

A Viable Food Future (Part II)

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A Viable Food Future



PART II



UTVIKLINGSFONDET
THE DEVELOPMENT FUND • EL FONDO DE DESARROLLO

A Viable Food Future

Part II

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The Development Fund is an independent Norwegian non-governmental organisation (NGO). We support environment and development projects through our local partners in Asia, Africa and Latin America. We believe that the fight against poverty must be based on sustainable management of natural resources in local communities.

A Viable Food Future

PART II

Published by Utviklingsfondet / The Development Fund, Norway

What kind of food production can

drastically reduce poverty,

reduce climate change and cool the planet,

restore biodiversity, soil fertility and water resources,

improve livelihoods and provide employment for billions of people,

produce enough, good, and nutritious food for 9 billion people or more ...



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Process and acknowledgement

This is Part II of a two-part report. Part I is published separately. Both are built on contributions from many people – the knowledge and experiences of small-scale food producers, activists in social movements and NGOs, politicians, technicians, writers and scientists as well as representatives of international institutions and organisations.

The report is the result of many people's work. Angela Hilmi has written the draft of the main parts of the report, both Part I and Part II. Marta G. Rivera Ferre has written the chapter on livestock and pastoralism and KG Kumar has written the chapter on fisheries. Elenita Daño has contributed to the section on biotechnology and Jonathan Ensor has contributed to sections on climate issues and also edited some of the case studies. Anuradha Mittal and Mia Henriksen have edited case studies on good practices and projects.

The first draft of the report (both parts) was reviewed by an Advisory Committee and discussed during a two-day meeting in Norway whereby rich contributions were provided. The following persons took part in the advisory meeting: Angela Hilmi, Bell Batta Torheim, Dena Hoff, Devinder Sharma, Eric Holt-Gimenez, Faris Ahmed, Jonathan Ensor, Marta G. Rivera Ferre, Elenita Dano, Nnimmo Bassey, Nora McKeon, Olav Randen and the editor. Their comments and suggestions were very valuable and important in formulating the final version of the report. Many, many thanks to all of them.

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In this Part II the authors of different sections are named. They are responsible for the content and it does not necessarily reflect the viewpoints of the publisher or the editor.

My role as editor of part II has mainly been to organize the work and writing of the text, help structure the report and work on the political conclusions and recommendations.

Aksel Nærstad, editor



I. ISSUES FOR A VIABLE FOOD FUTURE

Angela Hilmi (The whole section I, except the introduction which is written with the editor.)

Introduction

Angela Hilmi and Aksel Nærstad

Our planet is shrinking; our notion of time is being cut short. The once-described planet endowed with a profusion of fruits ready for humanity to reach out and take, suddenly seems to have become too small, too fragile, too unstable to hold an ever-increasing human population. The sense of belonging, the attachment to the roots, the feeling of being part of a tradition, of a history is being replaced by an increased sense of instability and threat. Doubts on the idea of progress, on the assumption of a linear process of development have been challenging the genuine efforts to bring a better life. It is now the very idea of a future that is being challenged.

Through crisis after crisis, the global community meets to propose better ways to cope with the challenges ahead. The very long-term objectives do not differ much in their expression, but the different paths to reach them seem often far apart. Despite greater understanding of the complexity and interrelation of the various factors affecting livelihoods across the earth, options do not appear easy to implement. The one-size-fits-all solutions have disappointingly shown their limitations and some grandiose promises have fallen short of results.

If the goal is not to follow the path of vanishing empires of the past, then we need to revisit our relation to the earth, our sense of solidarity, and the way we fulfil our basic needs. This can mean returning to the origins of our daily foods in order to understand where they came from, how they were produced over the millennia, and decide how we want to shape our common future.

Literature provides us with a profusion of information and knowledge on the production of foods, the drivers of climate change, and the transformations of the environment. Enormous research efforts have focused on understanding their interconnectedness and on inventing new mechanisms and architectures to better cope with the challenges ahead. Scientists and organisations from all over the world have worked together to analyse the ecosystems of the earth, the state of the art of agriculture, science and technology, drawing scenarios and proposing directions for an informed policy to build a more ethical future for humankind.

A Viable Food Future brings to the forefront one of the earth's least recognized life systems – the small-scale food systems, systems that have produced a long tradition of accumulated knowledge and innovation. Based on latest scientific information, the report shows that these systems, coupled with the latest knowledge on sustainable agriculture, can be the key to facing the most acute challenges today: poverty, the climate, nature, employment and health. It demonstrates that embracing more sustainable practices is necessary and urgent, and argues for a strong support to those who feed the planet today: the small-scale food producers.

In its reporting, *A Viable Food Future* brings together salient issues of food, climate and the environment to emphasize and showcase possible paths towards more viable alternatives for the future. Based on the latest available data in selected fields, it reaffirms the basis of some assumptions for which policy makers and other interested fora may wish to have additional insights and references for informed policy decision. Practice and implementation is beyond the scope of this paper, but transition steps are proposed as a follow-up stage with some lines of thought on priority lines of action.

The report has been divided in two parts. Part I provides facts and ideas for what is needed to meet some of the most important challenges in the world today. It describes what kind of food production can:



- drastically reduce poverty,
- reduce climate change and cool the planet,
- restore biodiversity, soil fertility and water resources,
- improve livelihoods and provide employment for billions of people,
- produce enough good and nutritious food for 9 billion people or more.

Part I of *A Viable Food Future* takes stock of the fact that humanity is at a crossroads and proposes to unveil and explore existing opportunities that are known as well as an available wealth that remains unknown and unrecognized. This wealth, these opportunities can only be explored and developed if we recognize the need to embrace development through different lenses. Changing perspective will mean reformulating the questions we ask ourselves. It will mean shifting the focus and approaches for a path ahead.

Part II of *A Viable Food Future* illustrates this shift, puts it in context. It briefly provides a snapshot of some recent projections, strategic visions and development initiatives to add to the general picture, and suggests to focus on an existing wealth, presenting the key issues that may be overlooked, unknown or poorly understood, choosing some of the latest scientific knowledge in selected fields to illustrate the facts. This includes rethinking our food models, not only as a physiological or corporate exercise, but as the most important and deeply rooted base of the wealth of nations. A wealth that can no longer be described in purely economical terms but that will need to be readjusted to encompass wider dimensions beyond GDP. In other words, it promotes advancing the richness of human life, rather than the richness of the economy in which human beings live.

In this Part II there are also separate chapters on fisheries and livestock as well as an extended version of the recommendations in Part I. The authors of different sections in Part II are named. They are responsible for the content of their articles and it does not necessarily reflect the viewpoints of the publisher or the editor.

DEFINING OUR TERMS

This report draws upon a broad set of references to underpin its content, and as is often the case, we have found that experts use different terms to refer to the same issues. Thus, it is important to define the terms we are using.

Sustainable agriculture, ecological agriculture, agro-ecology are used intermittently according to the context but all refer to agriculture that centres on food production that makes the best use of nature's goods and services while not damaging these resources. Further, these terms reflect:

- the application of ecology to the design and management of sustainable agroecosystems,
- a whole-systems approach to agriculture and food systems development based on traditional knowledge, alternative agriculture, and local food system experiences,
- linking ecology, culture, economics, and society to sustain agricultural production, healthy environments, and viable food and farming communities.

Industrial agriculture is based on maximising large-scale production and productivity of individual commodities and products through mechanisation and motorization, the development of agrochemicals to fertilize crops and control weeds and pests, and the use of high-yield varieties of crops.

Traditional agriculture refers to forms of farming, resulting from the co-evolution of local, social and environmental systems. It exhibits a high level of ecological rationale expressed through the intensive use of local knowledge and natural resources, including the management of agrobiodiversity in the form of diversified agricultural systems

Small-scale food producers are those men and women who produce and harvest field and tree crops as well as livestock, fish and other aquatic organisms. They include smallholder peasants, family crop and livestock farmers, herders and pastoralists, artisanal fisherfolk, landless farmers and farm workers, gardeners, forest dwellers, indigenous peoples, hunters and gatherers, and any other small-scale users of natural resources for food production.



