Global Chapter 2

Tables, Boxes, Figures

Table 2.1. Roles of agriculture (adapted from FAO-ROA project)

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 res. institutions	*social and economic:* consumer demand *trade:* international trade agreements *economic:* cheap energy; externalization of health and environmental costs
industrial ag. 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 ag. 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 -- export-led growth	*economic and policy:* post-colonial drive for food self-sufficiency *cognitive:* faith in rational sci. & 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 agric. 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 through e.g., Farmer Field Schools; documentation and dissemination of local knowledge; Cuba's model of centers to reproduce biological pest control agents North: producers' organizations, independent R&D institutions networking among producers government funding for research on organic and sustainable farming	South: *social:* social capital, collective effort *economic:* high cost of external inputs; negative impact on yields of high input ag. *policy:* sustainability *cognitive:* farmer concern with resource / ecosystem damage *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 ag. 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	South : *globalisation and investments:* international organisations (IFOAM) *cognitive:* farmer and researcher recognition of externalities of high external input ag. North: *cognitive and social:* recognition of negative environmental effects of high input ag., and problems face by family farms *globalization and trade:* disease outbreaks leading to trade restrictions *institutional:* rise of Green movements and political parties

Table 2.4. Main SS NARS characteristics

Farmers´ Role	Very responsive to opportunity, increasing input use, effort and output where market opportunity has opened up; in indigenous crops, yield per ha and per unit of labour in general outperforms world averages; resource management has improved in many cases as pop densities have increased; farmers have proven superbly capable of innovating new farming systems in response to changing contexts.
Drivers	Maladministration and government priorities, wars, drought, civil unrest; increasing population density in absence of market opportunity; and recently, HIV/AIDs; as a result of colonial histories, growing drought susceptible crops, such as wheat and maize, in drought prone areas.
Critical restraining elements in market opportunity	Internal transport costs and low value-to-weight ratios of commodities; negative internal terms of trade; trade & production subsidies in countries exporting to Africa; patterns of population settlement.
Consequences	African agriculture has underperformed, but not nearly as badly as the agricultural statistics -which are very poor for roots and tubers and for many indigenous small grains- and collapse of NARs would indicate. Agricultural research in Africa has had reasonable pay-offs (e.g. NERICA rice, which was introduced on the back of replication of Participatory Varietal Selection effort at local levels throughout West Africa,), attention has been given to the strong gender organization of labor and roles and to gender preferences;. Contrarily, where this has been neglected, uptake of technologies has been dismally low.

Table 2.5. Constraints of university arrangements.

Funds	Universities have to share budgetary allocations with other public sector for agricultural research. In Latin America, for example, expenditure per researcher diminished strongly in the eighties, 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 multi-disciplinary, while most university departments are disciplinary. Research –specially in the agricultural colleges in comprehensive universities- produces fundamental knowledge under high standards of rigor focused on "manageable" (well defined) or "technical problems", not always pertinent to social immediate needs. Teaching follows the same disciplinary pattern, moving from simple units to complex ones in five to six year programs or more. The chair-model system provides little latitude for interdisciplinary or multidisciplinary work. Not much room for social sciences and humanities, 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 on 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 developed 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. So change is sometimes cosmetic.
Enrollment and graduate rates	Enrollment of agricultural students is today very low if 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 American countries where agriculture is a major source of income, employment and export earnings, and thus critical to alleviating rural poverty and safeguarding natural resources, graduates percent is very 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 trained in agriculture due to factors deeply rooted in the gendered nature of culture and society. Then they are less employed or self-employed than men. But 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 2.6. Public-private partnerships in the CGIAR.

Partnership Approach Research Topic	CGIAR Center(s)	Private Sector Partners	Other Partners
Collaborative Research-Global Programs			
Apomixis	CIMMYT	Pioneer Hi-brid (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]	

From (Spielman and von Grebmer, 2004)
[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 2.7: Agricultural and food revolutions and their implications for food-related health

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 mal-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)

Table 2.8. Number of contraventions cited for United States Food and Drug Administration Import Detentions and their Relative Importance for the Period July 1996 to June 1997.

Origin **Reason for contravention**	**Africa**	**Latin America and the Caribbean**	**Europe**	**Asia**	**Total**
Food Additives	2 *(0.7 %)*	57 *(1.5 %)*	69 *(5.8 %)*	426 *(7.4 %)*	554 *(5.0 %)*
Pesticide residues	0 *(0.0)*	821 *(21.1 %)*	20 *(1.7 %)*	23 *(0.4 %)*	864 *(7.7 %)*
Heavy Metals	1 *(0.3)*	426 *(10.9 %)*	26 *(2.2 %)*	84 *(1.5 %)*	537 *(4.8 %)*
Mould	19 *(6.3 %)*	475 *(12.2 %)*	27 *(2.3%)*	49 *(0.8 %)*	570 *(5.1 %)*
Microbiological contamination	125 *(41.3 %)*	246 *(6.3 %)*	159 *(13.4 %)*	895 *(15.5 %)*	1425 *(12.8 %)*
Decomposition	9 *(3.0 %)*	206 *(5.3 %)*	7 *(0.6 %)*	668 *(11.5 %)*	890 *(8.0 %)*
Filth	54 *(17.8 %)*	1253 *(32.2 %)*	175 *(14.8 %)*	2037 *(35.2 %)*	3519 *(31.5 %)*
Low Acid Canned Food	4 *(1.3 %)*	142 *(3.6 %)*	425 *(35.9 %)*	829 *(14.3 %)*	1400 *(12.5 %)*
Labelling	38 *(12.5%)*	201 *(5.2%)*	237 *(20.0%)*	622 *(10.8%)*	1098 *(9.8%)*
Other	51 *(16.8 %)*	68 *(1.7 %)*	39 *(3.3 %)*	151 *(2.6 %)*	309 *(2.8 %)*
Totals	303 *(100 %)*	385 *(100 %)*	1184 *(100 %)*	5784 *(100 %)*	11166 *(100 %)*

Source FAO (1999)

Table 2.9 Microorganisms most commonly associated with food-borne illness and examples of foods that are typical vehicles for those illnesses.

CAUSE	FOODS MOST OFTEN ASSOCIATED WITH THE PROBLEM
BACTERIA	
Bacillus cereus	Reheated cooked rice, cooked meats, starchy puddings, vegetables and fish. Improper handling after cooking is a common feature of foods causing B. cereus associated food-borne illness.
Clostridium perfringens	Reheated foods including buffet dishes, cooked meat and poultry, beans, gravy, stews and soups.
Clostridium botulinum	Improperly canned (home preserved) foods such as vegetables, fish, meat and poultry.
Escherichia coli (E.coli)	Salads and raw vegetables, undercooked meat, cheese, unpasteurised milk.
Campylobacter jejuni	Raw milk, poultry.
Listeria monocytogenes	Unpasteurised milk and milk products such as soft cheeses, raw meat, poultry, seafood, vegetables, paté, smoked meat and fish, coleslaw.
Salmonella	Undercooked poultry, meat, shellfish, salads, eggs and dairy products.
Staphylococcus aureus	Ham, poultry, eggs, ice-cream, cheese, salads, custard and cream-filled pastries and gravies, are the most common sources. Improper handling of food or poor hygiene could help S.aureus spread into food.
Vibrio parahaemolyticus and other marine Vibrio	Raw and undercooked fish and shellfish.
PARASITES	
Trichinella spiralis	Undercooked pork or game.
Toxoplasma gondii	Undercooked meat and poultry and raw milk.
VIRUSES	
Hepatitis A virus	Shellfish, raw fruits and vegetables can be the uncommon cause of hepatitis A. Hepatitis A can be spread by contaminated food handlers inadvertently transferring the virus to the food they handle.

Table 2.10 : Food security policy options.

Policy by category	Policy	Potentially affected by trade policy on:
Food production (production entitlements)	1. Input credit	Domestic subsidies
	2. Subsidised or free inputs	Domestic subsidies
	3. Research and extension	Tariffs (revenue)
	4. Capital expenditure and investment promotion	Domestic subsidies
	5. Land reform	—
Marketing (trade entitlements)	1. Market development and regulation	—
	2. Parastatal reform	State trading enterprises
	3. Food price stabilisation (buffer stocks)	Domestic subsidies (including Green Box conditions on buffer stocks/funds) Export regulation
	4. Food price stabilisation (buffer funds)	Tariffs, Green Box conditions on buffer stocks/funds
Labour (labour entitlements)	1. High-value export crops	Developed country market access Domestic subsidies
	2. Small- and medium-enterprise development	—
	3. Micro-finance	—
	4. Minimum wages	Process criteria
Transfers and safety nets (transfer entitlements)	1. Labour-intensive public works programmes	Export subsidies
	2. Targeted feeding programmes	Export subsidies
	3. Food stamps	Export subsidies
	4. Food price subsidies	Domestic subsidies

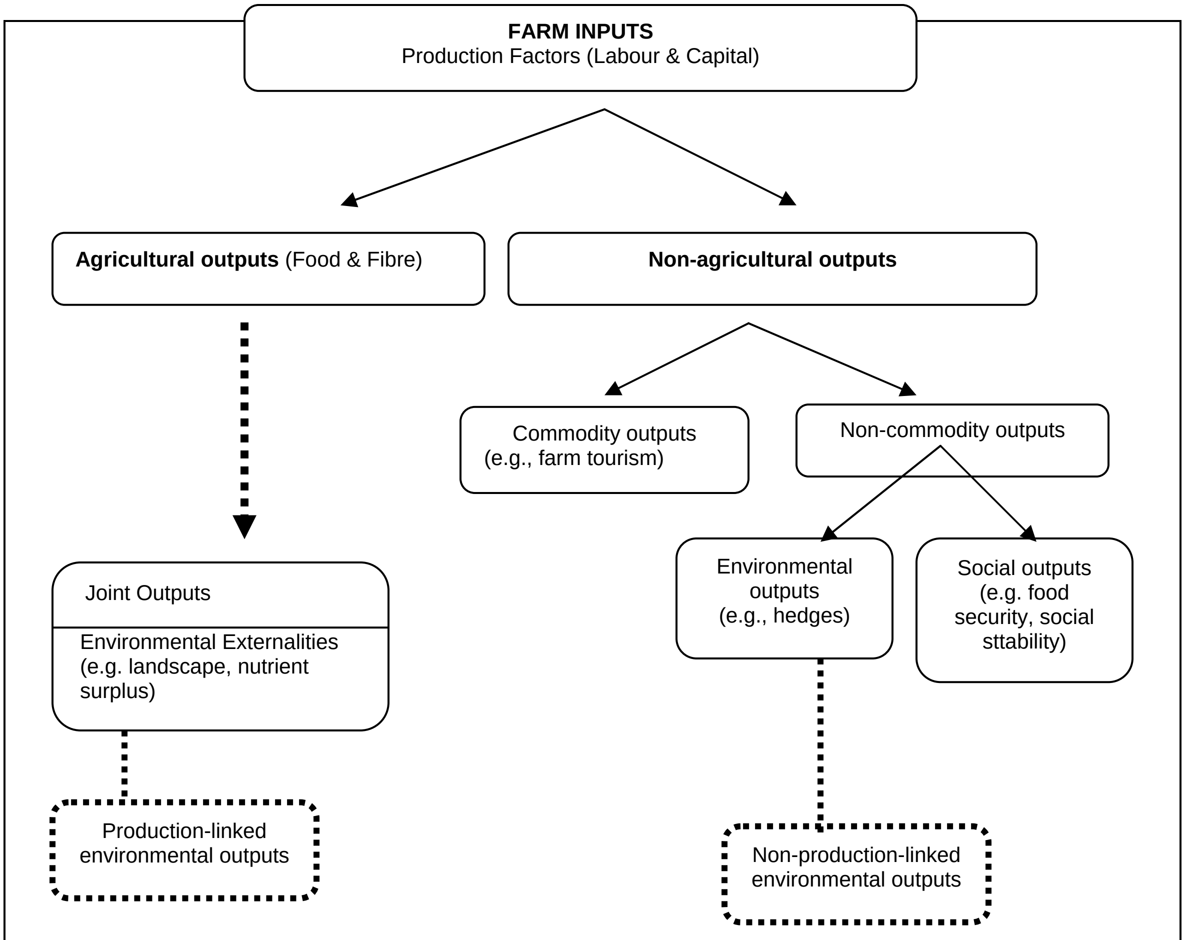
Source : Stevens, C., Devereux, S., Kennan, J., 2003. International Trade, Livelihoods and Food Security in Developing Countries. IDS Working Paper 215, December

