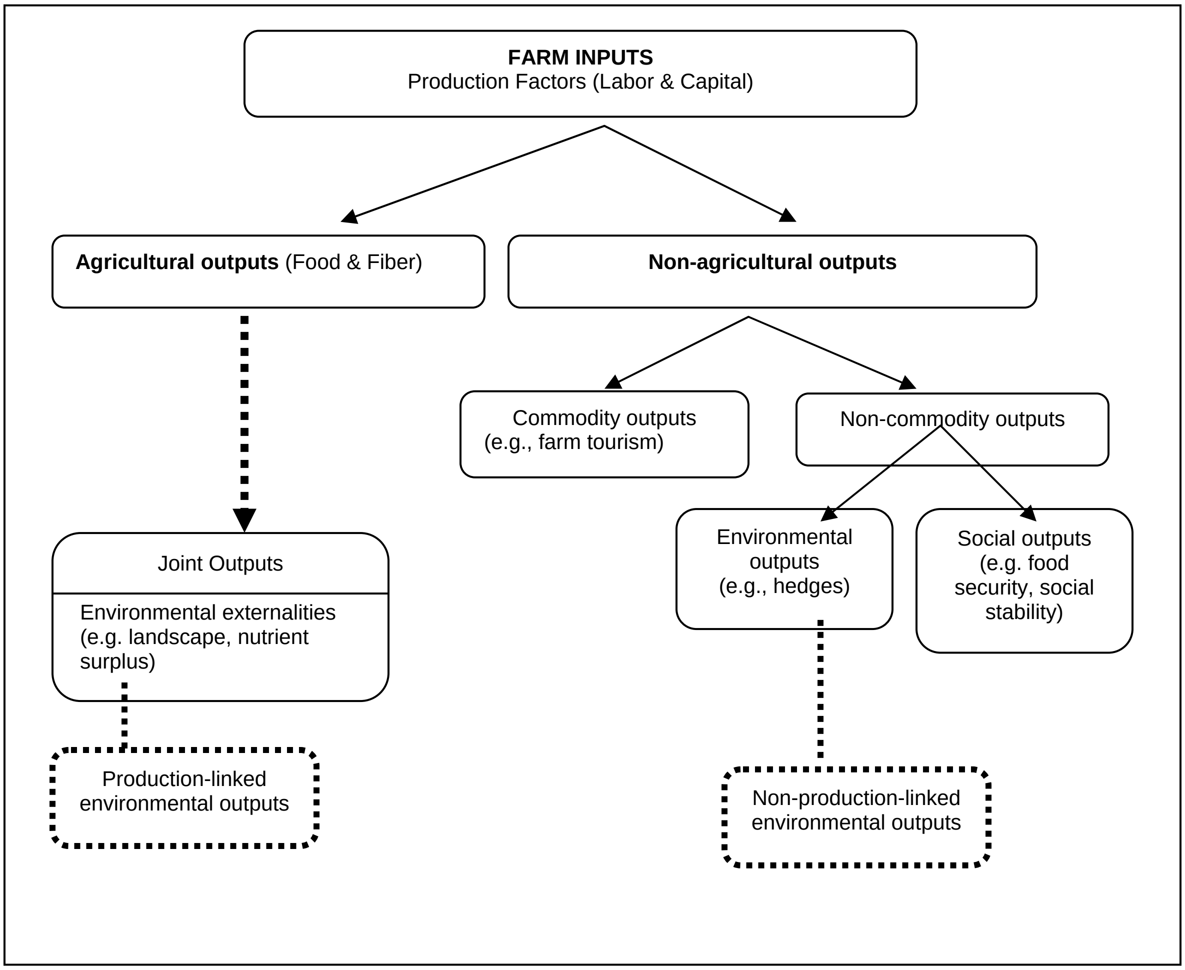


Figure 2.2 Modes of science.

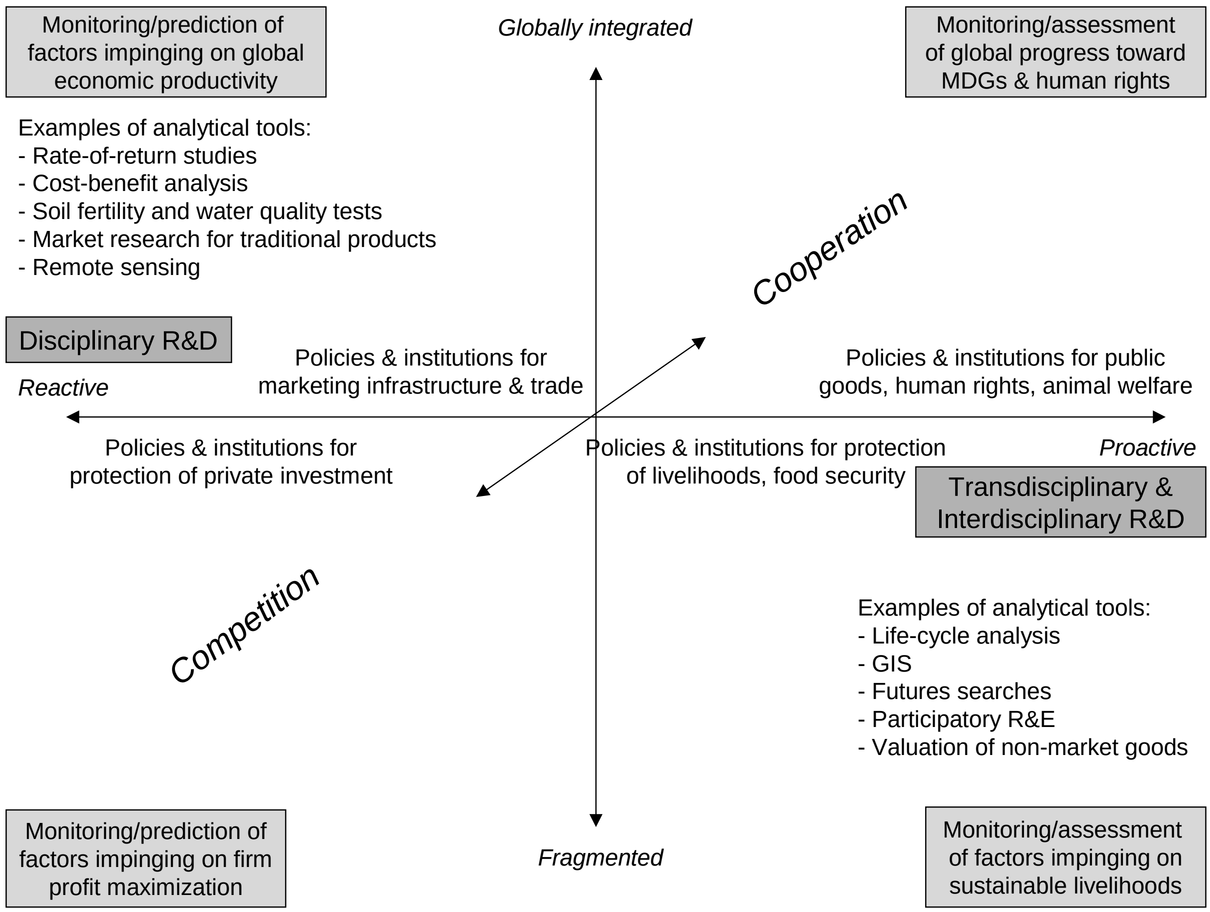


Figure 2.3 Elements of an agricultural innovation system.