Readjusting our lenses can have a significant impact on the way our societies look at themselves, and therefore on the way in which policies are designed, implemented and assessed, as what we measure shapes what we collectively strive to pursue. In this renewed vision, it will be crucial to give sustainable agriculture its due place and to ensure that the contributions of small-scale producers to the well-being of societies are truly understood, recognised, supported and rewarded. A whole new world is still to be invented, a world that is democratic, creative and knowledge-based – able to reconnect humans to nature and to the Earth. A step in that direction is the purpose of this paper.

Business as usual and some ongoing initiatives

Before moving to new ways of looking at our foods and to those who have produced it for millennia and without whom we would not be able to talk about what we eat, where we eat and how we eat, this first section of Part II briefly portrays a few on-going initiatives and provides references on some of the recent projections and models for the future of food, providing an idea of the basis on which major policies and programmes are drawn, financed and implemented today. Some are business as usual in the sense that they are based on approaches which have already been experimented in the past, others are offering new perspectives for a different approach for the future. It should be noted that these are just a few examples to add to the general picture, and that many more initiatives and models are being implemented.

The following selected projections, visions and initiatives are presented in more detail in Annex I.

FAO expert meeting on how to feed the world in 2050

In an FAO Expert meeting held in June 2009, entitled “how to feed the world in 2050”, models and perspectives were provided, based on three background papers on world food and agriculture to 2030/50. An integrated agro-ecological and socio-economic spatial global assessment of the interlinkages of emerging biofuels developments, food security, and climate change was provided to understand how climate change and biofuels may alter the long-term outlook for food which was developed by FAO in “Agriculture towards 2030/2050”. The report (Fishcher 2009) finds that, according to the reference projections in the simulations, the estimated number of undernourished would slowly decrease to 530 million by 2050, and to 150 million by 2080.

Another report (Alexandratos, 2009) provides a reality check of the OECD/FAO projections, concluding that the projections are still broadly valid, but that the advent of biofuels requires a fresh look at the long-term picture, as the potential exists for biofuels to be a major disruptive force conditioning agricultural futures because of the growing integration of the energy and agriculture markets. Finally the third report from Bruinsma (2009), provides an indication of the additional demands on natural resources derived from the crop production levels in 2030 and 2050 as foreseen in the FAO 2006 projections. The paper indicates that growth in agricultural production will continue to slow down. It estimates that the agricultural production would need to increase by 70 percent by 2050, to cope with a 40 percent increase in world population and to raise average food consumption to 3130 kcal per person per day by 2050. This translates into an additional billion tonnes of cereals and 200 million tonnes of meat to be produced annually by 2050 (as compared with production in 2005/07).

The outcome of this expert meeting was challenged by the CSOs, and a CSO Statement was released on 14 October 2009 expressing concerns regarding the fact that the forum did not discuss the origins of the multiple crises, including climate change, that are exponentially increasing hunger; that it missed a discussion on how to realise the Right to Food; and that it did not build on the most significant expert scientific assessment that addressed the specific question of this forum – the International Assessment on Agricultural Knowledge, Science and Technology for Development (IAASTD). The statement considered that the forum overlooked many of the key questions and did not achieve consensus on solutions.



Livestock in a changing landscape (Volume I and II)

This is the most comprehensive and recent publication on the livestock today, fruit of a large inter-institutional collaboration between FAO and other organisations. It states that the growing worldwide demand for meat is likely to have a significant impact on human health, the environment and the global economy in the next 50 years. Global meat production has tripled in the past three decades and could double its present levels by 2050. The livestock industry is massive and growing. The rapid growth of commercialized industrial livestock has reduced employment opportunities for many. In developing countries it has displaced many small, rural producers. The report concludes that “given the planet’s finite land and other resources there is a continuing need for further efficiency gains in resource use of livestock production through price correction for inputs and the replacement of current suboptimal production with advanced production methods”.

Reaping the benefits. The UK Royal Society (2009)

The publication provides a wide overview of the agricultural situation and a vision for the future. It proposes to move towards intensifying sustainable practices while exploring all potential options of modern technologies. It provides 12 recommendations with strong emphasis on research for the future.

UNEP Green New Deal (2009)

The Green New Deal is based on green growth centred on increased energy efficiency and reduced consumption. The core idea is complemented by financial regulations and development aid based on climate adaptation and support to renewable energies.

The High-Level Task Force (2008)

The dramatic rise of global food prices led the UN Chief Executive Board in April 2008 to establish a High Level Task Force on the Global Food Security Crisis. The primary aim is to promote a comprehensive and unified response to the challenge of food security. In July 2008, it developed a Comprehensive Framework for Action (CFA).

AGRA, the Alliance for a Green Revolution in Africa

AGRA is one of the most important and controversial on-going large-scale initiative in Africa. It aims at achieving a food secure and prosperous Africa through the promotion of rapid, agricultural growth based on smallholder farmers. The goal is to develop Africa’s high potential breadbasket areas and transform smallholder agriculture into a highly productive, efficient, sustainable and competitive system, and do so while protecting the environment.

The above provides a snapshot of some of the on-going projections, visions and initiatives that shape the development frameworks in food and agriculture today. The following will move from the global scale to a more down to earth perspective. After picturing where we are today in terms of mindset, the second and third sections of this report Part II, propose to revisit what happens in the field, which we sometimes seem to be unaware of. Models, projections, strategies and visions are useful tools but not sufficient in themselves if not grounded in both historical and spatial knowledge. This report argues that, despite the genuine efforts of organisations to project and achieve prosperity, the Millennium Development Goals have not been reached. Nobody actually knows what the future of food will look like, and no-one can tell who will actually feed us (ETC, 2009). Though we cannot know what the future will look like, we can still make sure, in our choices today, that the next generations will have a choice tomorrow. This will depend on how creative we can be to reinvent new economies better endowed to grasp the complexity of people and nature.



What we don't seem to know

This Part II of *A Viable Food Future* offers a reminder of an existing wealth that is often neglected, the wealth of traditional knowledge coupled with cutting-edge agroecological practices which make best use of nature and ecosystem services. Policies and modelling exercises, rapidly painted in the first section of Part II of this report, sometimes do not take full account of what exists today and has been evolving during millennia. There is a great potential to unleash and expand which we do not seem to be aware of. Thus, Part II pulls together the strings of people and nature, rectifying some figures and beliefs on who feeds the planet today, who are the small farmers and where our foods come from. It also pulls together the strings of nature and people – i.e. how the earth's biocapacity is being impacted by people, how the climate is changing because of people, how the agricultural diversity is nurtured by people – and it includes a story on roots, those parts of plants we never see, but when you learn more about them, you understand their underground world is almost like science fiction scenario.

This section is about what used to be and what is today which we do not see.

People and nature

Why is it that what is most obvious is the most difficult to see? If we look around us, we find a landscape full of stories, full of history, living testimonies of generations of small farmers, men and women, sometimes more women than men, who have nurtured and modelled nature and have been modelled by it in their minds and bodies. Sometimes it is too late; some agrarian systems have gone extinct. Walking through abandoned or neglected fields, we become temporary archaeologists, ethnobotanists, walking and observing what is left, the stones of ancient terracing, the intricate mix of wild plants, trying to find a path to move ahead, reflecting about time and space, picturing what it used to look like.

In our families, in our personal histories, we also have stories that were recounted to us, about great-grandparents and others before them who lived in the countryside, or cultivated the land, or migrated in search of land, those who survived with the land, those who were evicted from their land, those who shared land, shared grazing land, sharing trees, sharing crops, applying sophisticated irrigation rights, using common property resources in deeply rooted social systems, and many more.