Table 2.11: Overview of the core documents on food sovereignty statements and declarations

Date of publication	*Title*	*Author/location*
April 1996	'Tlaxcala Declaration of the Via Via Campesina	Tlaxcala, Mexico Campesina'
	'The right to produce and the access to land. Food Sovereignty:	Via Campesina, Rome, Italy
November 1996	A Future without Hunger'	Rome, Italy
November 1996	'Profit for a few or food for all'	'WTO – Shrink or Sink!'
	Our World is Not for Sale Network	
March 2000	'End Hunger! Fight for the Asian regional Consultation, Right to Live'	Bangkok, Thailand
August 2001	'Our World is Not for Sale. Our World is Not for Sale	Network WTO: Shrink or Sink'
September 2001	'Priority to Peoples' Food	Via Campesina
August 2001	'Final Declaration of the World Forum on Food Sovereignty'	Havana, Cuba
June 2003	'How TRIPs threatens	Hyderabad, India
November 2001	Sovereignty' 'End World Hunger – Commit to Food Sovereignty'	Kathmandu, Nepal
May 2002	Food Sovereignty: A Right for All. Political Statement of the NGO/CSO Forum for Food Sovereignty'	'Rome, Italy
June 2002	'Statement on People's Food Sovereignty: Our world is not for sale. Priority to Peoples' Food Sovereignty. WTO out of Food and Agriculture'	Cancun, Mexico
September 2003	'Statement on People's Food Sovereignty: Our world is not for sale. Priority to Peoples' Food Sovereignty. WTO out of Food and Agriculture'	Cancun, Mexico
Papers:		
November 2001	'Sale of the Century? Peoples Friends of the Earth International, Food Sovereignty. Part 1 the implications of current trade negotiations'	Amsterdam, the Netherlands
November 2001	'Sale of the Century? Food Sovereignty' Part 2 – a new multilateral framework for food and agriculture'	Peoples Friends of the Earth International
November 2001	'Food Sovereignty in the Era Suppan of Trade Liberalization: Are and Trade Policy (IATP) Multilateral Means Feasible?'	Institute for Agriculture
June 2002	Sustaining Agricultural Biodiversity and the integrity and free flow of Genetic Resources for Food for Agriculture'	ETC/GRAIN/ITDG
January 2003	'What is Food Sovereignty?	Via Campesina
February 2003	'Towards Food Sovereignty: International Workshop on the Constructing and Alternative to Review of the AoA. the World Trade Organization's Switzerland Agreement on Agriculture Farmers, Food and Trade'	Geneva
April 2003	Trade and People's Food Sovereignty' biodiversity and Food Sovereignty' Conclusions and recommendations from NGO perspectives.	Friends of the Earth

Source: Windfuhr and Jonsén (2005)

Figure 2.1: Multiple outputs produced from farm inputs



Source: Adapted from OECD (2001), Verhagen et al. (2002), Wustenberghs et al. (2004).

Figure 2.2: Knowledge processes in the ToT model

Scientists	→	*Extension agents*	→	*Farmers*
source of		transmit messages,		passive receivers &
innovation		transfer knowledge		adopters

Figure 2.3: Knowledge processes in FPR-E models

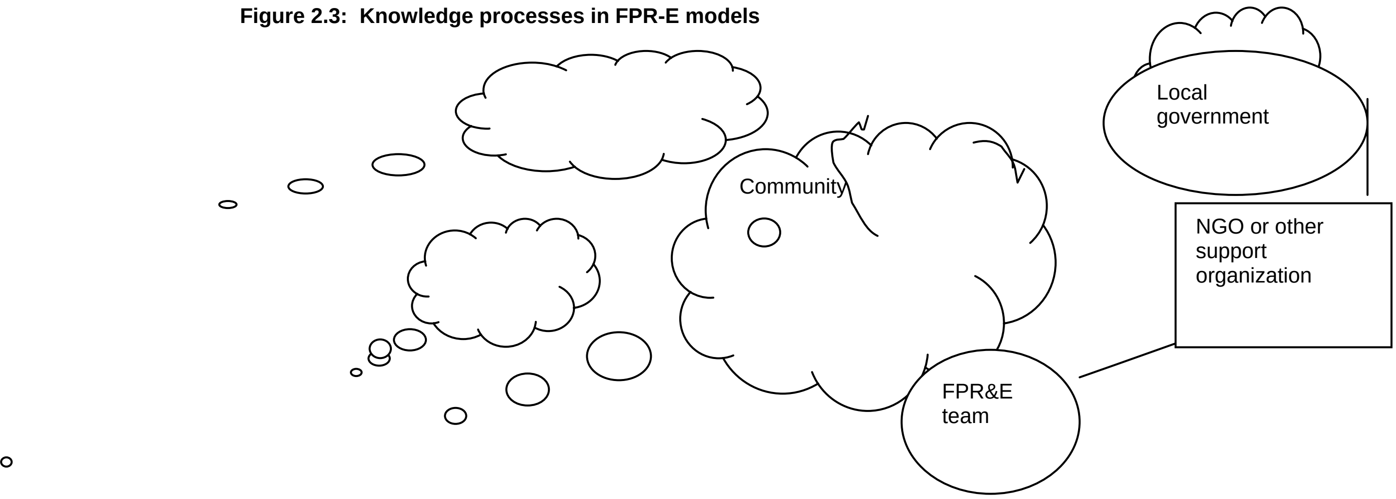


Figure 2.4: A model of a participatory research process, linking IK and formal science

A participatory research approach

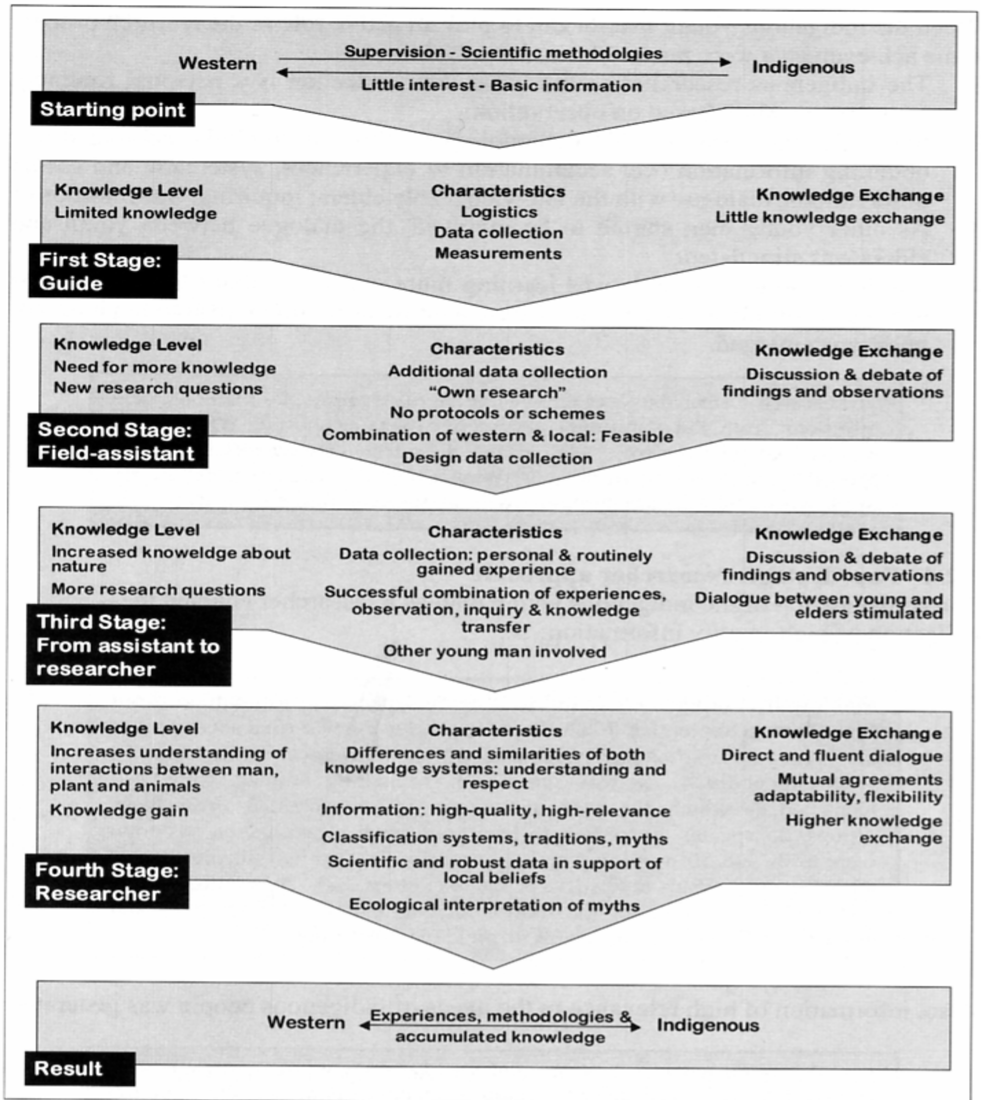


Figure 7.1. Process for developing knowledge exchange through a participatory approach within a research project examining fruit availability and the relationships with seed dispersers of the tree species most widely used by the indigenous community Nonuya of Peña Roja. The starting point of the process is a distant relationship between scientific and indigenous peoples' knowledge. The end state is a closer relationship and a direct interaction between scientific and indigenous knowledge. The stages describe the process of the indigenous people from passive field guides to active researchers participating in the project.

Source: Figure 7.1. in (Parrado-Rosselli, 2006), based on a collaborative research project with the Nonuya community of Peña Roja of the Colombian Amazon.

Figure 2.5: Knowledge processes in the chain-linked model

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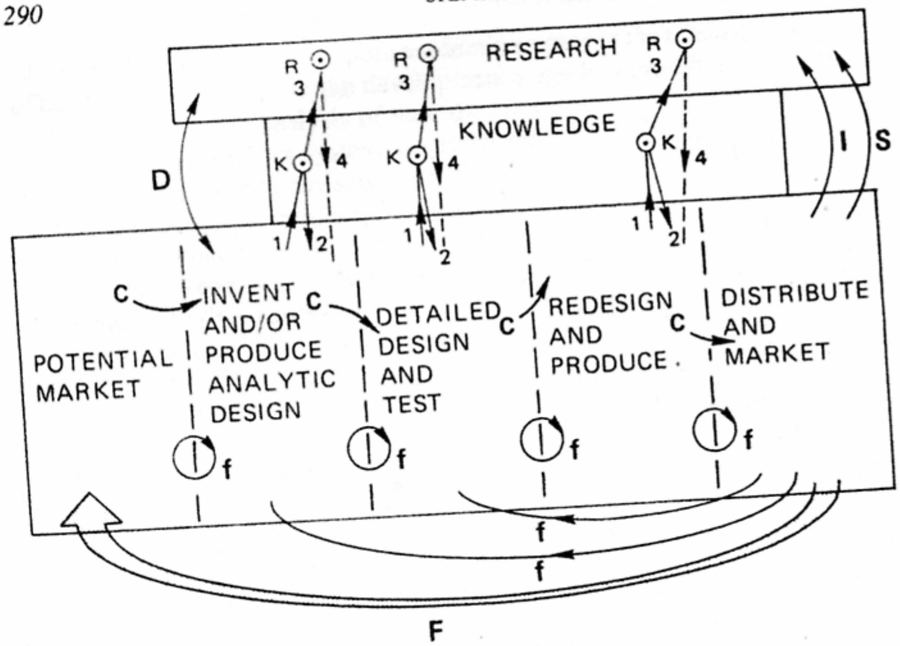


FIGURE 3 Chain-linked model showing flow paths of information and cooperation. Symbols on arrows: **C** = central-chain-of-innovation; **f** = feedback loops; **F** = particularly important feedback.