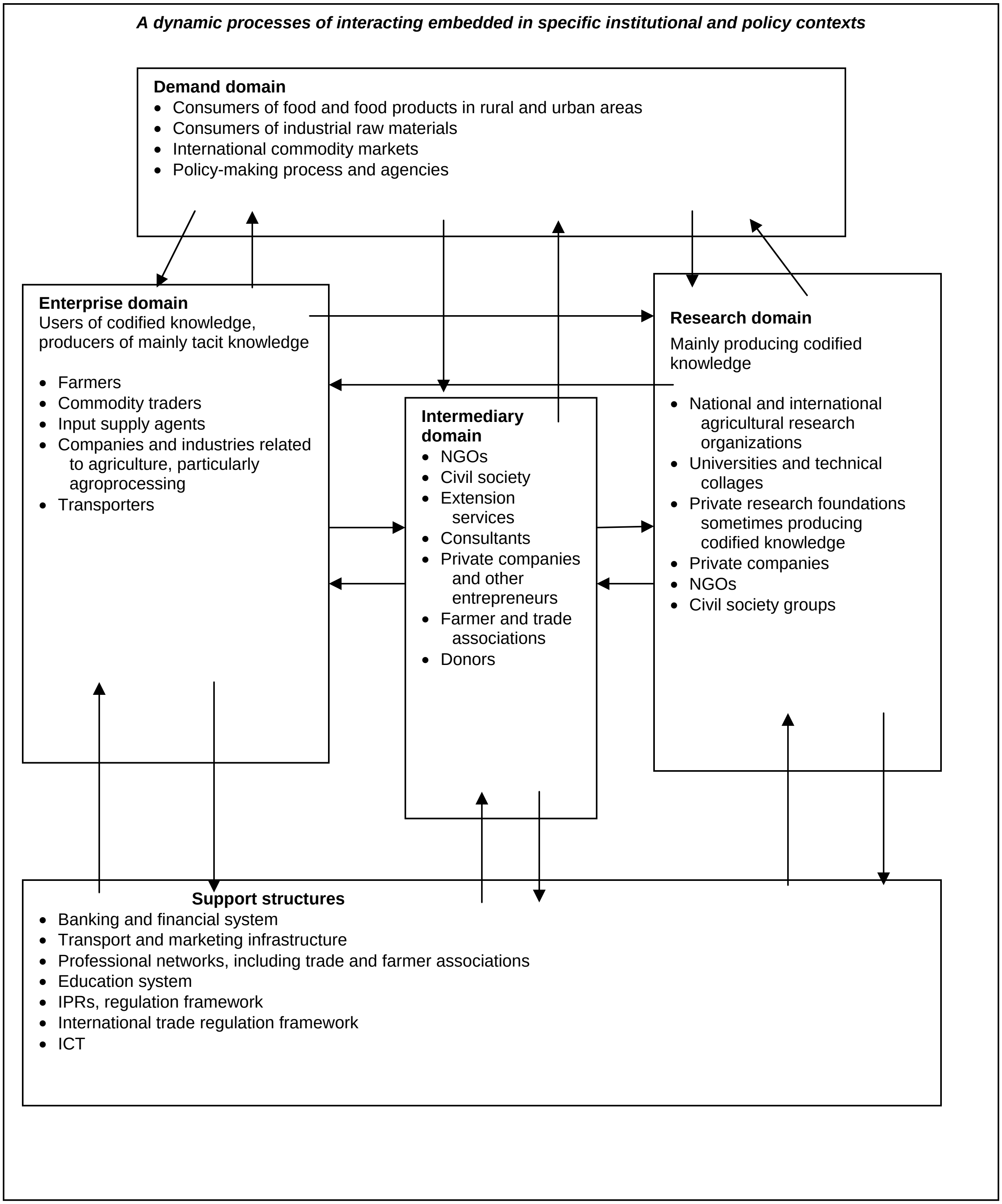


Figure 2.4 The food systems. Source: Combs et al., 1996.

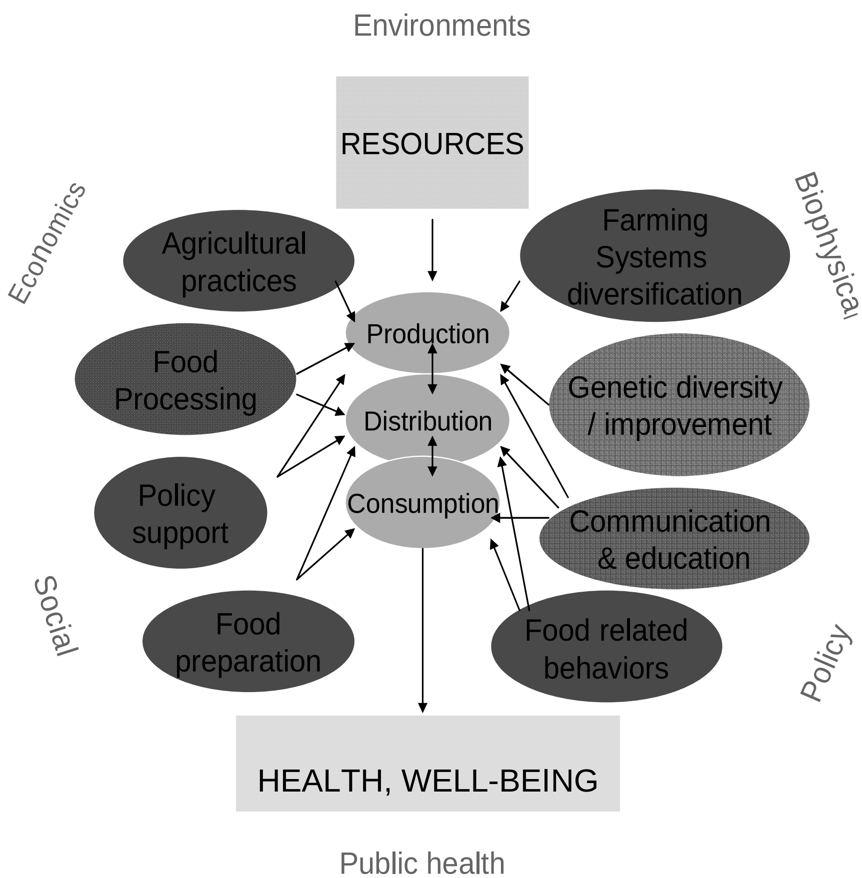


Figure 2.5 Food system activities and outcomes. Source: Adapted from www.gecafs.org/research/food_system.html

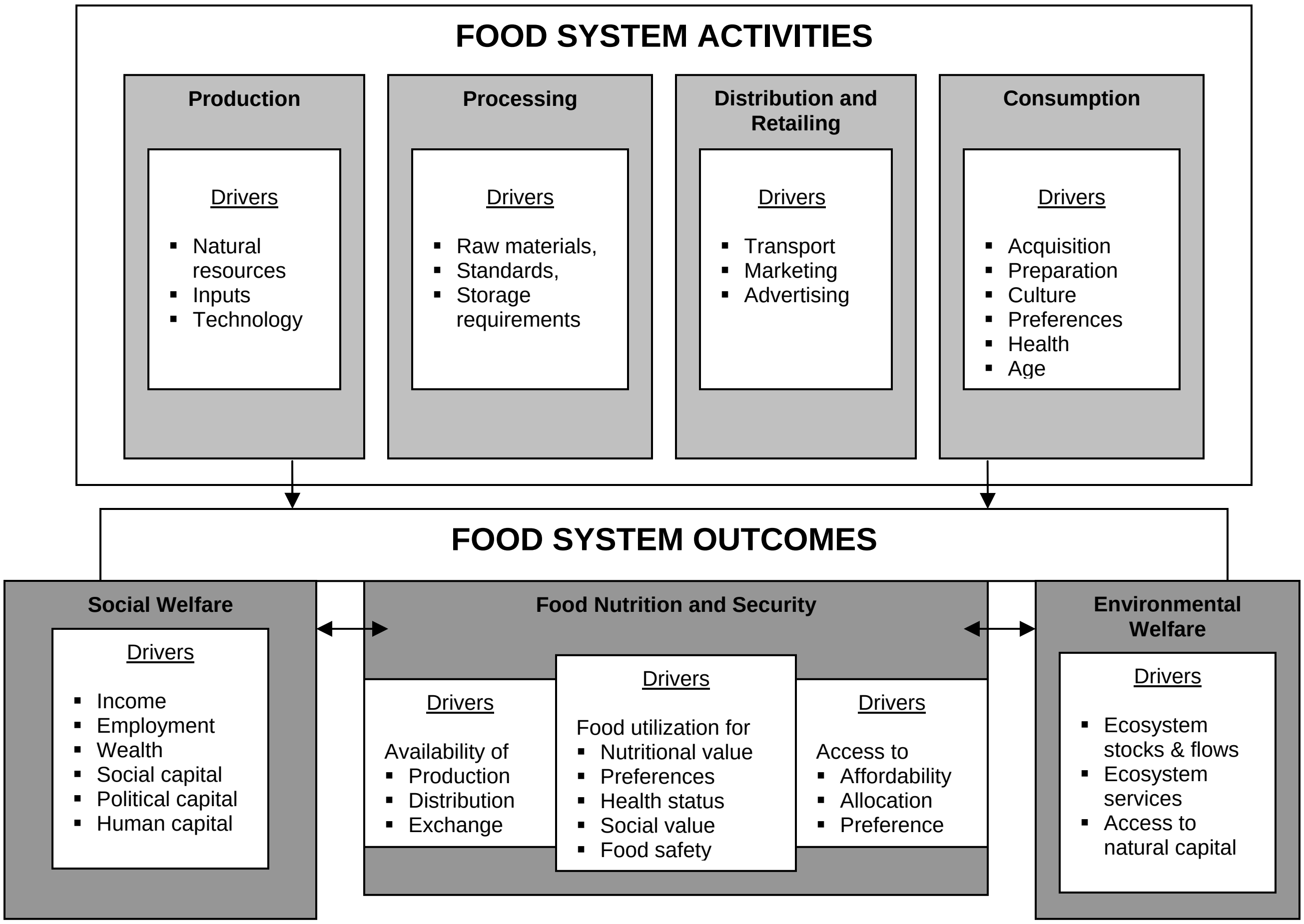


Figure 2.6 Potentially problematic social and environmental aspects of global food systems sustainability.
Source: adapted from Knudsen et al., 2005.