According to Eyzaguirre (2006), an anthropologist at Bioversity International in Rome, “culture is the fundamental instrument and process by which humans adapt and evolve. It guides the development of institutions, decisions, social cohesion, rights and collective action. Culture contains and transmits bodies of knowledge. Perhaps it is the very centrality of culture within agriculture that made it so difficult for agricultural scientists, and development experts to see it for so long. Culture was well hidden right in front of us, all around us, all the time. No wonder we did not see it”.

What we do not seem to know, what we do not seem to question, is that perhaps these traditional ways of producing food, were not so backwards after all. Perhaps beyond food they were also providing labour, one of the most acute problems today, perhaps beyond food they were also providing viable landscapes, maintaining renewable resources rather than exploiting them to extinction or until they become too polluted to continue to be used and misused. Perhaps they provided diversity and health. Perhaps they were rooted in a wider perspective of time, seeing beyond immediate profit, what was required to plan for the very long term; perhaps they were grounded in nature and had a bigger sense of belonging.

Who feeds us?

What we ignore is that it is not the industrial food system that is providing enough food to feed humanity. Because some of the food produced and exchanged locally is not accounted for in national statistics and, in fact, statistics can only provide an approximate picture of reality, we have a tendency to transpose the figures of traded commodities on the idea of how people are being fed. Statistics can only give us what can be measured, what can be accounted for, no less, no more. But there is much more, more complex and more diverse.



Despite the general discourse, policies to support small-scale farmers have not reached them in a significant and transformative way. – Surprisingly enough, small-scale farmers are on the increase in the USA and other countries where, for “efficiency” purposes, they were supposed to become extinct. The actual miracle is that they remain in existence and continue to struggle despite all the forces against them. Many of them have no choice. There is no longer another sector of the economy that can absorb them as labourers. They continue cultivating the land in a difficult environment rather than migrating or increasing the “*vivid multidimensional picture of people living in poverty*”.

The commonly used total figure on the number of smallholder farmers is 1.5 billion (including family members). However, the reality when including other small-scale producers such as urban gardeners, livestock keepers, nomadic pastoralists, fishers and forest-keepers around the world, is probably double that number (almost half the world’s human population). In total, they provide at least 70 percent of the world’s food (ETC, 2009).

ETC (2009) has published the figures for the different small-scale food producers (including urban gardeners, livestock keepers, nomadic pastoralists, fishers and forest-keepers) and reaches the conclusion that while we are considering the figure of 1.5 billion (or so) smallholder farmers, in reality it is probably the double.

ETC (2009) calculates that of the 450 million farms, 382 million (85%) have 2 hectares or less. If we count 4 people per farm that means that 1.5 billion small holders and their families live in the global South of which 370 million are indigenous farmers.

In total, peasants probably have significantly more than half of the world’s cropland with 764 million hectares held by peasants and not less than 225 million held by big farmers.

In addition it is estimated that 640 million peasant farmers and an additional 190 million pastoralists raise livestock for their own consumption and local markets. Since pastoralists move about and routinely cross national boundaries, they are seldom included in food security calculations.

Regarding fishers, the figure is between 30 and 35 million fishers and there are also more than 100 million peasants involved in fishing, processing and distributing what amounts to half the world’s fish caught for direct human consumption (or 30 million metric tons). The volumes outside the market are not reflected in these figures. In total, 2.9 billion people get 15% or more of their protein from ocean or fresh water fish.

The least known figures are those of urban farming. Before the food crisis, an estimated 800 million peasants were involved in urban farming. Of these, 200 million produce food primarily for urban markets and manage to provide full-time employment for about 150 million family members. On average, the world’s cities produce about one-third of their own food consumption.

Though it has not been possible to quantify the proportion of the food supply that comes from forests, roadsides, and other “marginal” land, we know that 1.6 billion people get some portion of their food and livelihood from forests around the world.

ETC clearly states that despite all the studies we have, we do not know where our food comes from, and we do not know who is feeding the hungry today. We have absolutely no idea who will feed us in 2050.

What we do know, as per the references in ETC’s publication, is that 85 percent of the world’s food is grown and consumed within the “100 mile diet” or within national borders and the same eco-regional zone. Most of this food is grown from peasant-bred seed without the industrial chain’s synthetic fertilizers. “Peasants breed and nurture 40 livestock species and almost 8000 breeds. Peasants also breed 5000 domesticated crops and have donated more than 1.9 million plant varieties to the world’s gene banks. Peasant fishers harvest and protect more than 15,000 freshwater species. The work of peasants and pastoralists maintaining soil fertility is 18 times more valuable than the synthetic fertilizers provided by the seven largest corporations.



Together these peasants make up almost half the world's peoples and they grow at least 70% of the world's food. Better than anyone else, they feed the hungry. If we are to eat in 2050 we will need all of them and all of their diversity."

Who are the small farmers?

Discussions with the experts from the FAO Statistics Division brought a surprising realisation: we actually do not know exactly who the small farmers are. The reason is simple, country censuses do not systematically report on very small holdings or on small farmers simply because there has never been a universally agreed definition of small farmers. Are they small because of the size of their holdings? But then, this is relative and varies from country to country. For example, the average size of holding estimated in Bangladesh agricultural survey of 2005 comes to only 0.3 ha (FAO, 2010c) while in a country like Australia the mean size is 3243 ha. And in the case of China, the mean size of holdings is about 250 times lower than the mean size of the US holdings (0.67 ha compared with 178 ha).

Characterisation of small farmers

The following text and tables come from discussions held with FAO statistical experts for the writing of this report, and from background documents kindly shared by them:

- Characterisation of small farmers in Asia and the Pacific, Asia and Pacific Commission on Agricultural Statistics Twenty-third Session – Siem Reap, Cambodia, 26-30 April 2010.
- Report on the 2000 World Census of Agriculture (WCA) – International comparison tables on structure of agriculture (1996-2005) – FAO Statistical Development Series 13, under peer-review, to be published December 2010.
- Excel table Changes in distribution of number and area of holdings in 2000 WCA round as compared to the previous three rounds.
- Excel table Number and area of holdings classified by size of holdings.

Average size and fragmentation of agricultural holding during (1995-2005)

Countries by continent (Number of reporting countries is given in parenthesis)	Average area per holding (ha)	Average number of parcels per holding
WORLD TOTAL (114)	5.5	3.5
AFRICA (25)	11.5	3.0
AMERICA, NORTH & CENTRAL (14)	117.8	1.2
AMERICA, SOUTH (8)	74.4	1.2
EUROPE (29)	12.4	5.9
ASIA (29)	1.0	3.2

Countries adopt varying criteria for coverage and classification of agricultural holdings in their census and surveys, which make international comparisons difficult. Often classification and tabulation of data from agricultural surveys are not carried out to adequately reflect the role played by small farmers. There is a need to consider data requirements of policies for small farmers at the time of planning agricultural surveys. The marginal cost for provision of such data, according to FAO statistical experts, will be negligible. There is also need to evolve an internationally comparable criterion for characterisation of small farmers.



Agricultural holding, for the collection of census information is defined by FAO in the Statistics Division and cited in its paper “*Characterisation of small farmers in Asia and the Pacific, Asia and Pacific Commission on Agricultural Statistics Twenty-third Session*” – Siem Reap, Cambodia, 26-30 April 2010 as “the economic unit of agricultural production under single management comprising all livestock kept and all land used wholly or partly for agricultural production purposes, regardless to title, legal form or size. The holding could comprise more than one parcel located in one or more villages and the single management may be exercised by one household or jointly by two or more households or by a juridical person including authorized companies or public institutions.”

Most countries however restrict this definition for practical purposes.

The cut-offs, based on scale of operations of holdings, are also used to keep the surveys and censuses cost-effective and under manageable limits. But for statistical purposes, it would also be important to have knowledge of activities which may be tiny in their individual capacity but together may contribute significantly to the agriculture sector or to food security.