K–R: Links through knowledge to research and return paths. If problem solved at node K, link 3 to R not activated. Return from research (link 4) is problematic—therefore dashed line.

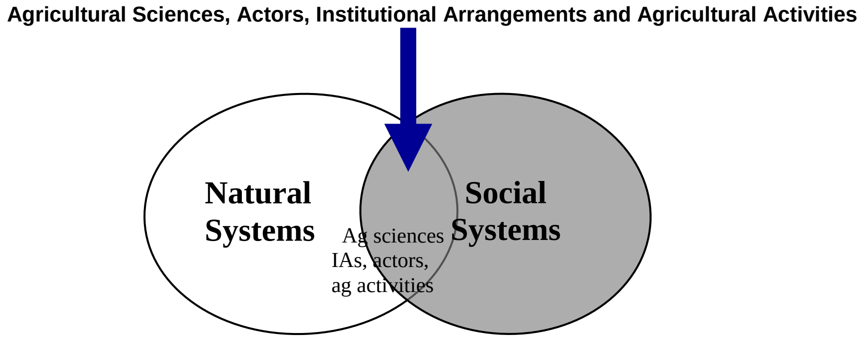
D: Direct link to and from research from problems in invention and design.

I: Support of scientific research by instruments, machines, tools, and procedures of technology.

S: Support of research in sciences underlying product area to gain information directly

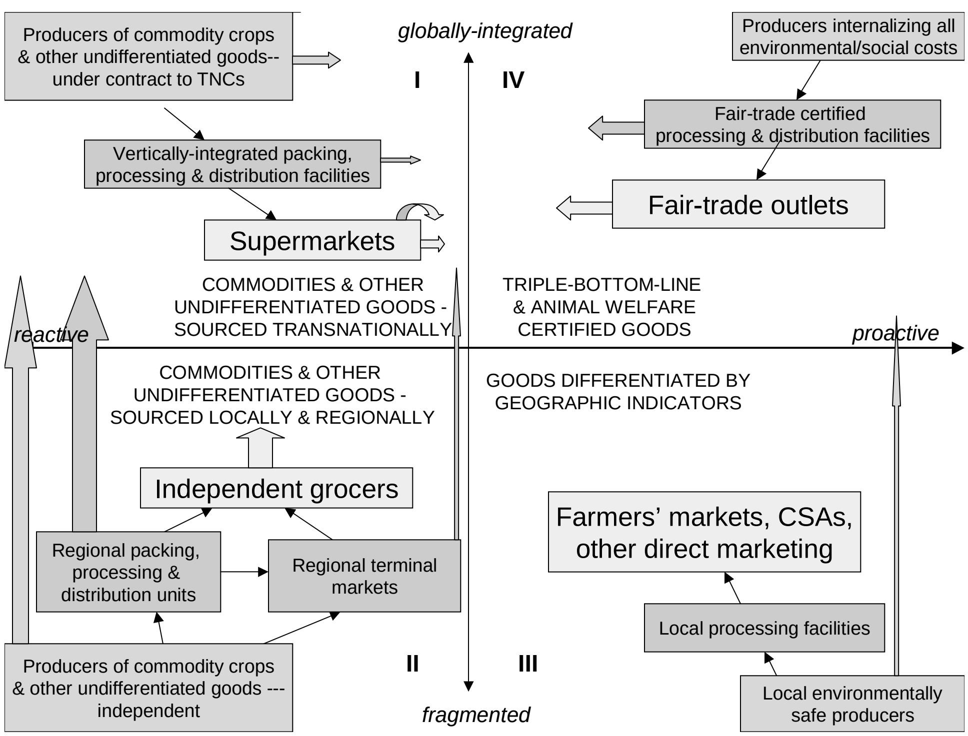
Source: Kline and Rosenberg, 1986.

Figure 2.6 Agricultural sciences interface.



Source: Plencovich et al. 2005.

Fig 2.7. Current Trends of Innovation



Source: Chapter 1, North America/Europe Sub-Global Assessment, IAASTD (Sergey Alexanian, Molly D. Anderson, Leslie Firbank, Dorota Metera)

Fig 2.8. Modes of science

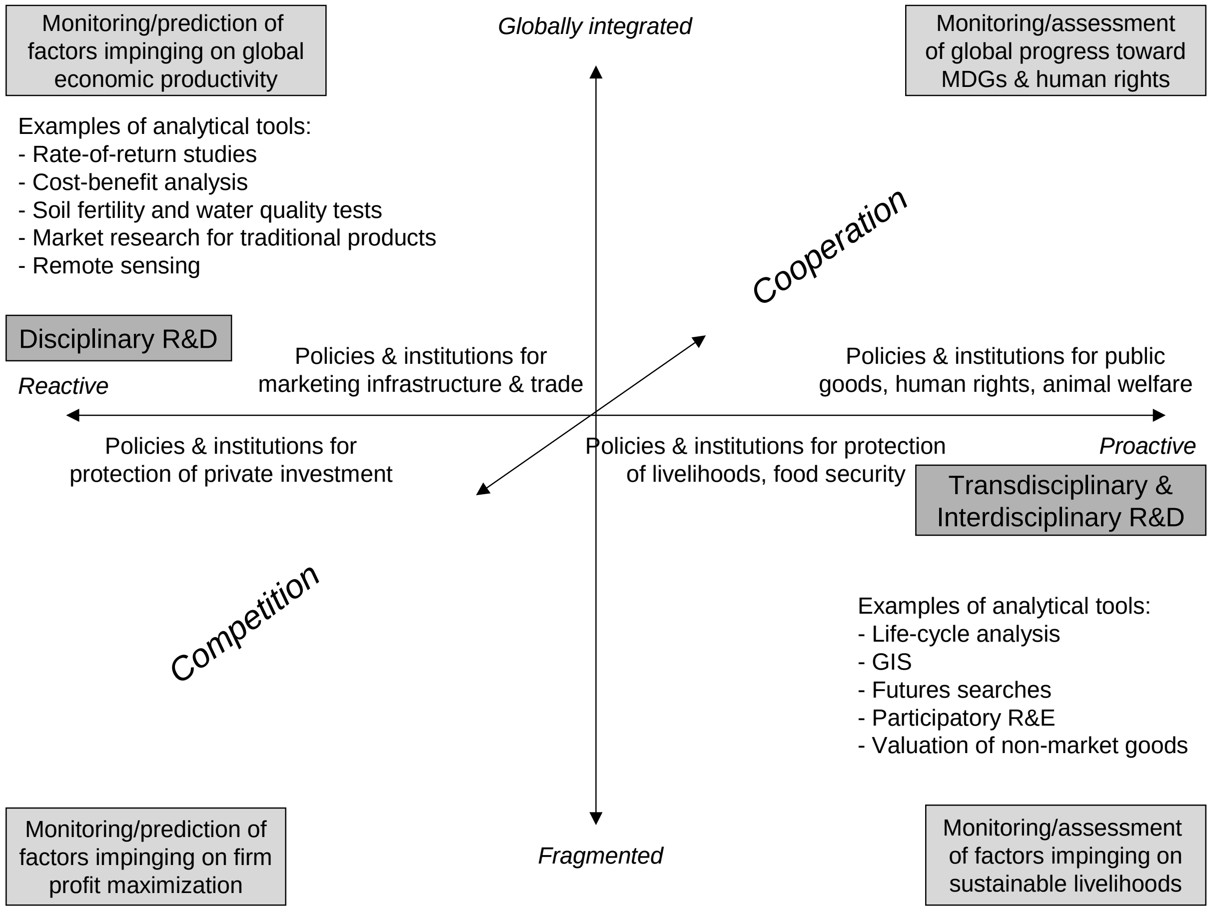
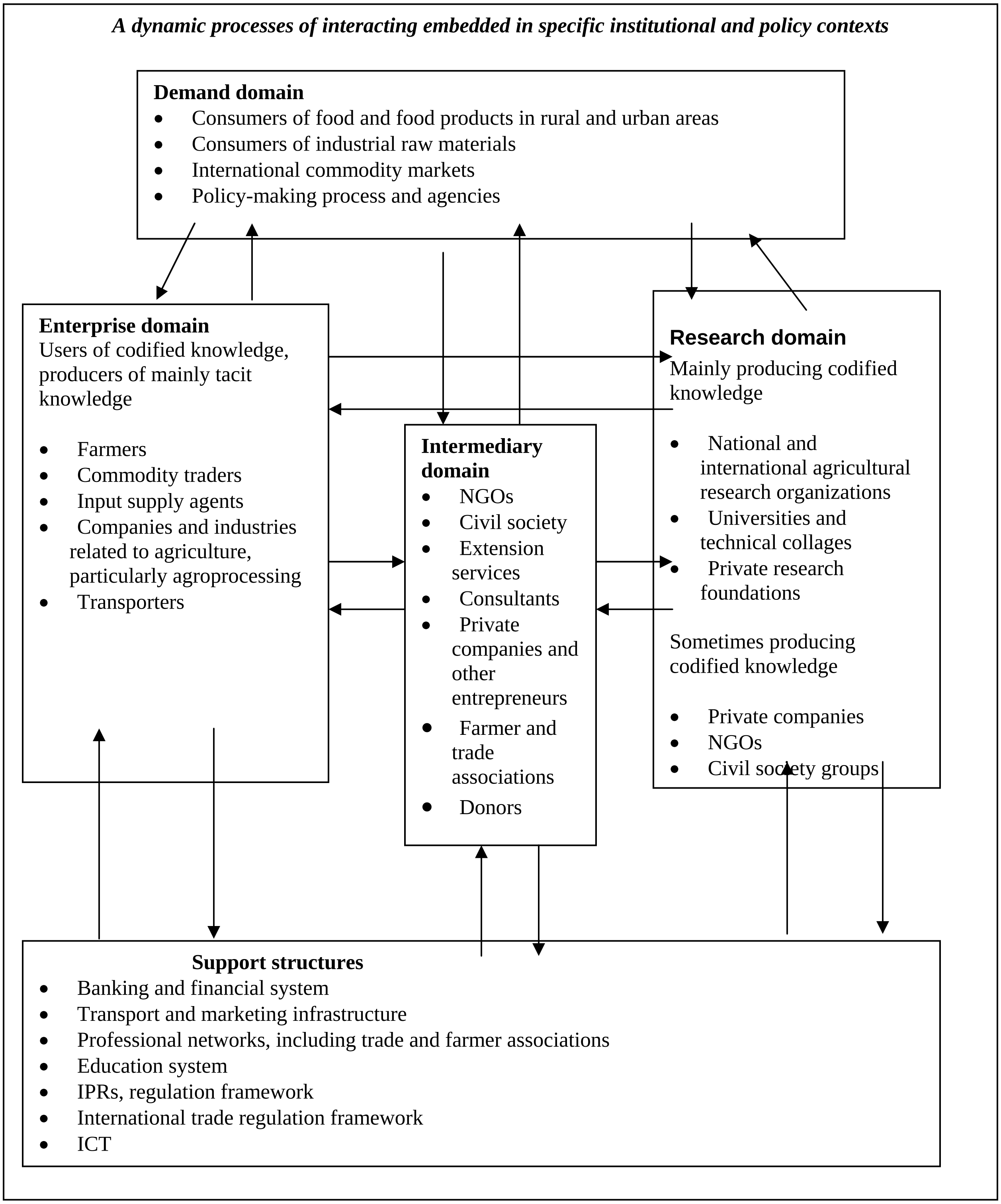
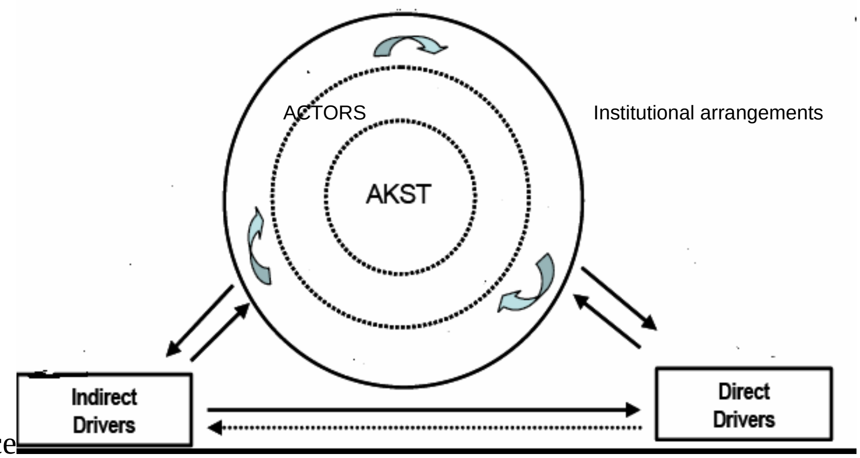

Monitoring/prediction of factors impinging on global economic productivity
Globally integrated
Monitoring/assessment of global progress toward MDGs & human rights
Examples of analytical tools:
- Rate-of-return studies
- Cost-benefit analysis
- Soil fertility and water quality tests
- Market research for traditional products
- Remote sensing
Cooperation
Disciplinary R&D
Policies & institutions for marketing infrastructure & trade
Policies & institutions for public goods, human rights, animal welfare
Reactive
Policies & institutions for protection of private investment
Policies & institutions for protection of livelihoods, food security
Proactive
Transdisciplinary & Interdisciplinary R&D
Competition
Examples of analytical tools:
- Life-cycle analysis
- GIS
- Futures searches
- Participatory R&E
- Valuation of non-market goods
Monitoring/prediction of factors impinging on firm profit maximization
Fragmented
Monitoring/assessment of factors impinging on sustainable livelihoods

Figure 2.9 Elements of an agricultural innovation system



Source: Adapted from Arnold and Bell (2001 : 279) in Hall A. 2006



Science

Figure 2.10 : Synergistic links among key actors, institutional arrangements and drivers having an impact on the IAASTD goals.