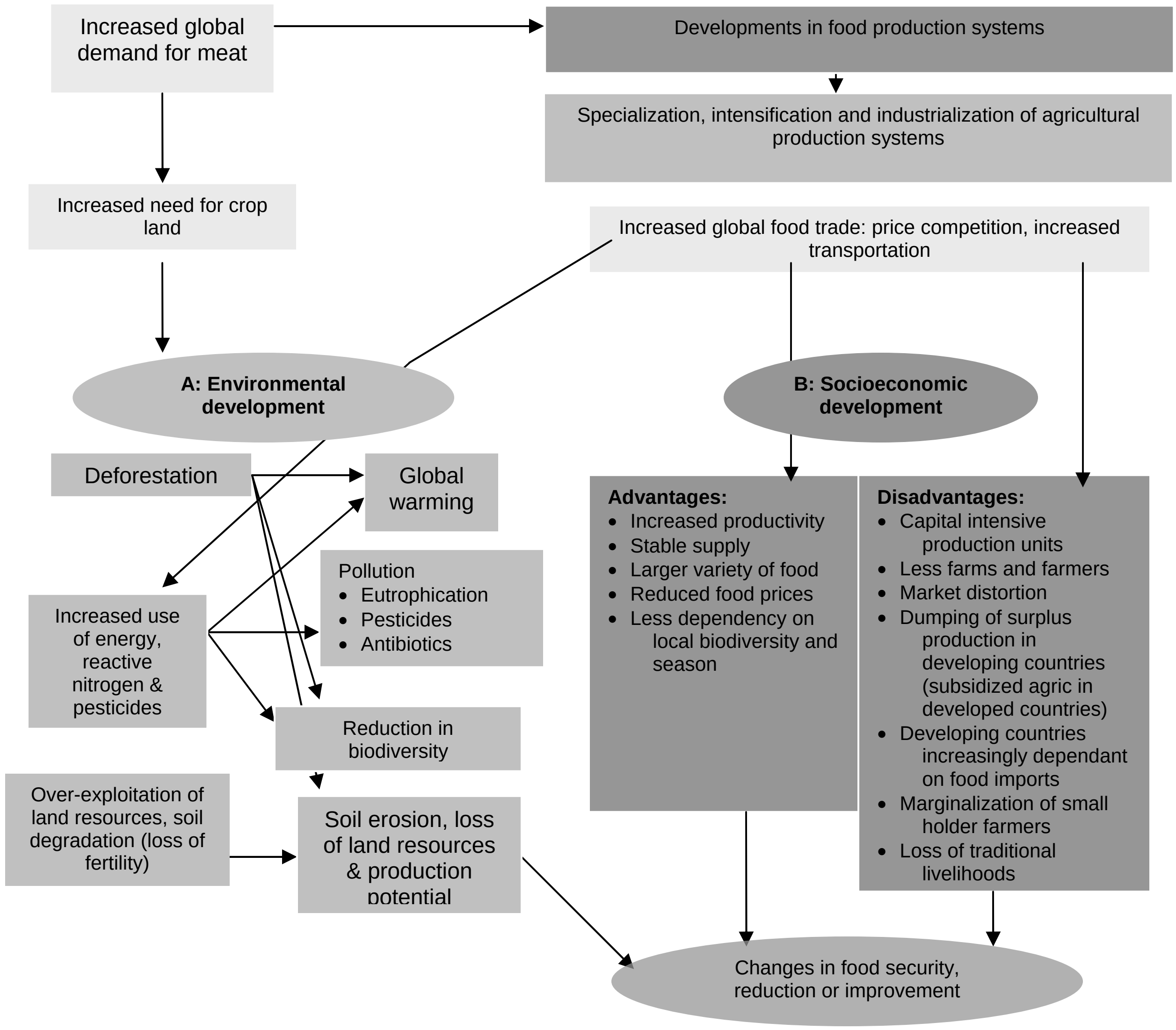


Figure 2.7 A framework for understanding food security. Source: Webb and Rogers, 2003.

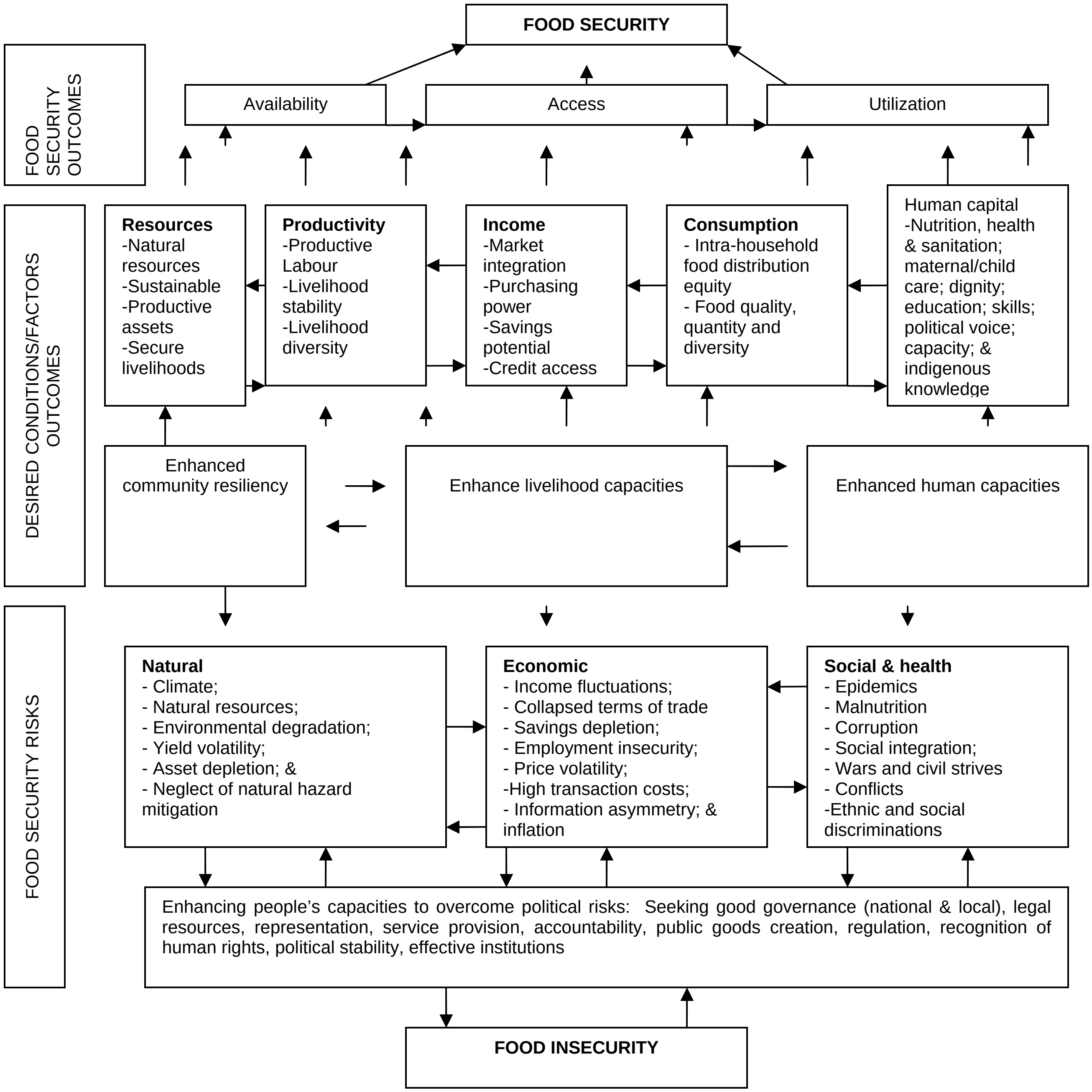
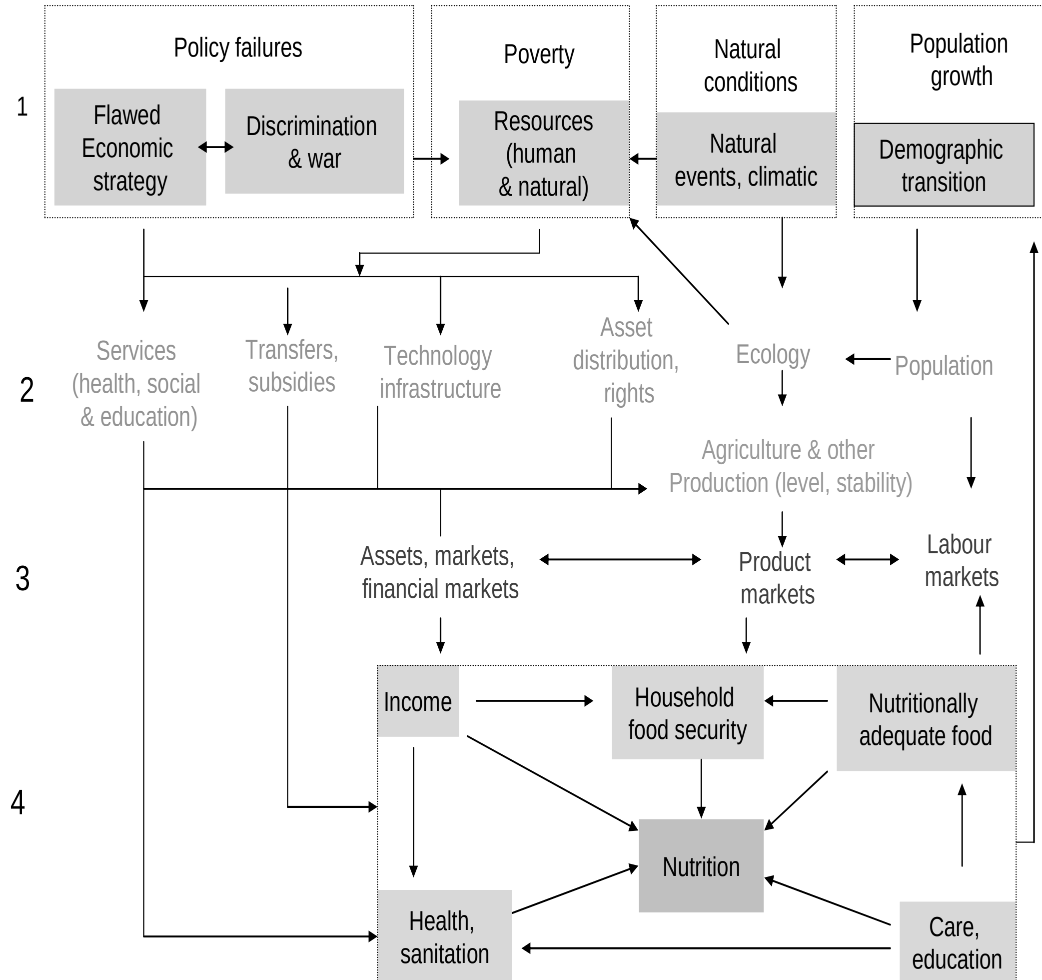
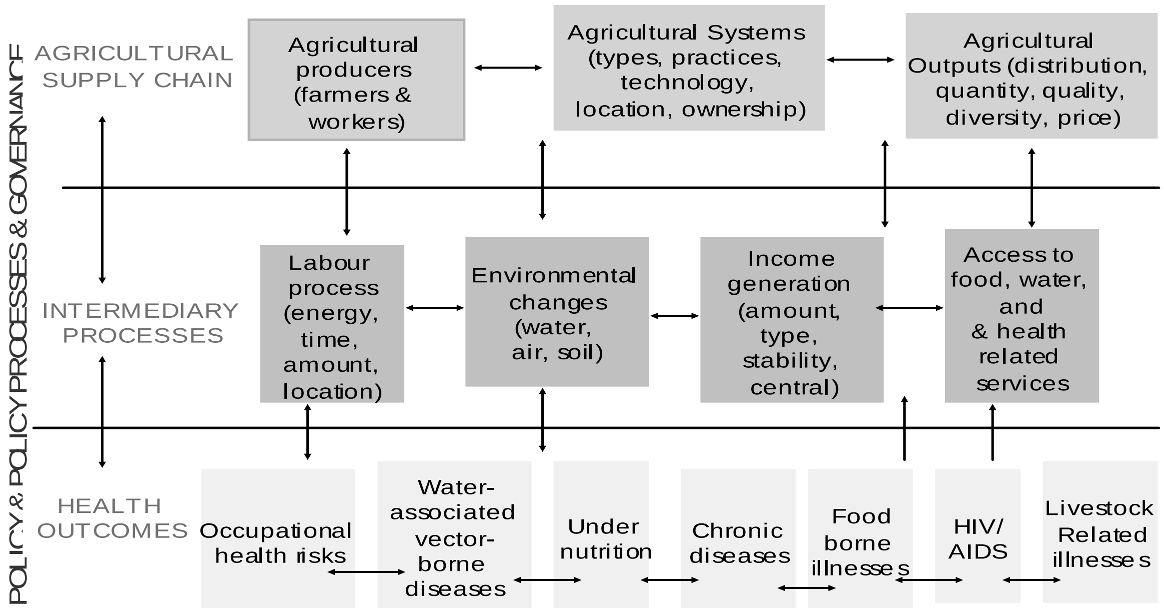