Out of 114 countries reviewed by the Statistics Division of FAO, only two countries carried out sample surveys to assess the contribution of the small-scale sector which usually remained outside the purview of the agricultural census. The fact that very small holdings are excluded from the statistics does not allow to reflect their importance, which in turn does not allow to develop policies that can be targeted to supporting them.

MULTIDIMENSIONAL POVERTY INDEX OR MPI

Developed and applied by The Oxford Poverty and Human Development Initiative with UNDP, the MPI will supplant the Human Poverty Index as of 2010.

Oxford University and the United Nations Development Programme combined expertise to develop a new poverty measure that would give a more accurate account of the true picture of poverty. It was announced in London, 14 July 2010.

“The Oxford Poverty and Human Development Initiative (OPHI) of Oxford University and the Human Development Report Office of the United Nations Development Programme (UNDP) launched a new poverty measure that gives a “multidimensional” picture of people living in poverty which its creators say could help target development resources more effectively. The new measure, the Multidimensional Poverty Index, or MPI, was developed and applied by OPHI with UNDP support, and will be featured in the forthcoming 20th anniversary edition of the UNDP Human Development Report. The MPI supplants the Human Poverty Index which had been included in the annual Human Development Reports since 1997.

The 2010 UNDP Human Development Report will be published in late October, but research findings from the Multidimensional Poverty Index were made available at a policy forum in London and on line on the websites of OPHI (www.ophi.org.uk).

OPHI researchers analysed data from 104 countries with a combined population of 5.2 billion (78 per cent of the world total). About 1.7 billion people in the countries covered – a third of their entire population – live in multidimensional poverty, according to the MPI. This exceeds the 1.3 billion people, in those same countries, estimated to live on USD 1.25 a day or less, the more commonly accepted measure of ‘extreme’ poverty. Half of the world’s poor as measured by the MPI live in South Asia (51 per cent or 844 million people) and one quarter in Africa (28 per cent or 458 million). Niger has the greatest intensity and incidence of poverty in any country, with 93 per cent of the population classified as poor in MPI terms. Even in countries with strong economic growth in recent years, the MPI analysis reveals the persistence of acute poverty. India is a major case in point. There are more MPI poor people in eight Indian states alone (421 million in Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Orissa, Rajasthan, Uttar Pradesh, and West Bengal) than in the 26 poorest African countries combined (410 million). The MPI also reveals great variations within countries: Nairobi has the same level of MPI poverty as the Dominican Republic, whereas Kenya’s rural northeast is poorer in MPI terms than Niger.”

From <http://hdr.undp.org/en/reports/global/hdr2010/news/title,20523,en.html>



For deciding the threshold level for holdings and for categorizing the farmers (holders) based on the scale of their operations, usually the main underlying criterion is “economic contribution”. At operation level, this categorisation is defined on the basis of one or more of the following factors:

- land size,
- herd size,
- marketable/marketed surplus/volume of sales, or
- income earning potential of the holding.

Operated land is the most important variable for characterizing the scale of operations, except perhaps for nomadic livestock holdings, because the land is the basic agricultural resource and is most closely related to other variables of scale, e.g. volume of production, volume of sale or herd size. Often a complex criterion involving land, livestock and sales is used to categorize agricultural holdings for the purpose of agricultural censuses and surveys, as well as for differentiated treatment in development policies. However, the use of such complex definition of agricultural holdings poses a challenge to international comparison of data on structure of agriculture. On the other hand, characterisation of holdings solely based on land size ignores other productive assets or activities of agriculture, such as livestock.

In the case of European countries, categorisation criterion is based on income generating potential. Standard Gross Margins (SGMs) are a way of classifying farms according to the type of enterprises on the farm, and their relative contribution to overall profit. The SGM provides a measure of a holding's business size, irrespective of its area and intensity of production.

A general picture

Some extracts – from FAO's International Comparison Tables on key structural characteristics of agriculture in FAO member countries, which are still under review, give an overview of the great diversity between countries, providing a perspective of small farmers within the global picture (FAO, report under peer-review).

There is an amazing diversity in the average size of farms across the world. For instance China has almost hundred times more holdings than the USA, but only four times its population. But the total area of the Chinese holdings represents one-third of the area of the USA holdings. Not more than 10 percent of farms in China are bigger than 1ha, but only about 10 percent of farms in the USA are smaller than 5 ha.. This is also greatly reflected on the distribution of holdings by size: out of 193 million Chinese farms, 180 millions are less than one ha, representing 93 percent of the Chinese farms. Vietnam (85 percent) and Indonesia (75 percent) present similar ratios.

Six countries that have a remarkably huge mean size of their farms are: Argentina (583 ha), South Africa (288 ha), Uruguay (287 ha), Canada (273 ha.), New Zealand (223 ha), the USA (178 ha) and Australia (3243 ha). For all other countries, the mean size never exceeds 100 ha. The situation is however very varied by continents:

- **In Africa**, except South Africa, the mean size of holding is always equal to or less than 10 ha (10.45 in Libya and 10.24 in Tunisia represent the maximum). The African countries with the lowest mean size of holdings are: Madagascar (0.86 ha), Egypt (0.83 ha), and Cape Verde (1ha), and Comoros (0.07). This may seem to qualify as backyard-gardening and not agriculture if one considers the Australian dimensions of an agricultural holding.
- **In North and Central America**, very large holdings in the USA and Canada and less than 30 ha elsewhere (Nicaragua has the maximum with 31.34 ha).
- **In South America**, in addition to Argentina and Uruguay already mentioned, some other countries also have quite large holdings including: Chile (83.74 ha) and Brazil (72.76 ha).
- **In Asia**, no country has more than 5 ha per holding, except countries of Near East: Saudi Arabia (16.70 ha) and Qatar (11.91 ha).



- **In Europe** no countries has more than 100 ha, but a number of countries have quite large holdings including: Czech Republic (99.28 ha), Sweden (93.87 ha), Finland (72.24 ha) and UK (70.86), and about 10 countries have between 10 and 50 ha.
- **In Oceania**, huge holdings are in Australia and New Zealand, but very small holdings in all other islands, except New Caledonia (51.95 ha).

While globally the average number of parcels per holding is 2 or 3, the highest numbers of parcels (10) are noted in Spain which is followed by Morocco with over 6 parcels per holding. Cyprus, Turkey, and the Czech and Slovak Republics, on an average, have 4 or 5 parcels per holding.

Gender. Most agricultural holdings in the world are managed by men. On all continents, among the 56 countries which reported data by gender, the percentage of holdings managed by women is always less than 25 percent, and even less than 15 percent in Asia and Africa. Only one country shows a balanced situation, Cape Verde, with 50.5 percent of holdings managed by women. This situation was perhaps because the men have migrated out for better work opportunities.

Land tenure. Land of the holdings owned by the holder or in owner-like possession represents the most common form of land tenure. In most of the countries, over 50 percent of the holdings (both in number and areas) belong to this category. However, there are some specific cases such as Panama (only 37 percent in number and 32 percent in area), Philippines (45 percent in number and 47 percent in area) and Venezuela (47 percent in number but 75 percent in areas, perhaps due to ownership of large farms). The USA presents a unique situation with 67 percent of holdings owned by their holders but cultivating only 38 percent of the area.

Legal status of the holder. Investigation on this aspect was recommended by FAO because of the economic importance of farms managed by juridical persons (in other words an entity such as a firm/legal entity, other than natural person/human being), being public or private persons: they may be not numerous in a country, but take a large part in the national production and employ many workers. Figures extracted from the 57 countries reporting on form of management of holding seem to confirm the hypothesis that institutions, though few in number could manage large chunks of lands. In most of the countries, farms managed by juridical persons are fewer than 10 percent. Only four countries have more than 10 percent of farms managed by juridical persons: France 19.0 percent, Uruguay 13.7 percent, UK 11.9 percent and the USA 10.3 percent.