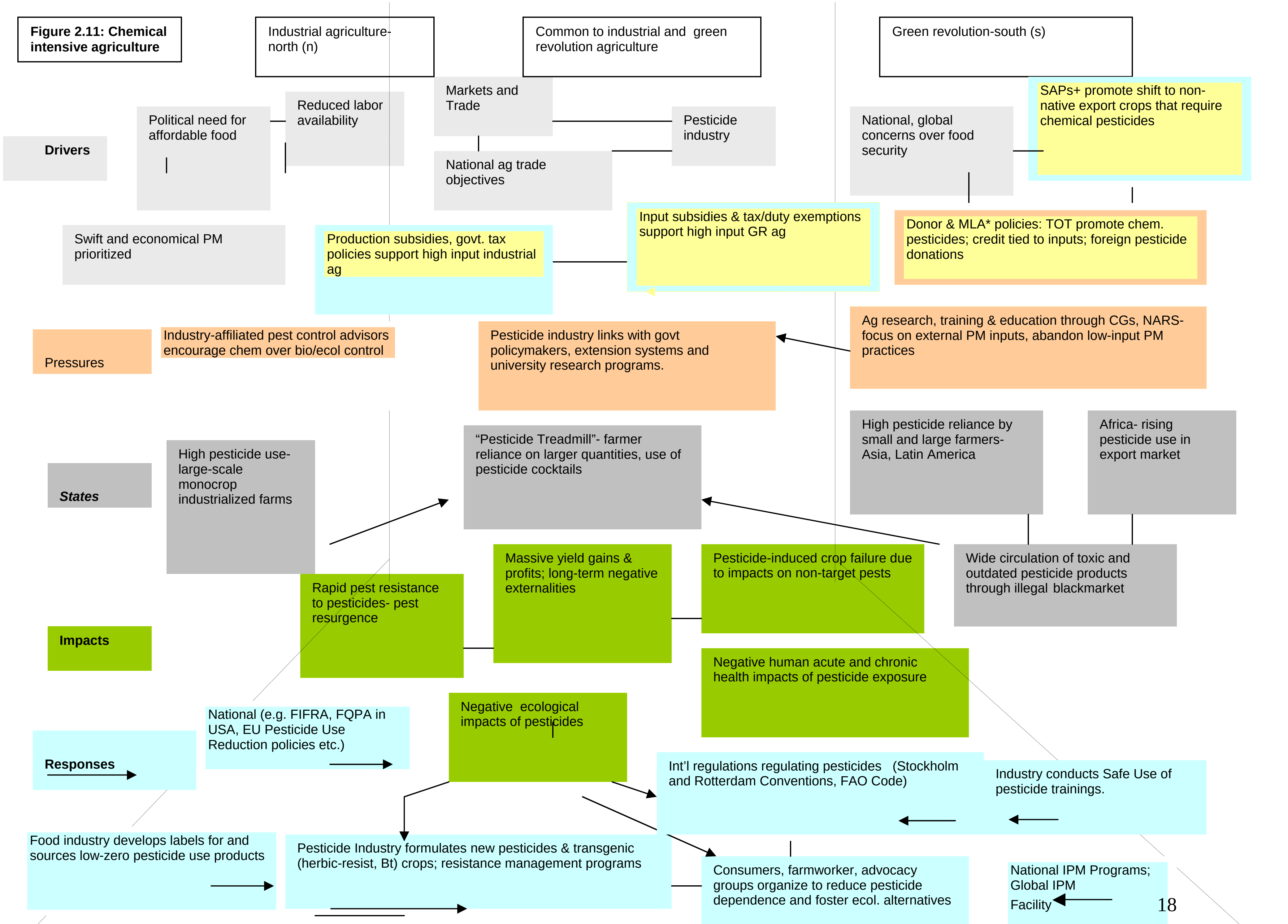


Figure 2.11: Chemical intensive agriculture

Notes. *-Multilateral lending agencies; + Structural Adjustment Programs

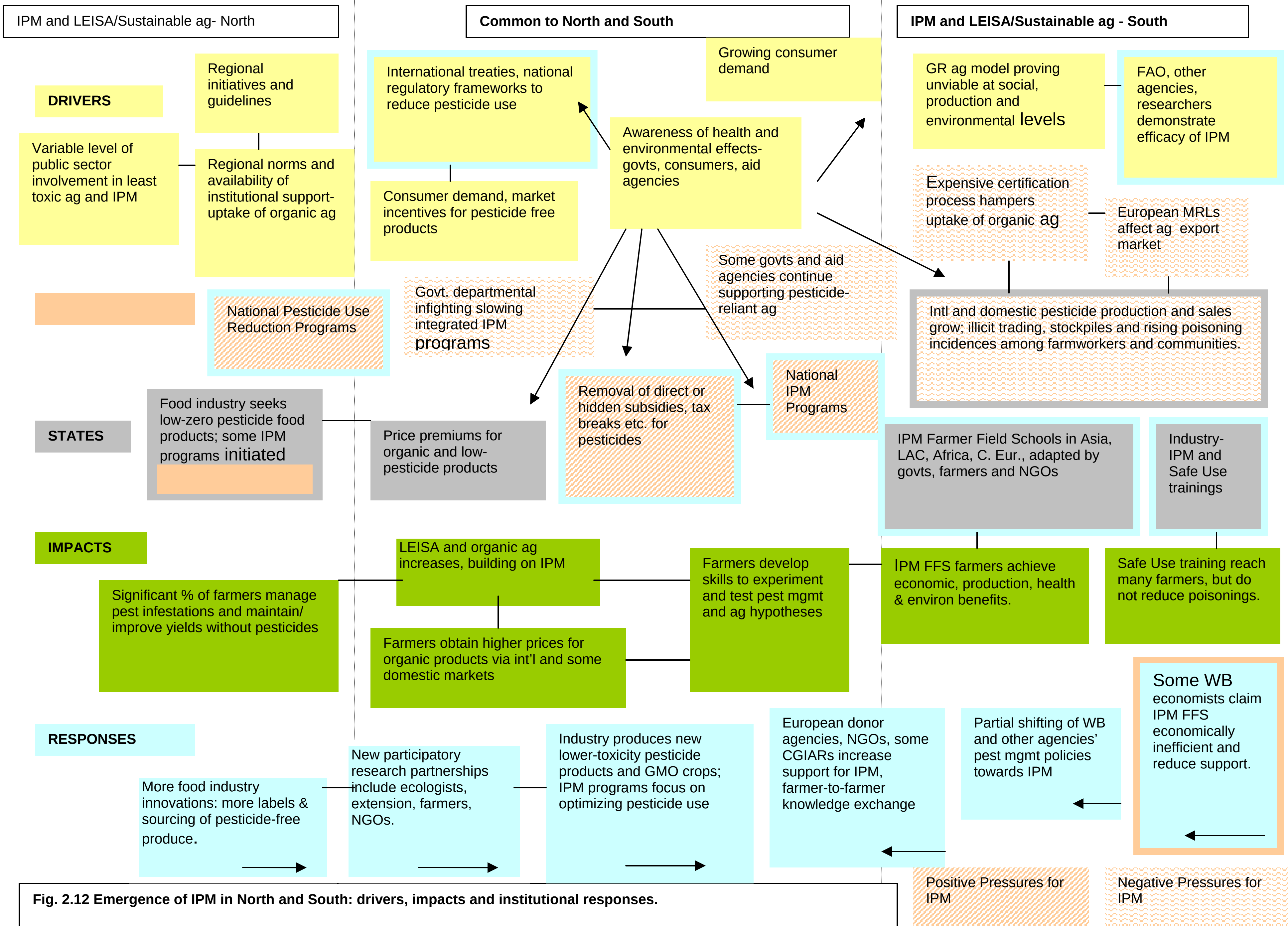
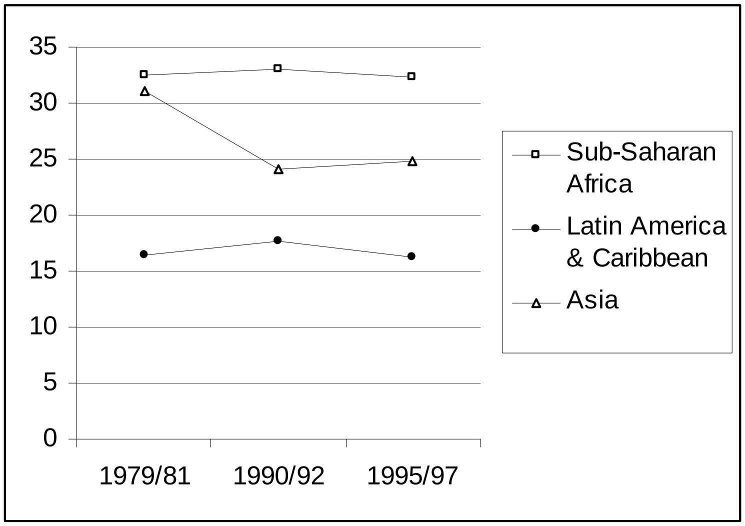


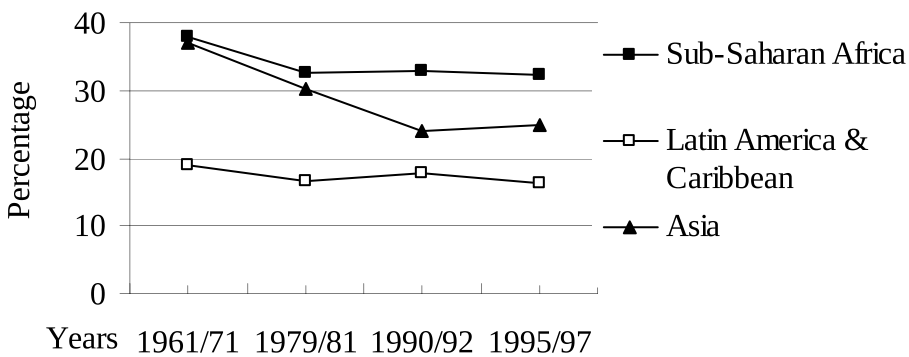
Fig. 2.12 Emergence of IPM in North and South: drivers, impacts and institutional responses.