Figure 2.8 Determinants of nutrition security: basic causes and links. Source: FAO, 1996a.



Notes: (i). Basic causes; (ii). Structural/institutional conditions, areas of public action;
(iii). Market conditions; (iv) Micro-level conditions (household, intra-household, gender).

Figure 2.9 Linkages between agriculture and health. Source: Hawkes and Ruel, 2006.



Box 2.1 Timeline of genetic resource management.

10,000 years of agricultural history. Farmers as the generators & stewards of crop genetic resources (e.g conservation, selection, and management of open pollinated varieties)

1800s. Agricultural genetic resources – apart from plantation crops- not a policy issue, and valued and managed by farmers as a common good; First commercial seed companies (e.g. Sweden) and agricultural experiment stations in Germany and England; National school of agriculture founded in Mexico (1850s); Discoveries of Darwin and Mendel (re-discovered and applied in 1900 only). 1883 Paris Convention on patents (not applied to plants for a full century).

1910s. George Shull produces first hybrids (1916); Wheat rust resistance breeding program in India
1920s. First maize hybrids available; Vavilov collects crop genetic resources systematically and develops the concept of Centers of Diversity.

1930s. 1930 Plant Patent Act (USA) to cover plants that are reproduced asexually (e.g. apples and roses), excluding bacteria and edible roots and tubers (potato).

1940s. Bengal Famine 1943-1944; International Agricultural Research is conceived and funded; Rockefeller Foundation sets up research program on maize, wheat and beans with Mexican government. Breeder's rights laws develop in Europe.

1950s. Ford and Rockefeller Foundations place agricultural staff in developing countries. Mexico becomes self-sufficient in wheat as a result of plant breeding efforts. Watson and Crick describe the double helix structure of DNA and Coenberg discovered and isolate DNA polymerase which became the first enzyme used to make DNA in a test tube; Reinart regenerates plants from carrot callus culture - important techniques for genetic engineering. The National Seed Storage Laboratory (NSSl) was opened in USA.

1960s. South Asian subcontinent on the brink of famine - High Yielding Varieties (HYV) introduced. International Convention for the Protection of New Varieties of Plants (UPOV, 1961) providing a sui generis protection to crop varieties with important exemptions for farmers and breeders. Establishment of IRRI, CIMMYT, IITA, CIAT. Crop Research and Introduction Center established by the FAO in Turkey for the study of regional germplasm.

1970s. Public inbred lines disappear from USA. European Patent Convention states that plants and animals are not patentable. Further development of international agricultural research centers under the auspices of the CGIAR; IR8 (high-yielding semi dwarf rice) grown throughout Asia. Hybrid rice introduced in China. First recombinant DNA organism by gene splicing. Genentech Inc founded and dedicated to products based on recombinant DNA technology. First international NGOs focus on the seed sector (FAFI). Technical meetings on genetic resources organized by FAO.

1980s. First patents granted to living organisms by US courts. Large scale mergers in the seed sector. International funding for R&D begins to decline. Methods developed for Participatory Variety Selection and Plant Breeding as new institutional arrangement for breeding for development. (1985). Establishment of the FAO Commission on Plant Genetic Resources for Food and Agriculture (CPGRFA) and the FAO-International Undertaking (IU-PGRFA): Legally non-binding undertaking that confirms a 'heritage of mankind' principle over plant genetic resources and recognises Farmers' Rights. US EPA approved the release of the first GE tobacco plants.

1990s. Agrochemical, pharmaceutical, and seed companies merge into 'life science' companies; Major technological advances (e.g. marker assisted breeding, gene shuffling, genetic engineering, rDNA Technology, and Apomixis); Share of HYV increases to 70% for wheat and rice in selected developing countries. Acceleration towards consolidation of seed industry with agrochemical companies as main investors. Introduction of first commercial transgenic crops (e.g. Calgene's 'Flavr-Savr' tomato and herbicide and insect-tolerant crops); Gradual change in CIMMYT approach from selection in high input environments to include drought and nitrogen stress. Rate of funding of CGIAR stagnant – more NRM-focused centers established. Regions where agricultural R&D relies on donors are particularly hard-hit. IU-PGRFA recognizes national sovereignty over PGRFA in the wake of CBD. CBD as legally binding agreement among all countries (except USA and some tiny states in Europe) lays the foundation for bilateral negotiations over access and benefit sharing to genetic resources, including PGRFA. Cartagena Protocol seeks to regulate international movement of transgenics. Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) spurs a debate on plants and varieties in developing countries; European Patent Office moves to grant patents on plants (1999). UPOV 1978 treaty closed to new accessions. Latest UPOV Act prohibits farmers from sharing seed of protected varieties. Campaigns against strong IPRs in medical and agricultural research grow, notably against 'terminator technology.'

2000s. International Treaty on Plant Genetic Resources for Food and Agriculture (IT- IT-PGRFA) facilitating access and benefit sharing and defining Farmers' Rights; World Intellectual Property Organization member states set up an Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore. Developing countries join UPOV or develop their own *sui generis* protection (e.g. India, Thailand). Free Trade Agreements put pressure on developing countries for stronger than TRIPs protection. Over 180 transgenic crop events, involving 15 traits deregulated or approved in at least one of 27 countries. Top 10 companies control half of the world's commercial seed sales; however farmer-seed systems

Box 2.2 Historical limitations of CGIAR arrangements.