Employment on farms. Globally, the 250 million holdings in these 57 countries (including China)¹ employed 22 million workers, which is less than 1 worker per 10 holdings. Hiring of workers for agricultural activity – except perhaps for some specific productions in specialised areas, industrial crops, market gardening to meet seasonal demand – does not seem to be a common practice in most of the countries. Conversely, farms remain a huge source of employment in agriculture for household members of holders. In effect, of the 35 countries reporting on employment of household members, it appears that 228 million holdings employed 588 million members of households, with an average 2.58 household members working on the agricultural holding. China reported that 519 million household members were engaged in agriculture on 193 million holdings with 800 million persons an average of 2.7 agriculture workers in each household of 4 persons.

Land use for crops, permanent meadows and pastures, and forests. In Asian and African countries, cropland is the biggest part of the area of holding. In these countries, holders tend to limit the activities on their holdings to mainly crop cultivation. Since livestock are also present, permanent meadows may be someone else's property, perhaps collective or public, or for some nomadic livestock.

On the other hand, holdings in North and South America and Oceania generally establish a great part of permanent meadows for animals. They also keep significant areas of woodland and forests on their

¹ This set of countries represents 250 millions of holdings out of the 500 millions in the 114 countries having their census in the 2000 round.



holdings, perhaps in view of organising rotation with meadows. The share of cropland seems to be minimum in countries of South America, confirming the biggest part of agricultural activities on this continent devoted to livestock.

European countries present a more balanced situation, with between one-half and three-quarters of the area of holding serving as cropland, about a quarter for meadows and less than 10 percent devoted to wood and forest.

Crops. For main crops, Asian countries reporting census results cultivate 89.9 percent of all the world's rice, with India cultivating 44.2 percent and China 28.6 percent. Asia also cultivates 48.6 percent of the world's area under wheat and 39.9 percent of the area under maize. These ratios confirm the hypothesis that Asian countries tend to concentrate on the cropping of basic cereals. Globally speaking, more than half of the area under cereals is located in Asian countries. However, shares of production may be distributed differently over continents, because of differences of yields as well as of number of harvests per year (for rice for instance). The scale of production of a commodity differs from country to country. The largest wheat growing farms are in the Americas: Canada (149 ha of wheat per holding), USA (109 ha) and Uruguay (101 ha) while the same ratio in Asia is lower, with only 0.9 ha of wheat per holding in India.

Livestock. Cattle is the species that seems to be widely spread over the planet. Among African countries, the biggest stock of cattle is in Ethiopia. The USA owns about 80 percent of the cattle in North and Central America. In South America, Brazil owns about 60 percent of the cattle, a herd larger by more than three times than the next country, Argentina. India owns about 60 percent of the Asian cattle stock, much higher than China which owns a bit more than 20 percent. In Europe, France has about 20 percent of the stock, but the French stock represents only 2 percent of the total number of cattle worldwide.

The concentration ratios for cattle, which indicates the intensity by calculating the average herd size on a holding, cannot be calculated for all countries. However the countries with the largest stock of cattle do not have the highest concentration ratios. In Asian and African countries for which ratios are available, the mean herd size never exceeds 40 animals per holding (38 in Botswana and 27 in Japan, ignoring Cyprus which has so few holdings). In most of the European countries, individual herds are often between 40 and 100 head (96 in the UK). And the largest herds of cattle are certainly to be found in the Americas (94 in the USA, 127 in Canada, 212 in Uruguay).

Asian countries keep 97 percent of the world's buffalo. India alone has 62 percent of the buffalo, while China has only 13 percent. However, it is worth mentioning some specific location of buffalo herds in South America; there are 500 holders in Venezuela who raise more than 62,000 buffalo equally 117 head per holding, the peak of concentration worldwide. Italy also is an area of concentration, with more than 2000 holders raising about 180,000 buffalo, the source of the worldwide famous cheese "*mozzarella di buffala*".

Australia and New Zealand together have about 150 million sheep, a bit more than two-thirds in Australia, less than one-third in New Zealand. This Oceania herd represents only a bit more than 20 percent of the world herd. While Australia has only 1 percent of the total number of holders raising sheep worldwide, the mean size of individual herds reaches about 8500 head per holding, a figure certainly never seen in any other country. The Asian countries raised about 40 percent of the sheep (with almost as many sheep in China as in Australia). African countries also have a significant share (16 percent) of the world sheep stock, principally located in the Maghreb (Algeria and Morocco), Ethiopia and South Africa. European herds of sheep are about 16 percent, with peak of concentration in the UK where the mean size of individual herds is more than 500 head per holding, triple the Spanish herds.

Three-quarters of the world's goats are raised in Asian countries, mainly China, India and Pakistan, with less than 4 percent of goats in America and 3 percent in Europe, almost half of them located in Greece.

About 56 percent of the pigs are raised in Asian countries, mainly in China, which has more than 90



percent of the Asian pigs on its territory. European countries altogether, raise 25 percent of the pigs worldwide, practising mostly intensive raising with impressive peaks of concentration such as 1354 heads per holding on average in Ireland, 826 in the Netherlands, 751 in Denmark, 720 in Belgium (comparable to 765 in the USA). However, the record of concentration is in Australia where about 1000 producers raise more than 2.7 million pigs, less than half a percent of the world total, but an impressive average of 2400 pigs per holding.

One-third of the world's chickens are raised in North America, of which 90 percent are in the USA, which appears to be, by far, the main raiser (note that no figure is available for China). Brazil, the second country by the size of poultry population, has only 40 percent of the USA. India, the third, has only 25 percent of what the USA has. Chickens are spread all over Europe, but all the European countries together raised only 23 percent of the world poultry, a bit more than Asian countries (not counting China) and South America, which account for around 17 percent each.

Defining small-scale food producers

There is wide diversity in the way small farmers are defined. Various representatives of academia, development organisations, farmers' organisations and many other individuals were asked to provide their own definition of small farmers for the purpose of writing this paper. Their answers varied tremendously. One definition is given here, a definition of small-scale food producers from Pimbert, cited in the ETC Communiqué of November 2009. Reactions from two farmers are also cited.

"Small scale food producers are those men and women who produce and harvest field and tree crops as well as livestock, fish and other aquatic organisms. They include smallholder peasant/family crop and livestock farmers, herders/pastoralists, artisanal fisherfolk, landless farmers/workers, gardeners, forest dwellers, indigenous peoples, hunters and gatherers, and any other small scale users of natural resources for food production" (Pimbert 2009).

Reactions from farmers:

"Peasants? The language around us is changing all the time. Historically, we were peasants. Then when that term came to mean 'backward' we became 'farmers'. In these days 'farmer' has the connotation of inefficiency and we are strongly encouraged to be more modern, to see ourselves as managers, business people or entrepreneurs capable of handling increasingly larger pieces of territory. Well, I am a farmer and I am a peasant. I learned that I had much more in common with peasants than I did with some of my agribusiness neighbours. I am reclaiming the term peasant because I believe that small is more efficient, it is socially intelligent, it is community oriented. Being a peasant stands for the kind of agriculture and rural communities we are striving to build." - Karen Pedersen, past-president, National Farmers Union (Canada). (Pimbert 2009).

"This debate in the literature ... is a fabrication at a higher level, by those who know more. In the countryside, out there, there is no such debate. We continue being peasants. That's the way it is." - Emiliano Cerros Nava, Executive Commission, UNORCA (Union Nacional de Organizaciones Regionales Campesinas Autonomas), Mexico. (Pimbert 2009).

Where do our foods come from?

The way the question is being formulated in the various international *fora* is: "how to feed a human population that will reach nine billion by the year 2050?" Let us imagine for a moment what would happen if we would allow every cultivated ecosystem of the planet to lie fallow again. Each one would quickly return to a state of nature close to the one existing 10,000 years ago. Wild flora and fauna would overwhelm cultivated plants and domesticated animals. Nine-tenths of the world population would perish because in this Garden of Eden, simple predation (hunting, fishing, gathering) would not feed more than 500 million people. If such a scenario would unfold, modern industry would not be of much help either, as the fiction of a humanity fed by pills has not materialized. This means that, in reality, there is no other way then to feed 5 or 20 billion people than to cultivate and garden our planet.