Figure 2.13 Per Capita Food Supplies for Human Consumption



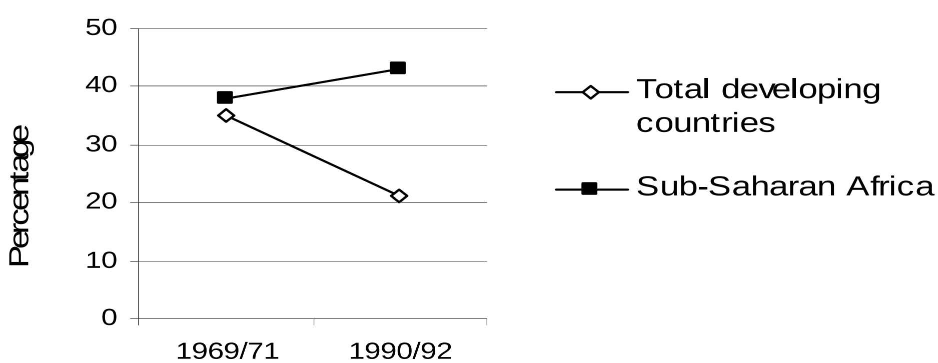
Data source: FAOSTAT, FAO, Rome and Alexandratos, 1995

Fig2.14: Trends of chronic under nutrition in Developing countries



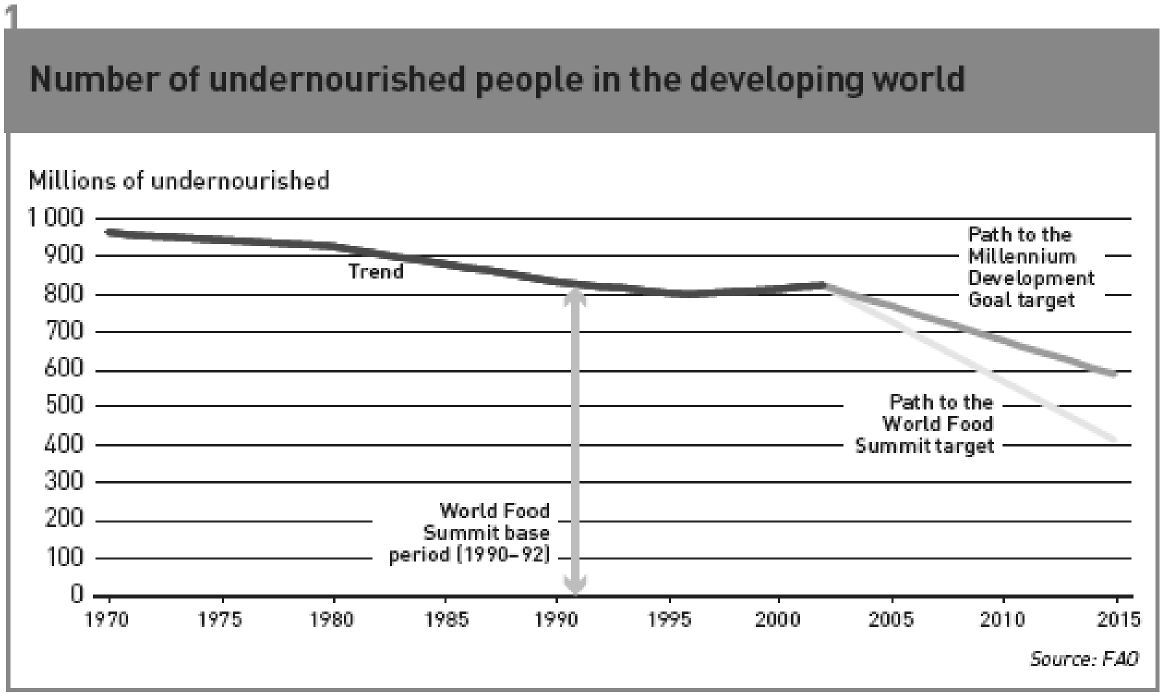
Source of data: FAO, 1996b; FAO, 1999; ACC/SNC, 2000

Figure2.15: Population with energy intake (kcal/capita/day) on average < 1.54 times the basal metabolic rate (BMR) over one year



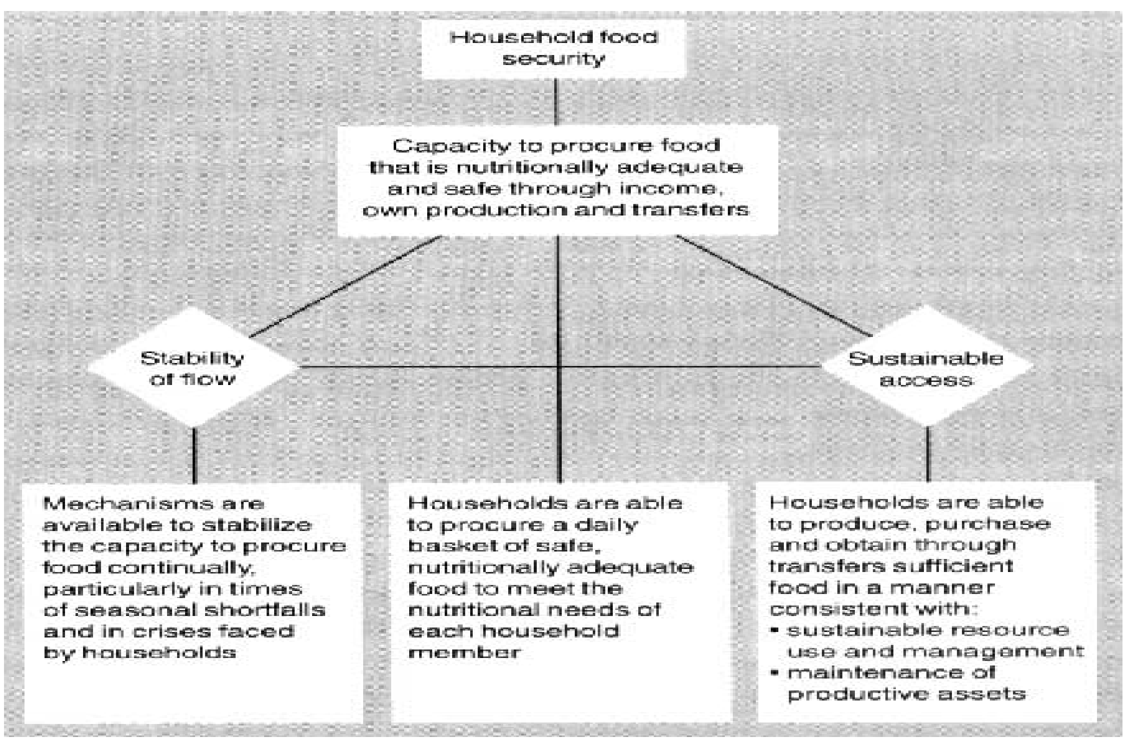
Source: FAO, 1997

Fig. 2.16 : Number of undernourished people in the developing world



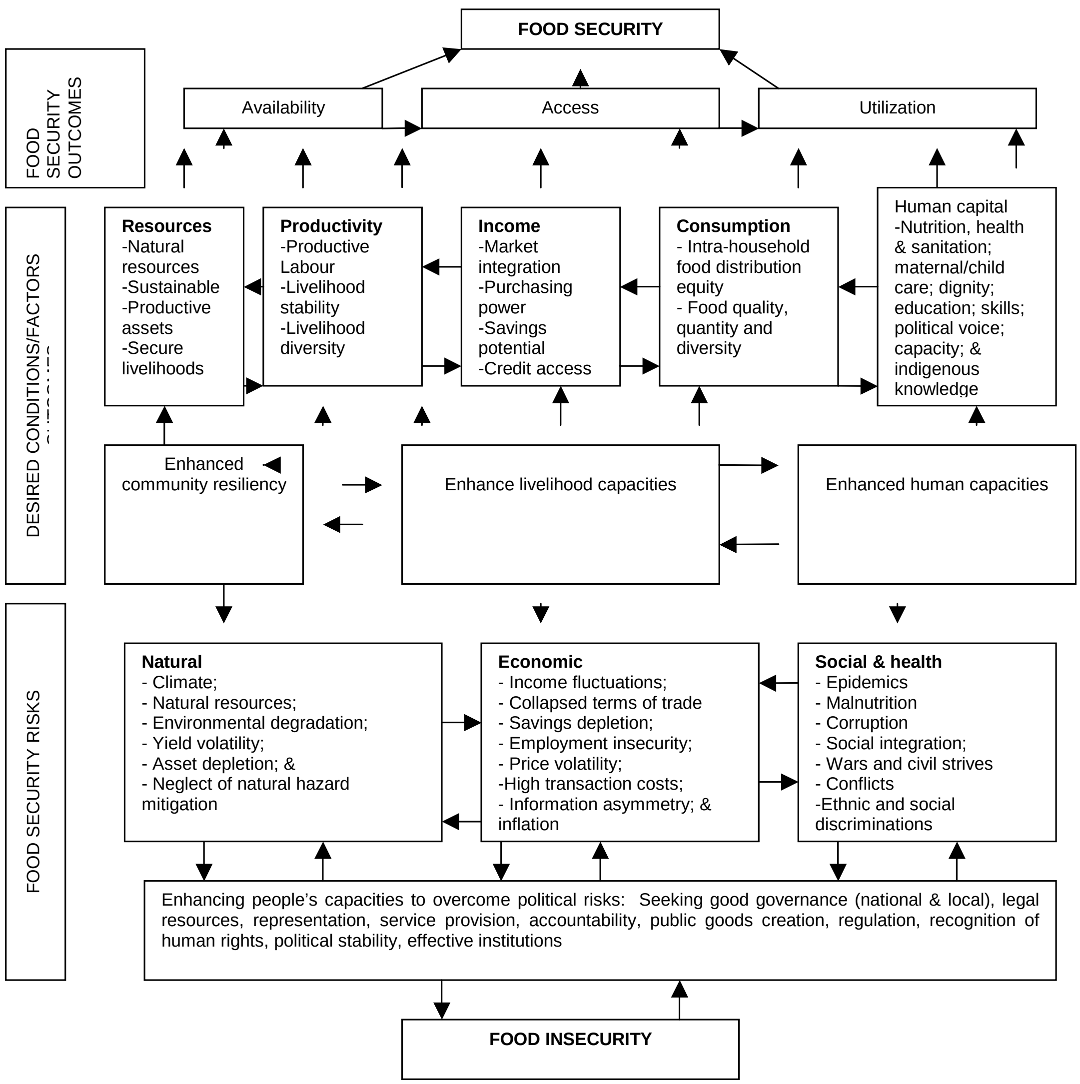
FAO, 2006.