Formal on-station breeding programmers have historically resulted in homogenous varieties that favor uniform conditions, such as obtained with high inputs, rather than the low-input heterogeneous ecological clines that characterize the majority of small farmer's fields. The prevalence of pests, disease, and variability of climate and land requires a wide range of locally adapted heterogeneous varieties (Brush, 1991; Wolfe, 1992; Lenne and Smithson, 1994; Brouwer et al,. 1993). In many cases, small farmers have been economically constrained from using high-input varieties. For instance, in Zimbabwe, drought in the 1990s affected poorer farmers who had adopted hybrid maize, whereas richer farmers who had benefited from an early adoption of the varieties had diversified into cattle, leaving them better protected from drought shock. Weak performance of the hybrid maize under drought conditions left poor farmers poorer. Following early lessons, the CIMMYT program began to develop varieties in sub-Saharan Africa under conditions of low nitrogen input and drought (CIMMYT, 2002). Gender played a role in the adoption of new varieties, with women preferring open-pollinated traditional varieties disseminated by social networks, while the men preferred the improved varieties. Networks and social relationships have both facilitates and constrained technology dissemination (Meinzen-Dick et al., 2004).

Box 2.3 Emergence of TRIPs-Plus.

International IPR regimes under the TRIPS agreements of the WTO allow for flexibilities for plant varieties, which may be exempted from patentability under the condition that an effective *sui generis* protection is provided for. This flexibility has been introduced by UPOV member countries, and creates a broad option for developing countries to develop their own systems, often balancing the rights of breeders with those of farmers. However, bilateral and multilateral trade agreements with IPR components dubbed 'TRIPS-plus' often go far beyond the baseline of TRIPS standards, eclipsing the relative flexibility that was offered in TRIPS in favor of "harmonisation" at a more stringent, developed country IPR, level. For instance, TRIPS-plus regimes may force countries to join UPOV under the strict Act of 1991 or to allow patent protection on varieties. TRIPS-plus type regimes may take many forms and raise concerns about bypassing appropriate democratic decision making based on the interest of the national seed systems. Such Free Trade Agreements may be bilateral between regional regional blocks, such as in the EU or the Andean Community. In addition, the WIPO (World Intellectual Property Organization) is working to harmonise (i.e. strengthen) IPR globally, through the Substantive Patent Law Treaty (SPLT), raising concerns about development or conservation objectives

In the field of agriculture, the CBD was a groundbreaking assertion of national sovereignty over genetic resources. The sovereignty principal was to be implemented through prior informed consent and mutually agreed terms for access to genetic resources. Its implementation is through bilateral agreements between provider country and user.

Box 2-5. International Treaty on Plant Genetic Resources for Food and Agriculture (adapted Nov 2001, came into force June 2004).

Goals
1. Ensure access to and conservation of plant genetic resources.
2. Equitable sharing of benefit arising from agricultural genetic resources.

The treaty is a legally binding mechanism specifically tailored to agricultural crops, in harmony with the CBD. Creates multilateral system for access to genetic resources and benefit sharing, which is designed to lower transaction costs of exchanges of materials to be used for research, conservation and training. The International Treaty links benefit sharing to access from the MLS as a whole. A proportion of monetary benefits arising from commercialization of new PGRFA developed using material from the MLS (when others are restricted from using the new PGRFA even for research) will be paid into an international fund, ultimately controlled by the Governing Body of the Treaty. Funds will be used for programs such as conservation and research, particularly in developing countries. The monetary benefit sharing provisions are not triggered when new PGRFA are made freely available for research and breeding. 64 major food crops and forages are included within the MLS. The list could be expanded in the future, by consensus of the Governing Body.

Positive Results
• It appears to be well on its way to becoming a truly global Treaty, with an increasing number of countries ratifying or acceding to it.
• Specifically tailored for agricultural genetic resources.
• Regularizes access to genetic resources under a single uniform multilateral regime using a single fixed legal instrument for all transfers.
•Includes a benefit sharing clauses, triggered through commercialization of new PGRFA products that incorporated materials accessed from the MLS when those new products are not made available for further research
• Provides a permanent legal status for the *ex situ* collections of PGRFA hosted by the CGIAR Centres, placing the Centres Annex 1 holding within the MLS (and making the Centres' non-Annex 1 holdings available on very similar terms.)
• Recognizes the principal of Farmers Rights, and creates some momentum for countries to implement national laws to advance Farmers' rights.

Problems
• Significant crops are excluded from the Treaty, (including soybeans, groundnuts, tomatoes, tropical forages, onions, sugarcane, melons, grapes, cocoa, coffee). The rules applying to those crops is therefore uncertain, falling by default under whatever systems countries put in place to implement the CBD. Of course, additional species or genera can be included within the MLS with the consensus of the Governing Body.
• While a number of major industrial countries have ratified the Treaty, the USA still has not, and it not clear if or when it will do so.
• The SMTA adopted by the Governing Body in June 2006 is relatively long and relatively complex. It will take some time before the global community fully understands what it says and becomes comfortable using it. In the meantime, ancillary efforts will be necessary, probably lead by organizations that are going to be participants in the MLS and consequently, users of the SMTA, to raise awareness about the MLS, assist countries in developing legal and administrative frameworks to implement the Treaty, and build organizations' capacity and comfort level in participating in the MLS and using the SMTA.

Box 2-6. Emergence of genetic engineering.
Genetic engineering (GE) or genetic modification of crops (GM) has emerged as a major agricultural technology over the past decade, mainly in North America, China and Argentina. Soybeans, maize, cotton and canola constitute 99 percent of the world's acreage of GE crops (James, 2004). Although GE traits encompass several categories (pest and disease resistance, abiotic stress tolerance, yield, nutrition and vaccines), herbicide tolerance and insect resistance dominate the market. A controversial dialogue has emerged as to the role of GE technology in addressing agricultural problems. Whether farmers have realized benefits from GE crops is a matter of debate. GE technology is seen as not being scale neutral by some (Benbrook, 2004; Pemsl et al., 2005; Rosset, 2005), and in certain instances, GE crops have been shown to increase income distribution differentials within the agriculture sector, favoring the establishment of large holdings and increased farm size (see Santaniello, 2003; Pengue, 2005), However, there is also evidence that GE has benefited farmers (Huang et al., 2001; Ismael, 2001; Traxler et al., 2001; Huang et al., 2002a; Cattaneo et al., 2006). The impacts on pesticide use are debated, with some studies indicating reduced use of insecticides (Huang et al., 2003) and others indicating significant rise in herbicide use (USDA, 2000; Benbrook, 2004). New evidence of high insecticide use by Chinese growers of GE insecticidal crops (*Bt cotton)* has demonstrated that farmers do not necessarily reduce their insecticide use even when using a technology *designed for that purpose (*Pemsl et al., 2005). This illustrates the frequently documented gap between the reality of how a technology is used (taken up in a given social context) and its "in the box" design.

Globally, agricultural producers are reported as receiving 13% of the benefits of GE soya. In Argentina, soya producers received 90% of the benefits of GE soya, partly owing to weak IP protection (Qaim and Traxler, 2005) , hence greatly favoring the expansion of the technology in Argentina. However, this increasing reliance on a single technology in Argentina is causing ecological and social concerns (Benbrook 2004, Pengue 2005). Similarly, social, economic, political and cultural concerns have been raised in Asia, Africa and Latin America, as GMOs have been assessed for their impacts on poverty reduction, equity, food sovereignty (de Grassi, 2003; FOE, 2005, 2006). Meanwhile, the roles and contributions of public institutions, scientists, governments, industry and civil society are now beginning to be closely analyzed (de Grassi, 2003).

GE risk analysis has historically acknowledged the possibility of negative ecological effects from the deliberate or inadvertent releases of transgenes into the environment through pollen mediated gene transfer to weedy relatives of GM crops **(**Haygood et al., 2003) and horizontal gene transfer. For most crops grown under regulatory approval such as maize in the USA, the likelihood is negligible (Conner et al., 2003). In other cases, such as canola in Canada, low levels of levels of transgenic DNA have entered non-GM seed supplies (Friesen et al., 2003; Mellon and Rissler, 2004). There have also been cases of contamination of food supply chain with possible litigation against farmers for the non-intentional presence of transgenic DNA in their crops. This is likely to emerge as an even larger issue as pharmaceuticals are introduced into crops (Nature Biotechnology, 2004; Snow et al., 2005). Despite technical solutions to prevent such gene movement (e.g. controversial 'terminator technology' and limitation of transgenes to the chloroplast genome not carried in pollen) and traditional plant variety purity protocols no method is likely to be completely effective in preventing movement of transgenes (NRC, 2004).

GE R&D in developing countries is behind that of the developed world for a number of factors including: (i) private sector in the developed world holds much of the IPR; (i) weak patent protection resulting in low investment by the private sector; (ii) consumer resistance and governmental regulations affecting international trade in GM products and flow of germplasm; (iii) and rising costs of development that inhibit the private research (Huang et al., 2002b). The costs of regulatory compliance has been cited as the largest obstacle to release of commercial GE crops in many developing countries (Atanassov, 2004; Cohen, 2005) and even developed countries. In developed countries like the UK, where public opinion has been exposed to food safety crises like BSE, studies highlight the mixed feelings about GMOs. More broadly, citizens are concerned about the integrity and adequacy of present patterns of government regulation, and in particular about official 'scientific' assurances of safety. Better science is necessary but may never resolve the uncertainties about the effects of new technologies (ESRC, 1999).