The question is “*how?*” There is no obvious answer. If the return to wild nature is only a pleasant fictional utopia, and the production of synthesized foods an unreal chimera, the thought of extending mechanized agriculture, as it is designed today, to the rest of the planet, is also a dangerous fallacy. Wisdom will not lay in quick fixes of technological silver bullets, but rather in the ability to live and adapt in connivance with nature, bringing back some dimensions we may have lost in the process. This seems to be our major challenge today, learning lessons from the past we came from, to be able to project ourselves further in time.

Little can be said if we do not first understand the need we have, as human species, to feed ourselves from a diversity of foods. *Homo sapiens sapiens* is above all, an omnivorous species that looks for the satisfaction of its physiological and also psychological and spiritual well-being for a range of different types of complementary foods prepared in an array of sophisticated cuisines which are expressions of cultures that have evolved across space and time. *Homo sapiens sapiens* can adapt to almost any types of foods. Unlike the koala-type dependency on singular foods, our species has been able to transform and adapt across greatly diverse agro-ecological environments.

Though humans do not appear to have been genetically programmed to farm as other species seem to be, they have, over the years, developed an extraordinary capacity to forge environments to satisfy their needs. Why and how, this is what is briefly presented in the following sections.

An eclectic, omnivorous and adaptable species

Some animal species transform their environments to create conditions of life for the species they exploit. Ants and termites are such cases. Some cultivate mushrooms which they enjoy eating, others raise aphids and delight on their honeydew. This intriguing story started 180 million years ago and we can witness living fossils that have been practicing agriculture and breeding for thousands of years. If we could change scale for a moment, we could travel through the nests, galleries and caves where they grow their fungi. The meticulous organisation of their production systems are astounding.

The ants’ galleries are several metres deep, leading to rooms with flat floors and vaulted roofs, which can reach 1 metre long and 30 centimetres wide, with the mushroom gardens perfectly laid out. At the heart of the gardens, a huge central nest links up to dozens of satellite nests in a 200-metre radius. Transportation is organised through a radiating network of trails several dozen metres long set up for double circulation with one column of ants going to their cultivated “fields” and the other one bringing back the harvest. Other species breed aphids either by permanent underground stabling, with aphids being placed in special stables, or in the open air, in which case the ants will regularly transport the aphids to find better pastures. These forms of agriculture and breeding are elaborated forms of mutualism. The well-being of both exploiting and exploited species is closely dependent on each other.

Homo sapiens sapiens is a very recent species among the thousands evolution has produced. As a product of evolution, it is not endowed with specialized anatomical tools or a genetically programmed mode of life that would, from the start, enable it to exercise a strong effect on the outside environment. Deprived of pincers, hooks, stingers, fangs, tusks, serrated teeth, hooves or claws, a human being, instead, has hands which are in themselves a weak tool and a feeble weapon. Poor in instincts but immensely educable, the principal asset of humans resides in the variety of dietary regimes and modes of life that can suit them. Humans are eclectic, omnivorous and adaptable. From one species of hominids to the next, an expanding cultural diversity multiplied the possibilities for innovations and adaptations to an ever increasing diversity of environments. Contrary to ants and termites, which exploit only one species, human forms of agriculture opened up to an increasing number of plant and animal species which evolved and co-evolved over time in a never-ending story of increased complexity.

It all started with climate change

Around 15,000 years ago, the planet was in the grips of large ecological disruptions. The climate became warmer, the polar icecaps melted and the billions of cubic metres of water thus released caused the sea level to rise by several metres. The vegetation on the different continents changed with different plant formations and forests covering the different regions of the world.



Controversy and heated debates have filled the evolving thinking on the origins of agriculture. For a long time, the emergence of Neolithic agriculture was understood as the simple invention and rapid generalisation of new techniques as a response to the growing limitations of wild resources. Recent archaeological studies in the different centres of origin have now demonstrated that this is absolutely not the case. The passage from a society of hunter-gatherers to a peasant society has been, on the contrary, an extremely long and complex process based on material, social and cultural transformations conditioning one another over hundreds of years.

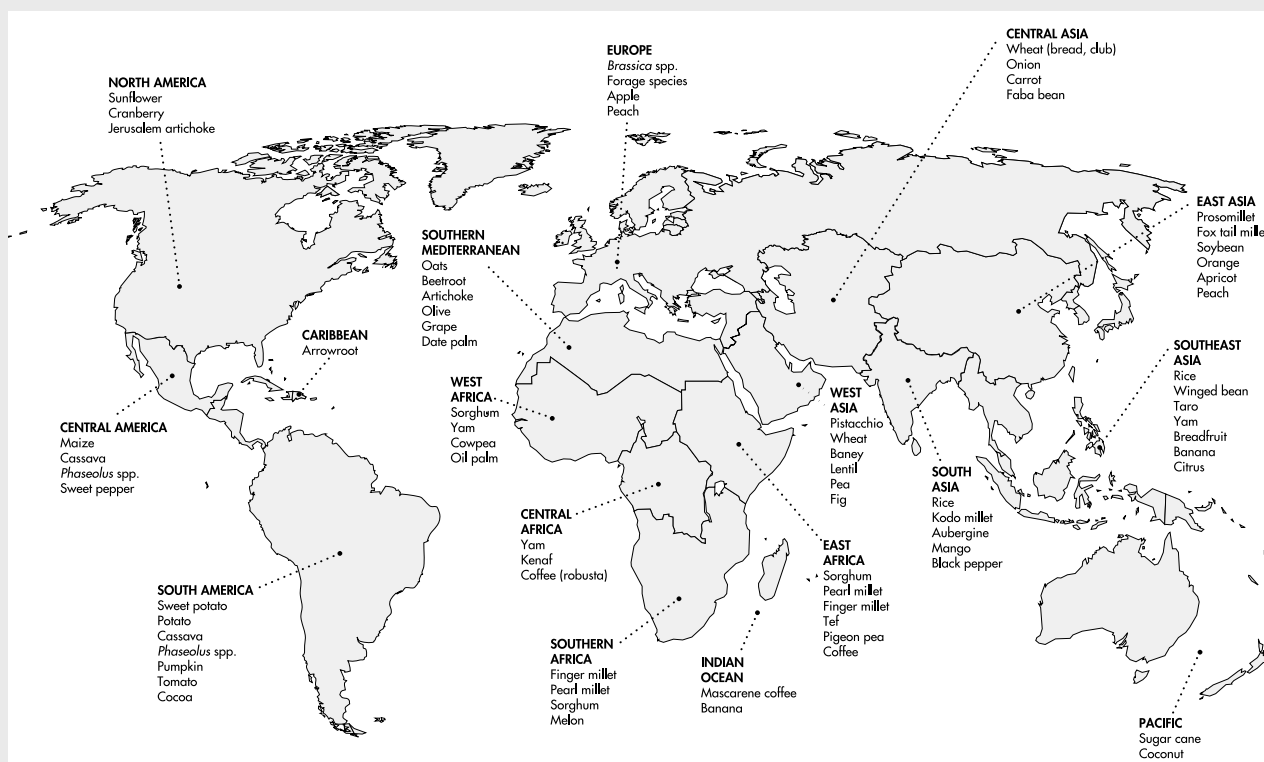
This intriguing story is the very story of humankind. Here, we only extract a short summary of the story related by Dufumier (2004). As the climate warmed up, the cold steppes in the mountainous arc between Mont Zagros, Mount Taurus and the mountains of Lebanon transformed into a savannah rich in wild cereals such as barley, wheat and einkorn,² legumes such as lentils, peas, vetch, but also rich in pistachio and in game such as aurochs, wild sheep and goats and boar.