Fig. 2.17: The normative dimensions of household food security



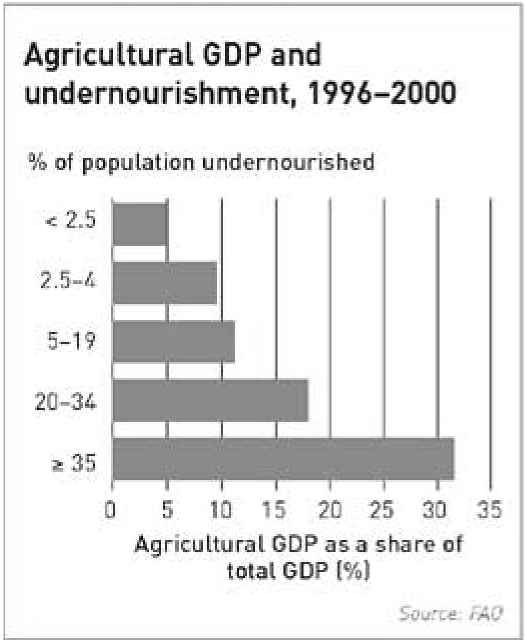
Source: Adapted from Frankenberger *et al, 1993*

Figure 2.18 : A Conceptual Framework for understanding Food Security



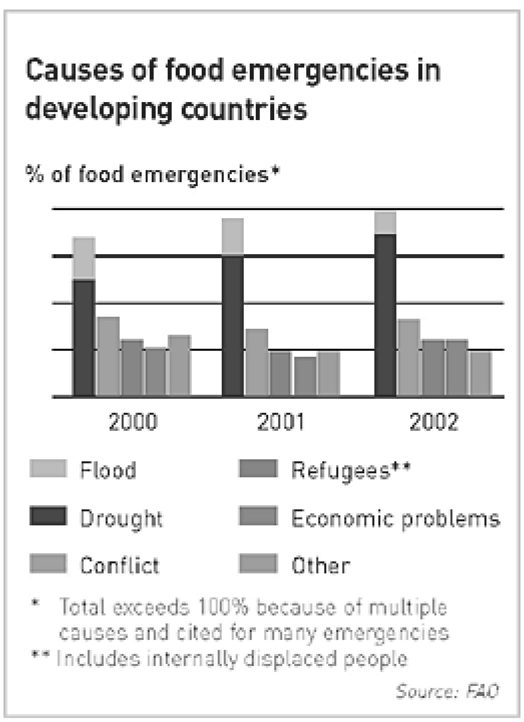
Source: Webb & Rogers 2003

Fig. 2.19 Agriculture and undernourishment



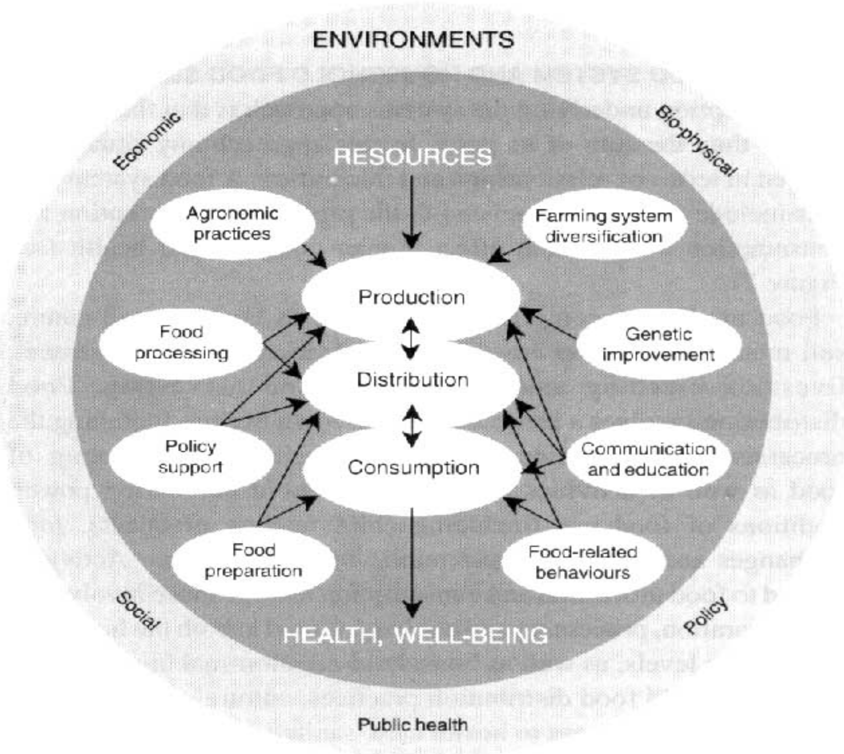
FAO, 2003

Fig. 2.20 : Causes of food emergencies



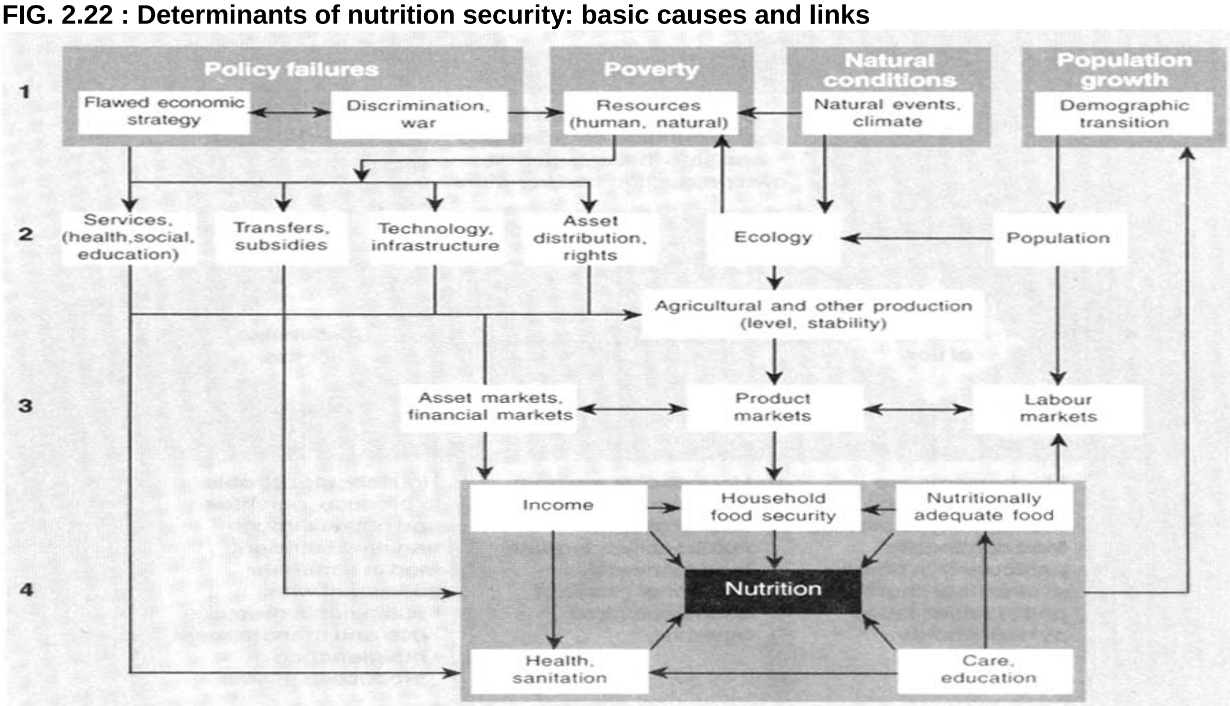
FAO,2003

Figure 2.21: The food system



Source: Combs et al., (1996)

FIG. 2.22 : Determinants of nutrition security: basic causes and links



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

Source: FAO 1996a

Global Chapter 2 : BOXES

Box 2. 1. Nine characteristics of innovation

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1. Research is an important component—but not always the central component—of innovation.
2. In the contemporary agricultural sector, competitiveness depends on collaboration for innovation.
3. Social and environmental sustainability are integral to economic success and must be reflected in interventions.
4. The market is not sufficient to promote interaction—the public sector has a central role to play.
5. Interventions are essential for building the capacity and fostering the learning that enable a sector to respond to continuous competitive challenges.
6. The organization of rural stakeholders is a central development concept. It is a common theme in innovation systems development and in numerous agricultural and rural development efforts.
7. Actors that are critical for coordinating innovation systems at the sector level are either overlooked or missing.
8. A wide set of attitudes and practices must be cultivated to foster a culture of innovation.
9. The enabling environment is a key component of innovation capacity.

Hall A., 2006

Box 2.2. Intervention options.

Box 2.2. *Intervention options.*

The innovation systems concept places great emphasis on the context-specific nature of arrangements and processes that constitute a capacity for innovation. For this reason, *principles of intervention* rather than *prescriptions* are emphasized here. Interventions in advanced phases of development typically can build on interventions from earlier phases; the more advanced the phase, the more varied interventions can take place simultaneously.

- *Initiating interventions* (for example, that build trust or improve the ability to scan and reduce risk for new opportunities), allow the transition from the pre-planned phase to the foundation phase.
- *Experimental interventions* (for example, supporting partnerships on emerging opportunities, or developing attitudes, practices, and financial incentives) allow the transition from the foundation phase to the expansion phase.
- *Interventions that help build on or nurture success* (for example, expanding proven initiatives, strengthening good practices, and addressing weaknesses) allow the transition from the expansion or emergence phase to a dynamic system of innovation.
- *Remedial interventions* (for example, building coherence and links between the research system and the sector, supporting coordination bodies, and strengthening or redesigning existing organizations) help resolve the weaknesses of innovation capacity in the stagnation phase.
- *Maintenance interventions* (for example, maintaining agility and the ability to identify new opportunities and challenges, enhancing collaboration across actors and sectors, and contributing to the maintenance of an enabling environment) are aimed at ensuring that dynamic systems of innovation do not deteriorate.

(Hall A., 2006)

Box 2.3 Timeline 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 Centres 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 (NSSI) was opened in Fort Collins, Colorado, (USA).

1960s

South Asian subcontinent on the brink of famine - High Yielding Varieties (HYV) introducted coined "Green Revolution" (by USAID -1968); International Convention for the Protection of New Varieties of Plants (UPOV, 1961 – subsequently revised 3 times) providing a sui generis protection to crop varieties with important exemptions for farmers and breeders. Establishment of International Rice Research Institute (IRRI, 1960), International Center for Maize and Wheat Improvement (CIMMYT, 1966), International Institute of Tropical Agriculture (IITA, 1966), International Center for Tropical Agriculture (CIAT, 1967). Crop Research and Introduction Center established by the FAO in Izmir, 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 Consultative Group on International Agricultural Research (CGIAR, 1971); IR8 (high-yielding semi dwarf rice) grown throughout Asia. Hybrid rice introduced in China. First recombinant DNA organism by gene splicing. Genentech Inc founded as a biotech company dedicated to developing and marketing products based on recombinant DNA technology. First international NGOs focus on the seed sector (FAFI). Technical meetings on genetic resources organised by FAO.

1980s

First patents granted to living organisms by US-courts. Large scale mergers in the seed sector. International funding for agriculture R&D begins to decline. Methods developed for Participatory Variety Selection (PVS) and Plant Breeding (PPB) 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) in 1983: Legally non-binding undertaking that confirms a 'heritage of mankind' principle over plant genetic resources and recognises Farmers' Rights. Tedious balance with PVP. The US EPA approved the release of the first genetically engineered tobacco plants.

1990s

Agrochemical, pharmaceutical, and seed companies merge into 'lifescience' 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 developin countries. Acceleration in trend towards consolidation of seed industry with (agro-)chemical 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 breeding approach from selection in high input environments to include also evaluation under drought and Nitrogen stress. Rate of funding of CGIAR stagnant – more NRM-focused centres established. Regions of the world where agricultural R&D relies on donors (e.g. Africa) particularly hard-hit. IU-PGRFA recognises national sovereignty over PGRFA in the wake of the Convention on Biological Diversity (CBD-1992). CBD as legally binding agreementamong almost 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 (e.g Philippines Exec.Order # 247; OAU Model Law, etc.). Cartagena Protocol under the CBD seeks to regulate internationalmovement of transgenics. Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS 1993) 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 (WIPO) member states set up an Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore (IGC, 2000). Developing countries join UPOV or develop their own *sui generis* protection (e.g. India, Thailand). Free Trade Agreements put pressure on developing countires to provide for stronger than TRIPs protection. Over 180 transgenic crop events, involving 15 traits deregulated or approved in at least one of 27 countries (end of yr 2000). Top 10 companies control half of the world's commercial seed sales; however farmer-see systems remain key source of seed. Nanotechnologies enter agricultural sciences.

Box 2.4: Implications for farm-based genetic resource management
• *Biological Implications:* Conservation of allelic richness, specific environmental adaptations, localized divergence, diversity to meet temporal variation in growing conditions, and the continuing of the crop evolutionary process.
• *Policy Implications:* Preservation of links between crop genetic resources and indigenous knowledge systems, greater farmer control over use and benefits of genetic resources, promotion of local involvement leading to more robust conservation (modified from Brown, 2000).

Box 2.5: Key events in the history of international rice research
IRRI was established in 1960 by the Rockefeller and the Ford foundations. As for the other early Centers subsequently supported by the CGIAR, the main objective was to work on an important food crop of interest to developing countries, in reaction to the bias toward plantation crops of the former colonial research institutions. Located in Los Banos, near Manila, the new institute had a relatively small scientific staff, probably less than 20 senior scientists. Its first major success was the development and release of IR8 (1965), the first high yielding variety of Indica rice, the species grown in tropical countries. IR 8 was the product of a relatively simple and well known breeding technique: a cross which introduced a dwarf gene which had been discovered and used in Japan where Japonica rice, the species adapted to cooler climates, is grown. Thanks to the dwarf gene, IR 8 had a short straw, it was resistant to 'lodging' and thus was able to benefit from large applications of fertilizer and to give very high yields, a feature which assured its quick success. Thus, the creation of the new variety, which turned out to be a major innovation, was a relatively simple task performed by IRRI scientists working at their headquarters in Los Banos, without much collaboration with other partners, but admittedly building on much work done by many others before them.