Crops derived from GE technologies have faced a myriad of challenges stemming from technical, political, environmental, intellectual-property, biosafety, and trade-related controversies, none of which are likely to disappear in the near future. Advocates cite potential yield increases, sustainability through reductions in pesticide applications, use in no-till agriculture, wider crop adaptability, and improved nutrition (Huang et al., 2002b; Christou and Twyman, 2004). Critics cite environmental risks and the widening social, technological and economic disparities as significant drawbacks (Pengue, 2005). Concerns include gene flow beyond the crop, reduction in crop diversity, increases in herbicide use, herbicide resistance (increased weediness), loss of farmer's sovereignty over seed, ethical concerns on origin of transgenes, lack of access to IPR held by the private sector, and loss of markets owing to moratoriums on GMOs, among others. Finally, because new genetic technologies are not the only hurdle between resource-poor farmers and secure livelihoods (Tripp, 2000), GM technology can be only one component of a wider strategy including conventional breeding and other forms of agricultural research to provide a series of structural, regulatory, and economic evaluations that relate economic, political, and scientific context of GE crops to their region of adoption.

Box 2-7. Integrated Pest Management.

There are many diverse definitions of IPM; the internationally accepted FAO definition is “the careful consideration of a number of pest control techniques that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and safe for human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption of agroecosystems, thereby encouraging natural pest control mechanisms (FAO, 2002b, 2005b). Additional endorsement of the revised Code is reflected in the European Commission’s recent decision to include it in the forthcoming revision of the EU pesticides authorization directive 91/414, and to use it as the basis for proposing mandatory IPM for EU farmers by 2014.

Contrasting interpretations of IPM have emerged over the period, each with different emphases.
Toolbox IPM combines two or more tactics from an array of tools and is utilized primarily to optimize crop productivity (OTA, 1979; Cate and Hinkle, 1994). IPM is presented as a continuum of practices, with choices ranging from reliance mainly on prophylactic controls and pesticides to more biologically-intensive methods (USDA, 1993). The approach emphasizes a diversity of technical options, but not the integration of multiple tactics under a broader ecological framework and does not necessarily require monitoring or conservation of natural enemies (Ehler and Bottrell, 2000; Ehler, 2006; Gray and Steffey, 2007).

Integrated Pest/Pesticide Management. These programs focus primarily on the discriminate use of pesticides and improving the efficacy of pesticide applications (Ehler, 2006). The approach emphasizes pest monitoring and the use of less hazardous, lower dose and more selective pesticides, improved formulations, new application technologies, and resistance management strategies (CropLife, 2003; Syngenta, 2006). Industry IPM programs may also feature use of the manufacturers’ chemical products (Sagenmuller, 1999; Dollacker, 2000). Non-chemical approaches such as biocontrol are mentioned in some industry publications, but presented as “generally too often unreliable or not efficient enough to be commercially used on their own” (CropLife, 2003).

Biointensive IPM, also sometimes described as Preventative IPM (Pedigo, 1989, 1992; Higley and Pedigo 1993) and Ecological Pest Management (Altieri, 1987; Altieri and Nicholls, 2004), emphasize the ecological relationships among species in the agroecosystem (Shennan et al., 2005) and the availability of options to redesign the landscape and ecosystem to support natural controls (Dufour, 2001). Biological and ecological pest management offer robust possibilities to significantly and sustainably reduce pesticide use without affecting production (van Lenteren, 1992; Badgley et al., 2007; Scialabba, 2007). Implementation remains limited globally as it often requires structural changes in production systems (Lewis et al., 1997) and redirection of market, research, policy and institutional support to favor ecosystem-oriented approaches.

Indigenous pest management, based on detailed Indigenous technical knowledge (ethnoscience) of pest ecology, local biodiversity and traditional management practices, focuses on achieving moderate to high productivity using local resources and skills, while conserving the natural resource base (Altieri, 1993). Weeds, insects pests and crop pathogens are at times tolerated and provide important foods, medicines, ceremonial materials and soil improvers (Bye, 1981; Chacon and Gliessman, 1982; Brown and Marten, 1986). Control methods rely on a wide range of cultural, biological, physical and mechanical practices, water and germplasm management and manipulation of crop diversity (Altieri and Letourneau, 1982; Matteson et al., 1984; Altieri, 1985) and are supported by knowledge of the local agroecosystem and surroundings (Brush, 1983; Atteh, 1984; Richards, 1985). In Africa, farmers traditionally practice intercropping with various crops, which can drastically reduce pest densities, especially if the associated crop is a non-host of the target pest species (Khan et al., 1997; Schulthess et al., 2004; Chabi-Olaye et al., 2005; Wale et al., 2006), although farmers are not always aware of the beneficial effect that mixed cropping has on pest infestations (Nwanze and Mueller, 1989). Partnerships between formally trained scientists and farmers skilled in ethnoscience show promise for strengthening agroecological approaches (Altieri, 1993).

Box 2-8. Biological control.

Biological control refers to the use of natural enemies of pests (i.e. their predators, parasitoids and pathogens) as pest control agents. Globally, the annual economic contribution of natural enemies has been estimated in the hundreds of billions of dollars worldwide (Costanza et al., 1997; Naylor and Ehrlich, 1997; Pimentel, 1997; Pimentel et al., 1997; Gurr and Wratten, 2000; Alene et al., 2005; Losey and Vaughan, 2006). Biological control provides natural enemies with suitable habitats and resources (Doutt and Nakata, 1973; Jervis et al., 1993; Kalkoven, 1993; Idris and Grafius, 1995; Murphy et al., 1998; Ricketts, 2001; Gurr et al., 2006) and limits use of disruptive pesticides. Since these approaches are locally adapted, they rarely produce products that can be widely marketed and have attracted little interest from the private sector. Yet they form the cornerstone of much ecological pest management (Altieri and Nicholls, 2004). Farmers and public sector scientists have demonstrated practical applications in, e.g. the Biologically Integrated Orchard Systems (BIOS) of California (Thrupp, 1996), vineyard habitat management (Murphy et al., 1998), and rice ecosystem conservation (Settle et al., 1996).

The importance of natural enemies is highlighted by the often explosive outbreaks of pests introduced into regions where they lack specific natural enemies. Classical biological control restores natural pest management by the identification and introduction of specific and effective natural enemies from the pest's home region (DeBach, 1964, 1974). Dramatic early successes in the late 19th century (cottony cushion scale in citrus, Caltagirone and Doutt, 1989) spurred classical biocontrol efforts around the world, but these methods were later displaced by the widespread adoption of cheaper and fast-acting synthetic pesticides. Under pressure to deliver fast results, entomologists economized on ecological studies and began releasing potential biocontrol agents prematurely with less success (Greathead, 2003). Confidence in biocontrol declined, until problems arising from pesticide use re-kindled interest (Perkins, 1982). With better institutional support and funding, the success rate improved (Greathead, 2003). Initially, work in developing countries focused on large scale commercial, industrial and export tree crops with less direct impact on small-scale farmers (Altieri, et al., 1997). Subsequent programs focused on staple food crops and on building indigenous capacity in biocontrol (Thrupp, 1996).

Institutional arrangements fostering collaboration enabled the scientific and technological processes associated with classical biocontrol in subsistence crops in Africa to provide a range of social, environmental, economic and cultural benefits (Norgaard, 1988; Zeddies et al., 2001; Bokonon-Ganta et al., 2002; de Groote et al., 2003; Neuenschwander et al., 2003; Moore, 2004; Macharia et al., 2005; Maredia and Raitzer, 2006; Omwega et al., 2006; ICIPE, 2006; Kipkoech et al. 2006; Macharia et al, 2007; Löhr et al., 2007). A noteworthy example is the control of cassava mealybug (Herren and Neuenschwander, 1991; Gutierrez et al., 1998; Neuenschwander, 2001, 2004). Follow-on effects included extensive training of African scientists in biocontrol and the establishment of national programmes targeting invasive insect and weed pests across the region (Herren and Neuenschwander, 1991; Neuenschwander et al., 2003). Technical and administrative staff played a key role in designing and maintaining complex networks of collaboration (Wodageneh, 1989; Herren, 1990; Neuenschwander, 1993; Neuenschwander et al., 2003).