The populations of hunter-gatherers no longer needed to move long distances to feed themselves. They progressively moved from living in caves to settling in villages close to the ecological areas most propitious for finding their foods and clothes. Manual tools had already diversified into, for example, flint sickles, knives, pestle, grindstone, and axes.

It is believed that many centuries, probably up to 2,000 years preceded the birth of agriculture. Demographic density increased and with it, the need to move further away from the villages. Forms of protoculture and protobreeding evolved, with a few seeds being planted close to the houses, and the taming of animals with preferential slaughter of the males and selection of the best females for reproduction. It is the repetition of this process during very long periods of time that gave birth to new

2 *Hordeum spontaneum*, *Triticum dicoccoides* and *Triticum aegilopoides*.

Regions of diversity of major cultivated plants



FAO (1997) the state of the world's plant genetic resources for food and agriculture



domestic species, “heirloom seeds” that were different from their wild ancestors, such as barley, emmer, other forms of einkorn,³ lentils, chick peas, linen, cattle, sheep, pigs, domestic goats etc. For a long time, fishing, hunting and picking continued to bring an important part of food calories and proteins.

Decisive for the future of humanity, the agriculture revolution of the Neolithic has been a very long process of progressive domestication of vegetable and animal species which had not been premeditated or anticipated. That seems to have happened at roughly the same time not only in the Near East, but also in widely scattered parts of the world, in the other centres of origin: in north China (7000 BC), in Mexico (6000 BC), in Papua New Guinea (8000 BC), in the Andes (4000 BC) and in the Mississippi. During this period, the world population grew from 5 to 50 million people (between 10,000 and 5,000 BC).

In this never-ending story about how our lives have always depended, and our future still depends, on how we grow our food, agriculture has always been and continues to be the fundamental activity that has provided the energy and shaped the form of all the world’s civilisations.

From the beginning, each region, each microclimate in the world, conditioned a unique pattern of farming and animal husbandry, with distinctive fruits and vegetables, distinctive animals, and distinctive farming methods. And coming from these unique patterns of farming, arose unique social customs and political organisations which in turn influenced the emergence of new patterns of farming. Wheat comes from the Middle East, corn from Mexico, potatoes from Peru, rice from Africa and chicken from China, just to mention a few. Our present daily staples originated all over the world. Very gradually, agriculture expanded from each of the original centres of origin to growing regions of the world.

How much do we depend on other countries for the origins of our foods?

A knowledge breakthrough on the origins of our foods was achieved in 1998 through the work of Flores Palacios for the FAO Commission on Genetic Resources. She studied the estimated range of dependency from genetic resources coming from elsewhere (Palacios, 1998). In other words, she was able to calculate how much of our foods originally came from other countries of the world. We often think of the foods we grew up with, as intimately related to our home countries. Realizing instead how little originated from within our country borders is astonishing. It also tells us how indebted we are to those who have cultivated, nurtured, and cared for the foods that reach us today, and without whom we would simply not exist.

The dependency study found out that the main food staples cultivated and consumed by the vast majority of the world’s population have their origins in the tropical and sub-tropical zones of Asia, Africa and Latin America.

It provides the following figures: a maximum range of dependency for North America of 99.74 percent, for Latin America 91.39 percent, for Europe 87.86 percent, for Africa 78.45 percent, for the Near East 56.83 percent and for Asia and the Pacific 53.30 percent. The report finds a global dependency of 77.28 percent which means that, on average, 77 percent of what humans eat originally came from another place of the planet, often thousands of kilometres away. This high dependency also has formidable potential for cooperation and synergy among the different countries of the earth, as to solve any problem with anyone of these crops, such as pests or diseases, means to search in the other countries of the world, especially in the country of origin, for the resistant varieties or wild relatives of these particular crops.

The following, based on the State of the World of Plant Genetic Diversity (1997) tells us more about what we eat:

It has been estimated that about 30,000 species of plants are edible and about 7,000 have been cultivated or collected by humans for food. It is often stated, however, that only 30 crops “feed the world”. These are the crops which provide 95% of dietary energy (calories) or protein. Wheat, rice and maize alone provide more than half of the global plant-derived energy intake. These three crops have received the most investment in terms of conservation and improvement. A further six crops or commodities,

³ *Hordeum vulgare*, *Triticum dicoccum* and *Triticum monococcum*.



sorghum, millet, potatoes, sweet potatoes, soybean and sugar (cane/beet), bring the total to 75% of the energy intake. Analysis of food energy supplies on a country by country basis shows that 90% of the per caput food plant supplies of all nation states are provided by only 103 plant crops. Yet there are many other species that are important to large numbers of people at sub-national levels, which fall outside the list when aggregated at a national level. These include local staples such as oca, teff, fonio or bambara groundnut, all of which tend to be neglected in terms of conservation and crop improvement programmes.

Minor crops and underutilized species

“Minor staples” include various species of yam, proso millet, fonio (“hungry rice”), bambara, groundnut, oca, taro/cocoyam, canihua, breadfruit, *Amaranthus*, quinoa, acanyt and buckwheat. Vegetables, fruits and other species, including wild plants and “weeds” gathered for food which contribute to nutrition and dietary diversification. Multipurpose trees, include trees managed in agroforestry systems and wild species that are harvested. Crops that can contribute to agricultural diversification include uncultivated or little cultivated species with alimentary or agricultural potential.

Wild species

Wild species are important, both nutritionally and culturally, to many people. People in different countries use wild food during periods of famine and especially during the hunger season that precedes crop harvests. Such foods form an integral part of the daily diets of many poor rural households. Wild foods are a source of important vitamins, minerals and other nutrients which complement the staple crops eaten by many of the most vulnerable people, including children and the elderly.

The value of plant genetic resources for food and agriculture in modern varieties

The improvements in agricultural production brought about through the use of modern varieties have been possible because of the rich and varied genetic diversity in farmers’ landraces, together with material

**Example of some OECD countries’ estimated range of dependency
from genetic resources from elsewhere:**

Countries	Minimum (%)	Maximum (%)
Australia	88.40	100
Canada	84.00	99.48
France	75.55	90.67
Germany	83.36	98.46
Italy	70.82	81.21
Japan	43.15	61.29
Korea	30.47	54.41
Mexico	45.12	59.48
Norway	90.67	98.94
Spain	71.41	84.84
United Kingdom	89.23	99.10
United States	77.36	100



from wild and weedy species. The initial stages of breeding for most crops have been based on locally adapted landraces. For instance, the wheat variety “Marquis”, which was grown across 90% of the spring wheat area of the North American Great Plains originated from a cross between the Indian landrace ‘Hard Red Calcutta’ and the European landrace “Red Fife”. Similarly, the breeding of winter wheat in Europe is historically based on a large pool of selections derived from numerous wheat landraces from many countries.

Landraces have provided many individual traits which have been introduced into existing improved breeding lines. It should be noted that some genes which once appeared to be of no particular value have since proved crucial in developing new varieties and conferring various resistances.

Wild relatives can also make enormously useful contributions to plant improvement. They have evolved over a long period of time and have coevolved with pests and diseases. One particularly outstanding example is that of the tomato (*Lycopersicon esculentum*). Wild species have been used as donors of genes for fungus resistance (*L. hirsutum*, *L. pimpinellifolium*); virus resistance (*L. chilense*, *L. peruvianum*); nematode resistance (*L. peruvianum*); insect resistance (*L. hirsutum*); fruit quality (*L. chmielewskii*); and adaptation to adverse environments (*L. cheesmanii*).

A good example of the importance of wild relatives is recounted by Harlan (1975) when he talks about a variety of wheat he collected in Turkey in 1948 which became crucial when a wheat stem rust disease became a very serious threat in USA:

“The potential value of a collection cannot be assessed in the field. Perhaps this statement could best be illustrated by PI 178383, a wheat I collected in a remote part of Eastern Turkey in 1948. It is a miserable looking wheat, tall, thin-stemmed, lodges badly, is susceptible to leaf rust, lacks winter hardiness yet is difficult to vernalize, and has poor baking qualities. Understandably, no one paid any attention to it for some 15 years. Suddenly, stripe rust became serious in the north-western states of the US and PI 178383 turned out to be resistant to four races of stripe rust, 35 races of common bunt, ten races of dwarf bunt and to have good tolerance to flag smut and snow mould. The improved cultivars based on PI178383 are reducing losses by a matter of some millions of dollars per year.”