In spite of this spectacular early success, IRRI scientists had to quickly develop new institutional arrangements. IR8 turned out to be susceptible to many pests and to have a taste which many Asian customers did not care for[1]. New varieties were developed through multiple partnerships with national colleagues that permitted testing the same genetic material in multiple locations to select lines having broad resistance or lines adapted to specific circumstances, or specific tastes. This led to the creation of what became known as a second generation of high yielding varieties, the work of many scientists working in networks organized by and around IRRI.

In more recent years, new tasks called for, and led to, different sets of partnerships. The rice genome project was undertaken by a large consortium, including IRRI and many other public as well as private partners, led by the Japanese government. The development of the genetically engineered 'golden rice'[2] has been the product of collaboration involving two private foundations, an advanced research institution in Switzerland and IRRI scientists.

As an international centre, IRRI did not of course restrict itself to Asia[3]. New arrangements had to be created for Latin America with CIAT and in West Africa with WARDA, two other CGIAR centres. For many years, CIAT had a rice program, working much like other crop improvements programs in CGIAR centres, collecting germplasm, performing crosses, distributing germplasm and testing improved material. Several years ago, budget pressures and the fact that rice is mainly grown by large farmers in Latin America, notably in Colombia where CIAT is located, led to the early total closure of CIAT rice program and to a devolution of the bulk of its activities to a new research organization created by rice growers and mainly funded by them. This is another example of new circumstances leading to the creation of a new institutional arrangement.

The case of West Africa is still different. There, irrigated rice is the exception rather than the rule, contrarily to the situation in Asia and in Latin America. Early IRRI material did not have much to offer, incidentally leading to controversies and sometimes-acrimonious debates. In addition the institutional scene is special because most countries in the region are poor; they have a relatively small population and their research organizations are weak at best. In addition, WARDA was created as an association of governments, giving it an original governance structure quite different from that of other CGIAR centres.

[1] Actually, the Philippine officials had been very impressed with thIR8 and wanted it released despite the known insect and disease susceptibility.
[2]The purpose of this example is not to take side in the controversy on golden rice but to illustrate the diversity of institutional arrangements, which have been put in place by agricultural research organizations in recent years.
[3]Obviously, with more than 90% of the developing world's rice in Asia, it is understandable that IRRI concentrated most of its efforts in Asia.

Box 2.6: Historical limitations of CGIARs 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 programme began to develop varieties in sub-Saharan Africa under conditions of low nitrogen input and drought (CIMMYT 2002). Gender was found to play 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 (Adato and Meinzen-Dick, 2002; Meinzen-Dick et al. 2004).

Box 2.7: 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.

Box 2.8 : Convention on Biological Diversity
Adopted at the Earth Summit in Rio de Janeiro, Brazil 1992 , coming into force 29 December 1993
Goals
1. Conservation of biological diversity
2. Sustainable use of its components
3. Fair and equitable sharing of benefits arising from genetic resources

The CBD asserts sovereignty rights to regulate access to genetic resources. It recognizes, and is to be interpreted consistent with, intellectual property over genetic resources. The sovereignty principal was to be implemented through prior informed consent and mutually agreed terms for access to genetic resources.

The Nairobi Final Act, 1993, resolution 3, signed by the signatories to the CBD acknowledged that the access and benefit sharing framework established by the CBD did not sufficiently address the situation of existing *ex situ* collections of PGRFA held around the world. It further states that it was important to promote cooperation between the CBD and the Global System of Sustainable Use of Plant Genetic Resources for Food and Agriculture as supported by FAO. This resolution set the stage for the further investigation into appropriate access and benefit sharing regime or regimes for PGRFA. This lead indirectly to the seven years of negotiations of the International Treaty on Plant Genetic Resources for Food and Agriculture.

Positive Outcomes
- Heightened awareness globally of the inequitable distribution of benefits associated with the use of genetic resources
- Heightened awareness globally of the need to value, use and conserve indigenous and local knowledge, and to promote *in situ* conservation.
- Created a framework for the development of a plan of coordinated work on Agricultural Bioversity
- Created a framework for funding for *in situ* conservation promotion projects through the Convention's funding mechanism: Global Environmental Facility

Problems
- The CBD does not distinguish between domesticated agricultural resources, collected in the form of ascensions of given crop (intra-species), and other biological resources, such as wild plants collected for pharmaceutical applications. In fact, the convention seems to have been drafted more with the latter in mind (bio-prospecting).
- The CBD links benefit sharing to being able to identify the country of origin of a resource. The CBD defines the 'country of origin of genetic resources' as "the country which possesses those genetic resources in *in situ* conditions." In turn, it defines '*in situ* conditions' as those "conditions where genetic resources exist within ecosystems and natural habitats and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties." Pursuant to this definition, the CBD requires more than simply identifying the country of origin of a crop—it requires the identification of the country of origin of the distinctive properties of the crop. Because of the international nature of the development and use of PGRFA, the CBD's method of linking the 'origin' of traits to benefit sharing is impractical and often impossible to make work.
- The CBD has contributed to and reinforced exaggerated expectations about the commercial market value for local crop and forages varieties, leading countries to take measures to restrict access to those resources as a means of eventually capturing their market value (through use licenses) rather than sharing them in cooperative research projects that would likely result in significantly higher overall public benefit.

As a result of these factors, some critics feel the convention is inappropriate for the agricultural genetic resources, while allowing that it may still have potential for redistributing benefits associated with the use of other forms of genetic resources
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 2.9 : International Treaty on Plant Genetic Resources for Food and Agriculture adapted November 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 2.10 : 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 the agricultural problems of developing and developed countries. 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, 2005; Rosset, 2005; Pemsl et al., 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 (Traxler et al., 2001; Ismael, 2001; Huang et al., 2001; Quaim and Traxler 2002; Huang et al., 2002a, Catteneo 2006). The impacts on pesticide use are debated, with some studies indicating reduced use of insecticides (Huang et al. 2002, 2003) and others indicating significant rise in herbicide use (Benbrook, 2004; USDA, 2000). 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), a phenomenon illustrating 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 percent of the benefits of GE soya. However, for instance in Argentina, the soya producers received 90 percent of the benefits of GE soya, partly owing to weak IP protection and lack of technology transfer (Quaim and Traxler 2005). This has greatly favored the expansion of the technology in Argentina. However, this increasing reliance on a single agricultural technology in Argentina is causing concern at both ecological and social levels (Benbrook 2005, 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 agricultural crop plants (Nature Biotechnology, 2004; Snow, 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, the National Research Council of the USA (NRC, 2004) concluded that no method is likely to be completely effective in preventing movement of transgenes.

GE research and development in developing countries is behind that of the developed world for a number of factors including: (i) private sector in the developed world holding much of the IPR to transformation technology; (i) weak patent protection in most developing countries 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 are inhibiting the little private research that is done in developing countries (Huang 2002b). The costs of regulatory compliance has been cited as the largest obstacle to release of commercial GE crops in many developing countries (Cohen, 2005; Atanassov, 2004) and even developed countries. In developed countries like the UK, where public opinion has been exposed to food safety crises like BSE, studies highlight people's 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. An independent report by the Economic and Social Research Council[1] concluded that better science is necessary but may never resolve the uncertainties about the effects of new technologies that GMOs exemplify.

In summary, 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 (Christou and Twyman, 2004; Huang et al 2002b and many more). 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 the 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), the GM technology—if pursued, and there is not yet consensus in any region that it should be— 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.

[1] ***The Politics of GM Food: Risk, Science and Public Trust***, Special Briefing no 5, Global Environmental Change Programme, University of Sussex. Also available on the web at: http://www.gecko.ac.uk

Box 2.11: Timeline of key events in pest management

Early agriculture

- Indigenous knowledge, pest management by physical and preventative practices.

1800-1920s

- Early organic chemicals, nitro-phenols, chlorophenols, creosote, naphthalene, petroleum.
- US Insecticide Act formed to protect farmers from fraud.

1920s-30s

- First organic mercury seed dressings; classical biological control; development and first use of synthetic chemical pesticides.

1940s-1950s

- Large-scale use of synthetic chemical pesticides (organochlorines, organophosphates, carbamates, phenoxy herbicides) in high external ag systems of North and South.
- US Federal Fungicide, Insecticide and Rodenticide Act (FIFRA) to regulate pesticides.
- High yields achieved with chemical inputs, but pesticide resistance, pest resurgeance and secondary pest outbreaks start to occur.

1960s-70s

- Widespread adoption of chemical pesticides; yield gains impressive but not equally distributed; environmental and health impacts of pesticides begin to be documented.
- Publication of Rachel Carson's Silent Spring (1962) catalyzes attention of English-speaking world, with impacts on public's perception of pesticide effects.
- Integrated Pest Management introduced; mostly integration of biological, cultural and chemical controls, diffused through conventional TOT extension processes.
- New herbicides (e.g. paraquat, triazines, acetanilides, dinitroanilines), first systemic fungicides, amides, dithiocarbamates, synthetic pyrethroids, introduced.
- US Environmental Protection Agency formed (EPA), begins regulating pesticides.
- The International Federation of Organic Agriculture Movements (IFOAM) formed (1972); a democratic grassroots organization, it now has 750 member groups in 108 countries.
- *Bacillus thuringiensis* (Bt) a biological control agent, registered as an insecticide

1980s

- Explosion of pesticide plant in Bhopal, India (1984) focuses international attention on pesticide health effects, affected communities, and issues of accountability and liability.
- Pesticide Action Network, an international civil society network, formed and launches Dirty Dozen campaign in 40 countries, to eliminate most hazardous pesticides;
- Investigation of pesticide-induced crop failures in Southeast Asia by FAO scientists determine that sustainable rice pest management is achieved without pesticides; Indonesia bans 67 pesticides for use in rice, eliminates pesticide subsidies and establishes the first comprehensive National IPM Program in the South using (1986);
- IPM Farmer Field School methodology developed by FAO with farmers and national government in Indonesia subsequently spreads through Asia, Latin America and Africa.
- FAO Conference adopts Code of Conduct on the distribution and use of pesticides, and prohibits marketing of pesticides as "safe" (1985, revised in 2002);
- National Pesticide Use Reduction Plans undertaken in Netherlands, Denmark, Norway and Sweden, Belgium, Canada, Switzerland;
- Montreal Protocol (1987) agrees on plan to phase out methyl bromide world-wide.
- Conservation tillage widely used in US to reduce soil erosion.
  - Global Crop Protection Federation (GCPF) works to manage pesticide resistance, conducts IPM and safe pesticide use trainings.
  - Sulphonyl ureas, imidazolinone avermectins, juvenile hormone mimics, biological pesticides introduced.

1990s

- Scientific literature documents acute and chronic health effects of pesticides on communities in North and South; endocrine-disrupting effects observed.
- Phenomenon of cross-resistance to pesticides observed in insects.
- Genetically engineered herbicide-resistant and Bt seeds first planted in US, Argentina.
- UNCED endorses IPM in Agenda 21 (1992); European Community incorporates IPM into legislation; OECD initiates Pesticide Risk Reduction Project; adopts Guidelines on Pesticide and Pest Management;
- US Food Quality Protection Act (1996) to regulate pesticide residues and expedite registration of reduced-risk pesticides; requires setting new tolerance levels based on synergistic effects, multiple exposure sources and consideration of infants and children (1996); EPA sets Worker Protection Standards (1992)/
- EU Directive 91/414/EEC aims to harmonise the registration of pesticides across Europe and ensures that all pesticides (not just new ones) on the market are evaluated to the latest, harmonised standards, (previous registration at country level)
- Global IPM Facility established and begins providing technical assistance to governments seeking to shift towards IPM (1997); organic agriculture sector grows at 20-25% in US and Europe and begins to offer export opportunities to South;
- World Bank revises Operational Policy 4.09 to reduce pesticide reliance among borrowers, promote ecologically IPM, and use pesticides only as a last resort (1998);
- Rotterdam Convention, a multilateral environmental agreement formalizing "Prior Informed Consent" in trade of hazardous chemicals, is adopted (1998);
- UN Intergovernmental Forum on Chemical Safety, established to ensure sound management of chemicals. IFCS subsequently forms a Working Group on Acutely Toxic Pesticides (2001/2002)
- Triazoles introduced; consolidation of the agribusiness sector leaves 6 dominant multinational companies: Dow, DuPont, Monsanto, Bayer, Syngenta, BASF.