Ecologists have raised concerns regarding potential impacts on non-target organisms of introduced biocontrol agents (Howarth, 1990; Simberloff and Stiling, 1996; Strong, 1997). However, after several early failures due to vertebrate and mollusc predator introductions in the late 19th-early 20th century (Greathead, 1971), the safety record of invertebrate biocontrol has become well established (Samways, 1997; McFadyen, 1998; Wilson and McFadyen, 2000; Wajnberg et al., 2001; Hokkanen and Hajek, 2003; van Lenteren et al., 2003). A substantial body of research has investigated nontarget effects of classical biological control (Boettner et al., 2000; Follett and Duan, 2000) and rigorous screening protocols and methodologies for environmental risk assessment of biocontrol agents now exist (Hopper, 2001; Strong and Pemberton, 2001; Bigler et al., 2006). FAO, CABI BioScience and the International Organization of Biological Control have developed a Code of Conduct for the Import and Release of Biological Control Agents to facilitate their safe import and release (Waage, 1996; IPPC, 2005).

In contrast to classical biocontrol, augmentation involves mass production of naturally-occurring biocontrol agents to reduce pest pressure (DeBach, 1974; Bellows and Fisher, 1999). The decentralized artisanal biocontrol centers of Cuba offer one model of low-cost production for local use (Rosset and Benjamin, 1994; Altieri et al., 1997; Pretty, 2002). Augmentative control in Latin American field crops (van Lenteren and Bueno, 2003) and throughout the European glasshouse system (Enkegaard and Brodsgaard, 2006) offer others. Growing consumer interest in pesticide-free produce has helped establish a small but thriving biocontrol industry (van Lenteren, 2006), mostly in industrialized countries (Dent, 2005), with some uses in developing countries where pesticide use is difficult or prone to trigger pest outbreaks (i.e. sugarcane, cotton and fruit trees). The costs of production, storage and distribution of living organisms have made these products less attractive to the private sector than chemical pesticides; currently they comprise only 1-2% of global chemical sales (Gelertner, 2005). Their relatively limited use also reflects chronic under-investment in public sector research and development of biological products and a regulatory system that disadvantages biological alternatives to chemicals (Waage, 1997). Biological pesticides, on the other hand, have been more successful because they fit into existing systems for pesticide development and delivery. Nevertheless, the growth of the global market for biocontrol products, recently at 10-20% per annum, is expected to continue (Guillon, 2004), and is most likely to play a key role in crop systems where pesticide alternatives are required.

Opportunities and constraints. Successful biocontrol systems have required public sector investment, political commitment to maintain and adequately finance research, breeding and release programs, close collaboration between technical and regulatory agencies and donors at national and regional levels, and minimal pesticide use to create a safe environment for biocontrol agents (Neuenschwander, 1993, Neuenschwander et al., 2003; Maredia and Raitzer, 2006; Omwega et al., 2006). Where such commitments have existed (Western Europe; Kazakhstan, post-Soviet Cuba, many countries throughout Africa), biocontrol programs have been important contributors to agricultural production and national food security (Greathead, 1976; van Lenteren et al., 1992; Rosset and Benjamin, 1994; Pretty, 1995; Neuenschwander, 2001; Omwega et al., 2006; Sigsgaard, 2006; van Lenteren, 2006).

Biological control has provided effective control of pests in many cropping systems, while maintaining high agricultural production (DeBach 1964; DeBach and Rosen, 1991; Bellows and Fisher, 1999; Gurr and Wratten, 2000). Yet public sector investments, institutional support for research and practical applications have been uneven over the period, reflecting shifting priorities of dominant institutional arrangements (NRC, 1989; Cate and Hinkle, 1994; Jennings, 1997; Greathead, 2003; Hammerschlag, 2007). Substantial taxonomic, biological and ecological knowledge is crucial to support successful biocontrol (Pennisi, 2003; Herren et al., 2005), but these fields have been neglected in many research institutions (Jennings, 1997; Kairo, 2005). Greater public and private sector investment in institutional capacity could increase the ability of farmers, extension staff, scientists, policy makers and the food sector to capitalize on opportunities afforded by biocontrols (Neuenschwander, 1993; Waage, 1996; Williamson, 2001; van Lenteren 2006; Hammerschlag, 2007).

Global challenges for biocontrol include a possible growth in exotic pest problems due to globalization and climate change and the threat posed by degraded agricultural and natural ecosystems to maintaining natural enemy communities. The Convention on Biological Diversity raises important conceptual and practical issues for biocontrol: how to develop capacity and ensure safe and equitable sharing of resources, research and benefits among actors and countries (Waage, 1996). Natural enemies have previously demonstrated capacity to adapt to changing climates encountered in expanding their geographic range (Tribe, 2003) and to control invasive species (van Driesche and Hoddle, 2000; Greathead, 2003) in a safe and sustainable manner. These attributes, along with the imperative to reduce pesticide contamination of drinking water supplies, suggest that biological control will play an increasingly important role in future pest management practices.

Box 2-9. Policy instruments affecting pest management.

Many national, regional and international policies and agreements have focused on phasing out the most toxic pesticides, increasing public availability of information on pesticide bans and restrictions, and promotion of least toxic sustainable alternatives such as IPM. They include:

National regulatory instruments, policies and programs:

- Pesticide registration legislation, pesticide subsidies, use taxes and import duties; establishment of Maximum Residue Levels (MRLs)
- Pesticide use, residue and poisoning databases; Pesticide Use Reduction programs and Organic Transition Payments (Baerselman, 1992; Imbroglini, 1992; Blobaum, 1997; Reus and Leendertse, 2000; Jensen and Petersen, 2001; Chunyanuwat, 2005)
- National IPM extension programs (Briolini, 1992; Huus-Bruun, 1992; van Lenteren, 1992; FAO, 2005b)

Regional initiatives and frameworks (some examples):

- OECD/DAC Guidelines on Pest and Pesticide Management prioritize IPM and improved pesticide management, with formats for industry data submission and governmental pesticide evaluation reports (OECD, 1995). The OECD has also initiated a Risk Reduction project (OECD, 2006b).
- The European Commission's "thematic strategy" provides a policy framework to minimize hazards and risks of pesticide use (EC, 2006) filling a regulatory gap in the pesticide cycle between the before-use (product approval) and after-use (impact) stages.
- North American Commission on Environmental Co-operation (NACEC) of NAFTA has established a Sound Management of Chemicals Working Group which has developed action plans to reduce use of specific pesticides (http://www.cec.org/).
- Permanent Inter-State Committee for Drought in the Sahel (CILSS) regional convention to support collaborative management and regulation of pesticides (http://80.88.83.202/dbinsah/index.cfm?lng=en&sect1=avant1&id=28)

International agreements and treaties:

- *The UN Food and Agriculture Organization (FAO) International Code of Conduct on the Distribution and Use of Pesticides* (agreed in 1985 and revised in 2002) sets voluntary standards for the management and use of pesticides and provides guidance for the development of national pesticide legislation (FAO, 2005a; http://www.fao.org/ag/AGP/AGPP/Pesticid/Code/PM_Code.htm). FAO is updating its guidelines on pesticide labelling (FAO, 1995e) to include the UN Globally Harmonized System of chemical classification and labelling (FAO, 2006b) and is working with governments and commercial actors to phase out highly toxic pesticides (FAO, 2006ab, 2007).
- *The Rotterdam Convention on Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade* (1998) requires that exporting countries provide notification to importing countries of bans and restrictions on listed pesticides (http://www.pops.int/). By 2006, 107 countries had ratified PIC.
- *The Stockholm Convention on Persistent Organic Pollutants (POPs*), signed in 2001, provides phaseout plans for an initial twelve pollutants—nine of them pesticides—and defines a process for adding new chemicals such as endosulfan, lindance and chlordecone to the list (http://www.pops.int/). By 2006, 126 countries had ratified the POPs treaty. The non-governmental International POPs Elimination Network (IPEN) works alongside the POPs treaty process.
- *The Montréal Protocol (1987)* mandates the phasing out of the ozone-depleting pesticide, methyl bromide http://ozone.unep.org/). The Methyl Bromide Action Network, a coalition of environmental, agriculture and labor organization, was established in 1993 to assist governments in the transition to affordable, environmentally sound alternatives.
- *Intergovernmental Forum on Chemical Safety (1994)* is a WHO sponsored mechanism to develop and promote strategies and partnerships on chemical safety among national governments, intergovernmental and non-governmental organizations (http://www.who.int/ifcs/en/) . The *Inter-Organization Programme for the Sound*

Box 2-10. Evolution of the term food security.

Food security [is] a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. (FAO, The State of Food Insecurity 2001)

Food sovereignty is defined as the right of peoples and sovereign states to democratically determine their own agricultural and food policies.

The term food security originated in international development literature in the 1960s and 1970s (Ayalew, 1997, Stringer, 2000; Ganapathy et al., 2005; Windfuhr and Jonsén, 2005) and public interest in global and domestic food security grew rapidly following the oil crisis and related food crisis of 1972-74 (Saad, 1999; Stringer, 2000; Clover, 2003), the subsequent African famine of 1984-85, and emergence of growing numbers of food banks in developed nations. Food security is a term with many definitions, each used differently in international, national and local contexts1 (Ganapathy et al., 2005). Early definitions of food security focused on aggregate food supplies at national and global levels (Clover, 2003). Over time the concept evolved and expanded to integrate a wide range of food-related issues reflecting the complexity of the role of food in human society. Much of the paradigm shift of the concepts and definitions of food security over the years can be attributed to NGO and civil societies' movements in the early 1990s that led to the birth of the concept food sovereignty.