2000+

- CropLife Foundation and CropLife International, trade associations of the pesticide industry, form. Increased focus on sustainable agriculture and safe use of products.
- Stockholm Convention to eliminate Persistent Organic Pollutants (POPs), including nine pesticides, is signed in 2001, and Multilateral Strategic Approach to International Chemicals Management (SAICM) agreed on by governments (2006);
- FAO member countries adopt new Code of Conduct to support IPM and reduce pesticide poisonings (2002); major agrochemical companies endorse.
- New EU regulatory framework for the Registration, Evaluation and Authorization of Chemicals (REACH, 2003); European Food Standards Agency formed; Directive 98/8/EC: the Biocidal Product Directive aims to harmonise the European market for biocidal products.
- Global sales of agrochemicals total US$32.2 billion in 2004.

Box 2.12: Regulatory instruments affecting pest management

International instruments (treaties, agreements, and initiatives) on pesticides

International instruments to reduce environmental and human health harms that have been associated with pesticide use have focused on phasing out the most toxic pesticides, increasing public availability of information on pesticide bans and restrictions, and/or promotion of least toxic sustainable alternatives such as IPM. They include:

- 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. The 2002 revision emphasizes IPM based on natural pest control mechanisms and lowering pesticide use to minimize risks to health and the environment. It indicates that "prohibition of the importation, sale and purchase of highly toxic products [such as] WHO class Ia and Ib pesticides may be desirable" and recommends that pesticides requiring use of personal protective equipment (e.g. WHO Class II pesticides) should be avoided, where such equipment is uncomfortable, expensive or not readily available (e.g. in most developing countries).
- The Rotterdam Convention on Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (1998). PIC requires that exporting countries provide notification to importing countries of bans and restrictions on listed pesticides. 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 lays out a process for adding new chemicals such as lindance and chlordecone to the list. 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. 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 (IFCS, 1994) is a World Health Organization-sponsored mechanism to develop and promote strategies and partnerships on chemical safety among national governments, intergovernmental and non-governmental organizations. The Inter-Organization Programme for the Sound Management of Chemicals (IOMC) and International Programme on Chemical Safety (IPCS) are two other international coordinating organizations relating to chemicals. The IFCS sponsors a Working Group on Acutely Toxic Pesticides, which maintains a CD-ROM database on acute pesticide poisonings.
- UNEP's Strategic Approach to International Chemicals Management (SAICM) was established in February 2006. This international agreement lays out global commitments, broad strategies, and a range of tools for managing chemicals more safely around the world. The agreement emphasizes principles of prevention, polluter pays, substitution for less harmful substances, public participation, precaution, and the public's right to know.
- The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (1992) focuses on controlling the movement of hazardous wastes, ensuring their environmentally sound management and disposal, and preventing illegal waste trafficking. Now ratified by 149 countries including 32 of the 53 African countries, the convention explicitly includes obsolete pesticide stockpiles.
- The Africa Stockpiles Project, established by nongovernmental organizations Pesticide Action Network UK and World Wide Fund for Nature (WWF) in 2000, and supported by the Global Environment Facility, brings together diverse stakeholders including industry to clean up and safely dispose of all obsolete pesticide stocks from Africa and establish preventive measures to avoid future accumulation.

International agreements/statements prioritizing IPM

- UNCED Agenda 21, Chapter 14.7 of Article 21 (1992)
- Rome Declaration on World Food Security (1996)
- Convention on Biological Diversity (1993)
- World Summit on Sustainable development (WSSD, 2002)
- World Food Summit Plan of Action (1996)

Regional initiatives and frameworks

- OECD/DAC Guidelines on Pest and Pesticide Management (1998) established formats for industry data submission and for governmental pesticide evaluation reports.
- The European Union's Registration, Evaluation and Authorization of Chemicals (REACH) regulates the manufacture, import, export and notification of risks and use of approximately 30,000 chemicals. REACH illustrates use of the precautionary principle (which allows preventative action to be taken when substantial evidence points towards health or environmental harm) and the substitution principle, which requires that less harmful substitutions be sought and replace more dangerous chemicals.
- North American Commission on Environmental Co-operation (NACEC) of NAFTA has established a Sound Management of Chemicals Working Group, which produces North American Regional Action Plans (NARAPs) to reduce use of specific chemicals. The NACEC has developed NARAPs for DDT and chlordane, and is finalizing one for lindane.

National regulatory instruments and policies

- Pesticide registration legislation
- Pesticide use, residue and poisoning databases
- Maximum Residue Levels (MRLs)
- Pesticide Use Reduction programs
- Pesticide subsidies, use taxes and import duties

Box 2.13: From pesticides to IPM: the case of Indonesia.

Indonesia provides an illuminating case of widespread adoption of sustainable agriculture practices like IPM through FFS (Röling and van der Fliert, 2000). Indonesia introduced its National IPM Program in May 1989, catalyzed by a series of devastating pesticide-induced brown planthopper outbreaks in 1985–86. The Indonesian government declared IPM the national pest control strategy, prohibited 57 broad spectrum insecticides for rice, created government posts for pest observer personnel, required use of resistant rice varieties, prohibited continuous wet rice farming, and most importantly removed the 85 percent subsidy on the price of pesticides. IPM training was provided through the extension system.

The main driver for the policy shift was the Indonesian government, acting on evidence supplied by the UN FAO regarding the high costs of pesticide-dependent agriculture and the viability of rice IPM. After observing the low success rate of the "transfer of technology" approach, the Indonesian National IPM Policy adopted a national program using Farmer Field Schools in 1989. The role of government agency also proved critical: prior to 1992, the planning agency (BAPPENAS) implemented the program, rather than the Ministry of Agriculture. BAPPENAS worked with a decentralized, locally responsive agricultural training and innovation model, which gave it flexibility. The program fostered farmers' own expertise and mastery rather than only adoption of external information. It included a decentralized governance structure, with a Bureau at the central level, district and sub-district level officials and local pest observer staff. Subsequently, responsibility for the program was shifted to the Ministry of Agriculture, and funding was obtained from the World Bank. Some of the initial successes from the pilot phase have dissipated due to a number of Bank-imposed program specifications and budget cuts of various training and social components of the FFS (Röling and van der Fliert 2000). Sustenance of a successful IPM movement in Indonesia now depends upon the country's ability to create conditions at local levels, through NGO and local government funding, for the development of a network of progressive and influential farmers to advance ecologically-based community-driven IPM in their country.

Box 2.14: Milestones in the evolution of food standards (quoted from the FAO Corporate Document Repository):

Ancient times
Attempts are made by early civilizations to codify foods

Early 1800s: Canning is invented

Mid-1800s: Bananas are first shipped to Europe from the tropics

1800s: The first general food laws are adopted and enforcement agencies established;
Food chemistry gains credibility and reliable methods are developed to test for food adulteration

Late 1800s: A new era of long-distance food transportation is ushered in by the first international shipments of frozen meat from Australia and New Zealand to the United Kingdom

Early 1900s: Food trade associations attempt to facilitate world trade through the use of harmonized standards; The International Dairy Federation (IDF) develops *international* standards for milk and milk products. (IDF was later to be an important catalyst in the conception of the Codex Alimentarius Commission)

1940s: FAO is founded, with responsibilities covering nutrition and associated international food standards;
WHO is founded, with responsibilities covering human health and, in particular, a mandate to establish food standards;
Argentina proposes a regional Latin American food code, *Código Latino-Americano de Alimentos*.

1950s: Joint FAO/WHO expert meetings begin on nutrition, food additives and related areas;
WHO's highest governing body, the World Health Assembly, states that the widening use of chemicals in the food industry presents a new public health problem that needs attention;
Austria actively pursues the creation of a regional food code, the *Codex Alimentarius Europapaeus*, or European Codex Alimentarius.

1960s: The first FAO Regional Conference for Europe endorses the desirability of international - as distinct from regional - agreement on minimum food standards and invites the Organization's Director-General to submit proposals for a joint FAO/WHO programme on food standards to the Conference of FAO;
The Council of the *Codex Alimentarius Europaeus* adopts a resolution proposing that its work on food standards be taken over by FAO and WHO;
With the support of WHO, the Economic Commission for Europe (ECE), the Organisation for Economic Co-operation and Development (OECD) and the Council of the *Codex Alimentarius Europaeus*, the FAO Conference establishes the Codex Alimentarius and resolves to create an international food standards programme;
The FAO Conference decides to establish a Codex Alimentarius Commission and requests an early endorsement by WHO of a joint FAO/WHO food standards programme;
The Joint FAO/WHO Food Standards Conference requests the Codex Alimentarius Commission to implement a joint FAO/WHO food standards programme and to create the Codex Alimentarius;
Recognizing the importance of WHO's role in all health aspects of food and considering its mandate to establish food standards, the World Health Assembly approves establishment of the Joint FAO/WHO Programme on Food Standards and adopts the statutes of the Codex Alimentarius Commission.

Establishing of the Codex Alimentarius Commission (quoted from FAO).

Two landmark years in the foundation of the Codex Alimentarius were 1960 and 1961. In October 1960, the first FAO Regional Conference for Europe crystallized a widely held view when it recognized: "The desirability of international agreement on minimum food standards and related questions (including labelling requirements, methods of analysis, etc.) ... as an important means of protecting the consumer's health, of ensuring quality and of reducing trade barriers, particularly in the rapidly integrating market of Europe."
The Conference also felt that:
"... coordination of the growing number of food standards programmes undertaken by many organizations presented a particular problem."

Within four months of the regional conference, FAO entered into discussions with WHO, ECE, OECD and the Council of the *Codex Alimentarius Europeaus* with proposals that would lead to the establishment of an international food standards programme.

In November 1961, the Eleventh Session of the Conference of FAO passed a resolution to set up the Codex Alimentarius Commission.

In May 1963, the Sixteenth World Health Assembly approved the establishment of the Joint FAO/WHO Food Standards Programme and adopted the statutes of the Codex Alimentarius Commission.

BOX 2.15: Controversies in the US about regulation and control of pesticides in food

In 1996, Congress unanimously passed landmark pesticide food safety legislation supported by the Administration and a broad coalition of environmental, public health, agricultural and industry groups. President Clinton promptly signed the bill on August 3, 1996, and the Food Quality Protection Act of 1996 became law (P.L. 104-170, formerly known as H.R. 1627).

However, according to the Organic Consumers Association, it is rather easy to cast doubt on a scientific study -simply try to reproduce the study using methods that are sloppy enough to assure that the results will not be reproduced. "On the one hand we have a study showing harm, on the other hand some scientists have been unable to reproduce these results." So regulators are paralyzed.

Along with this opinion, in May 2006, representatives for thousands of U.S. Environmental Protection Agency scientists are publicly objecting to imminent agency approval for a score of powerful, controversial pesticides, while the agency "risk assessments cannot state with confidence the degree to which any exposure of a fetus, infant or child to a pesticide will or will not adversely affect their neurological development." Environmental advocates say the letter proves that there is serious dissent and concern about political interference within the EPA and other federal agencies, (Organic Consumers Association *(a),* **2006**).

Box 2. 16: Summary of Via Campesina's 'seven principles to achieve food sovereignty'

Summary of Via Campesina's 'seven principles to achieve food sovereignty'

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 agro-chemicals.
4. *Reorganizing Food Trade* – Food is first and foremost a source of nutrition and only secondarily an item of trade. National agricultural policies must prioritize production for domestic consumption and food self-sufficiency. Food imports must not displace local production nor depress prices;
5. *Ending the Globalization of Hunger* – Food Sovereignty is undermined by multilateral institutions and by speculative capital. The growing control 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* – Smallholder 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.

Source: Windfuhr and Jonsén, (2005)