Box 2-11. Food-borne illnesses: Trends and costs.

- Contaminated food contributes to 1.5 billion cases of diarrhea in children each year, resulting in more than three million premature deaths (WHO, 1999), in both developed and developing nations. One person in three in industrialized countries may be affected by food-borne illness each year. In the US foodborne diseases cause approximately 76 million illnesses annually among the country's 294 million residents resulting in 325,000 hospitalizations and 5,000 deaths (Mead et. al., 1999). Between 1993 and 2002, 21 Latin American and Caribbean countries reported 10,400 outbreaks of food- and waterborne illness causing nearly 400,000 illnesses and 500 deaths (CSPI, 2005).

- In 1995, the US experienced between 3.3–12 million cases of food-borne illness caused by seven pathogens costing approximately US $6.5–35 billion in medical care and lost productivity (WHO, 2002a).
- In the European Union, the annual costs incurred by the health care system as a consequence of Salmonella infections alone are estimated to be around EUR €3 billion (BRF, 2004).
- In the UK, care and treatment of people with the new variant of Creutzfeldt-Jakob disease (vCJD) are estimated to cost about £45,000 per case from diagnosis and a further £220,000 may be paid to each family as part of the government's no-fault compensation scheme (DHC, 2001). The range of economic impacts to the UK is from £2.5 to £8 billion, (Mathews, 2001).
- Analysis of the economic impact of a Staphylococcus aureus outbreak in India (Sudhakar, et. al., 1988) showed that 41% of the total cost of the outbreak was borne by the affected persons, including loss of wages or productivity and other expenses.
- Because of an outbreak of Cyclospora in Guatemalan raspberries in 1996 and 1997 the number of Guatemalan raspberry growers has decreased dramatically from 85 in 1996 to three in 2002.
- Realization of existence of BSE in cattle population in the US and Canada resulted in losses of $2.6 billion and $5 billion in beef exports in 2004 in the USA and Canada respectively.
- Meanwhile a new category of risks has emerged, of which BSE, genetically modified organisms (GMOs), and zootic diseases such as avian flu, are among the most prominent. The routes through which these risks may affect nature and society are more complex, less 'visible' and less detectable than 'conventional' risks, and are often highly dissociated over space and time (Mol and Bulkley, 2002).

Box 2-12. Common microbiological contaminants in food.

In Latin America, the most frequent bacterial agents involved were Salmonella spp. (20% of the reported outbreaks) (FAO/WHO, 2004), Staphylococcus aureus, and Clostridium perfringens (CSPI, 2005). Another pathogen, Escherichia coli O157:H7, has increased dramatically in Central and South America. Argentina has one of the highest incidences of HUS -- a serious complication of E. coli infection -- especially in the pediatric age group (CSPI, 2005).

Food items most commonly associated with the reported outbreaks were fish/seafood (22%), water (20%) and red meats (14%) (CSPI, 2005). Examples include a major E. coli O157:H7 outbreak in Japan linked to sprouts involving more than 9,000 cases in 1996, and several recent Cyclospora outbreaks associated with raspberries in North America and Canada, and lettuce in Germany (Bern et. al., 1999; Hodeshi et. al., 1999; Döller et al., 2002). In 1994, an outbreak of salmonellosis due to contaminated ice cream occurred in the USA affecting an estimated 224,000 persons. In 1988, an outbreak of hepatitis A, resulting from the consumption of contaminated clams, affected some 300,000 individuals in China (Halliday et al., 1991). In 2005 in Finland, the most common cause of food and water-borne food poisonings was noro-virus (EVIRA, 2006). A 1998 outbreak of Nipah virus typically associated with pigs and pork (WHO, 2004) killed 105 people in Malaysia. The parasitic disease trichinellosis is increasingly reported in the Balkan region among the non-Muslim population, owing in part to the consumption of pork products processed at home without adherence to mandatory veterinary controls.

Box 2-13. Chemical contamination of food: a few examples.

- Mercury. As many as 630,000 children are born each year exposed to mercury in the womb (Ahmed, 1991).
- Non-persistent organic compounds: In Spain in 1981-1982, contaminated rapeseed oil de-natured with aniline killed more than 2,000 people and caused disabling injuries to another 20,000 - many permanently (CDCP, 1982).
- Pesticide residues: The latest European monitoring of pesticide residues in food found 4.7% of all samples exceeding the legal threshold of pesticide residues in food and almost half of all samples had detectable levels of pesticide residues (EC, 2006); Viet Nam reports a high burden of disease associated with pesticide residues (Nguyên and Dao, 2001).
- Accidental pesticide poisonings: In India, in July 1997, 60 men were poisoned by eating pesticide-contaminated food at a communal lunch (Chaudry et al., 1998); in Tauccamarca, Peru, 24 children died in October 1999, after consuming a powdered milk substitute contaminated by the organophosphate pesticide methyl parathion, and 18 others suffered neurological damage (Rosenthal, 2003); in the Philippines, carbamate poisoning killed 28 schoolchildren and caused vomiting and diarrhea spells in 77 others in March, 2005 (Neri, 2005);
- Deliberate poisoning: In China, in 2002, more than 200 school children sickened and 38 died when rat poison was used to intentionally contaminate bakery products. (CNN, 2002).
- Naturally-occurring toxins: The chronic incidence of aflatoxin in diets is evident from the presence of aflatoxin M1 in human breast milk in Ghana, Nigeria, Sierra Leone, and Sudan and in umbilical cord blood samples in Ghana, Kenya, Nigeria, and Sierra Leone. Together with the hepatitis B virus, aflatoxins contribute to the high incidence of primary liver cancer in tropical Africa. Moreover, children exposed to aflatoxins may experience stunted growth or be chronically underweight and thus be more susceptible to infectious diseases in childhood and later life. (CSPI, 2005)
- Growth hormone: The EU banned the use of growth hormones in livestock in 1988 but the practice still continues in the US, Canada and in Australia.
- Dioxin: Exposure to dioxin causes serious adverse health effects, and remains a major public health concern in Europe, the United States and elsewhere (Schecter et al., 2001; NAS, 2003).

Box 2-14. Via Campesina's food sovereignty principles. Source: Windfuhr and Jonsén, 2005.

1. Food: A Basic Human Right – Everyone must have access to safe, nutritious and culturally appropriate food in sufficient quantity and quality to sustain a healthy life with full human dignity. Each nation should declare that access to food is a constitutional right and guarantee the development of the primary sector to ensure the concrete realization of this fundamental right
2. Agrarian Reform – A genuine agrarian reform is necessary which gives landless and farming people – especially women – ownership and control of the land they work and returns territories to indigenous peoples. The right to land must be free of discrimination on the basis of gender, religion, race, social class or ideology; the land belongs to those who work it.
3. Protecting Natural Resources – Food Sovereignty entails the sustainable care and use of natural resources, especially land, water, and seeds and livestock breeds. The people who work the land must have the right to practice sustainable management of natural resources and to conserve biodiversity free of restrictive intellectual property rights. This can only be done from a sound economic basis with security of tenure, healthy soils and reduced use of agrochemicals.
4. Reorganizing Food Trade – Food is first and foremost a source of nutrition and only secondarily an item of trade. Food imports must not displace local production nor depress prices;
5. Ending the Globalization of Hunger –The growing influence of multinational corporations over agricultural policies has been facilitated by the economic policies of multilateral organizations such as the WTO, World Bank and the IMF. Regulation and taxation of speculative capital and a strictly enforced Code of Conduct for Trans-National-Corporations is therefore needed;
6. Social Peace – Everyone has the right to be free from violence. Food must not be used as a weapon. Increasing levels of poverty and marginalization in the countryside, along with the growing oppression of ethnic minorities and indigenous populations, aggravate situations of injustice and hopelessness. The ongoing displacement, forced urbanization, repression and increasing incidence of racism of smallholder farmers cannot be tolerated; and
7. Democratic control – Small-scale farmers must have direct input into formulating agricultural policies at all levels. The United Nations and related organizations will have to undergo a process of democratization to enable this to become a reality. Everyone has the right to honest, accurate information and open and democratic decision-making. These rights form the basis of good governance, accountability and equal participation in economic, political and social life, free from all forms of discrimination. Rural women, in particular, must be granted direct and active decision making on food and rural issues.

Box 2-15. Definitions of organic agriculture.

- *IFOAM:* 'Organic agriculture includes all agricultural systems that promote the environmentally socially and economically sound production of food and fibers. These systems take local soil fertility as a key to successful production. By respecting the natural capacity of plants, animals and the landscape, it aims to optimize quality in all aspects of agriculture and the environment. Organic agriculture dramatically reduces external inputs by refraining from the use of chemo-synthetic fertilizers, pesticides and pharmaceuticals. Instead it allows the powerful laws of nature to increase both agricultural yields and disease resistance'

- *FAO/WHO Codex Alimentarius Commission:* Organic agriculture is a holistic production management system which promote and enhances agro-ecosystem health, including biodiversity cycles and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs. This is accomplished by using where possible, agronomic, biological, and mechanical methods as opposed to using synthetic materials to fulfill any specific function within the system.