The main crops on which humanity now depends have been bred and domesticated by thousands of farmers over the centuries. The agricultural role of the secondary centres and germplasm banks must also be taken into account. A good example is the case of modern bread wheat recounted by Toby Hodgkins in a personal statement in 1997 (Palacios 1998).

“Smale and McBride (1996) have identified seventeen major parents of modern bread wheat. The material comes not only from countries that are centres of diversity of wheat (South Russia, Turkey and Palestine) but also from Europe, India, Korea, Japan, Africa, United states, Uruguay and Australia. The authors examined the pedigrees of wheat varieties and local cultivars grown in developing countries and calculated the percentage contributions of each area of origin. The largest percentage contributions are from South Asia, Sub-Saharan Africa, the Southern Cone countries of South America, the countries of the former USSR, Poland and Germany. The wheat cultivar Sonalika, which was planted in over 6 million hectares in the developing countries in 1990, has 39 local cultivars and a pedigree drawing from at least 15 countries (Mexico, Kenya, Turkey, Japan, Brazil, Italy, Netherlands, United Kingdom, Poland, Australia, India, Russia, Spain, Argentina, Georgia). This is a clear example of the interdependence of all countries for the cultivation of modern varieties, in terms of primary centres but also secondary centres and germplasm banks.”

The pedigrees of modern varieties are often complex and include lines obtained from many distinct parts of the world generally situated outside the primary regions of diversity. In some cases, the material needed for the production of modern crops may well be located in a small part of the primary centre of origin, but in general it will be the result of a long process of domestication in other areas. Failure to take this into account ignores the contribution of many generations of farmers, away from the centres of diversity, who have provided the inputs needed for the development of today’s varieties.



Today's trend: vanishing resources?

Genetic erosion

Genetic erosion is the loss of genetic diversity, including the loss of individual genes, and the loss of particular combinations of genes such as those manifested in locally adapted landraces. The term “genetic erosion” is sometimes used in a narrow sense, i.e. the loss of genes, as well as more broadly, referring to the loss of varieties. The main cause of genetic erosion in crops, is the replacement of local varieties by improved or exotic varieties and species. As old varieties in farmers’ fields are replaced by newer ones, genetic erosion frequently occurs because the genes and gene complexes found in the diverse farmers’ varieties are not contained *in toto* in the modern variety. In addition, the sheer number of varieties is often reduced when commercial varieties are introduced into traditional farming systems.

There are a number of means by which the genetic vulnerability of crop production can be assessed. While such assessments are rare, it is known that many of today’s widely planted modern varieties of food crops are impressively uniform genetically. In the Netherlands, for example, the three top varieties of nine major crops covered from 81 to 99% of the respective areas planted. One cultivar accounted for 94% of the spring barley planted. In 1982, the rice variety “IR36” was grown on 11 million hectares in Asia. Over 67% of the wheat fields in Bangladesh were planted to a single wheat cultivar (“Sonalika”) in 1983, and 30% of Indian wheat fields to the same cultivar in 1984. Reports from the United States in 1972 and 1991 indicate that for each of eight major crops fewer than nine varieties made up between 50% and 75% of the total. Ireland’s cites 90% of its total wheat area sown to just six varieties (State of the World 1997).

The dangers of planting large areas to a genetically uniform crop variety must be recognized, as these varieties could suddenly become uniformly susceptible to new pathogen races and be wiped out. The most famous example of this is the potato famine of 1845-1848, when a pandemic of late blight (*Phytophthora infestans*) wiped out the potato crop in Europe and North America. In Ireland alone this led to the deaths of 1.5 million people who were wholly dependent on potatoes for their staple diet and did not have the economic or political means to avert catastrophe. The potatoes grown in Europe at that time were genetically uniform, as they were based on the two to four original varieties introduced into Europe from South America.

Some further examples of vulnerability are outlined below:

The genetic uniformity of resistance genes in modern wheat varieties in India was responsible for many severe epidemics of Shoot fly (*Atherigona* spp.) and Karnal bunt (*Tilletia indica*) in the 1970s. In 1970, a new race of maize leaf blight destroyed more than 15% of the United States maize crop as a result of the same cytoplasmic genes being used in the breeding of all the major varieties. In 1972, the winter wheat cultivar “Bezostaya” was grown over 15 million hectares in the Soviet Union. It had been moved beyond its original area of cultivation far into the Ukraine during a succession of mild winters. However it was wiped out in 1972 by a severe winter. In Cuba, during 1979/80, a rust attack on the variety of sugar cane which covered 40% of the country resulted in the loss of more than 1 million tonnes of sugar, worth about US USD 500 million.

The drastic genetic erosion accelerating in recent years has been well documented by many such as Jack. R. Harlan, plant explorer, archaeobotanist, geneticist, and plant breeder, who had a passion for understanding crop plants, their origins, the people who created them, and their use in sustaining the global human population. Pioneers of knowledge on the origin of cultivated plants have gone through extreme struggle in difficult times of history to undertake botanical-agronomic expeditions, collect seeds from every corner of the globe, create some of the largest world’s collections of plant genetic material and develop the theories and laws that have transformed our understanding of nature and of evolution.

Nikolai Ivanovich Vavilov, a prominent Russian botanist and geneticist, best known for having identified the centres of origin of cultivated plants, devoted his life to the study and improvement of wheat, corn and other cereal crops that sustain the global population. He died of malnutrition in a prison in 1943. It



is hard for us today to realize the total dedication of those who worked with what was then understood as being a treasure of the earth, a treasure of humankind. One such illustration is Vavilov's assistant who starved to death during the Siege of Leningrad, surrounded by edible seeds he diligently preserved for future generations.

"The coevolution of crops and man in subsistence agricultural economies is one of the most fascinating of all subjects for the student of evolution whether he be interested in plant or human cultural evolution. But, as with so many things in this world, the past is being destroyed by the present. Centers of diversity have been wiped out in recent decades. Indigenous tribal cultures and social customs have collapsed as well. Authentic indigenous cultivars and landraces are becoming collector's items as much as Luristan bronzes, African masks and figurines, or pre-Columbian Indian art. The world of N.I. Vavilov is vanishing and the sources of genetic variability he knew are drying up. The patterns of variation may no longer be discernible in a few decades and living traces of the long coevolution of cultivated plants may well disappear forever." (Harlan, 1975)

The State of the World Plant Genetic Resources for Food and Agriculture (FAO, 1997f) presented some worrying figures on the loss of this diversity. Of the 7098 apple varieties that were documented in the USA at the beginning of the twentieth century, 96 percent have been lost. Similarly 95 percent of the cabbage; 91 percent of the field maize; 94 percent of the pea and 81 percent of the tomato varieties cannot be found anymore. In Mexico, only 20 percent of the maize varieties reported in 1930 are now known. In the Republic of Korea, only 26 percent of landraces of 14 crops cultivated in home gardens in 1985 were still present in 1993. In China, in 1949, nearly 10,000 wheat varieties were used in production, by the 1970s only about 1000 remained in use.

In effect, the tendency over the years has been to substitute innumerable heterogeneous farmers' varieties with high-yielding commercial uniform varieties, resulting in drastic genetic erosion. The international community has been mobilized around these issues since the early 1970s with various actors actively involved, in particular FAO and the Commission on Genetic Resources for Food and Agriculture (CGRFA), the Convention on Biological Diversity (CBD), the United Nations Environment Programme (UNEP), Bioversity International, civil society organisations such as the ETC Group, and many others. The year 2004 was a turning point in the history of plant genetic resources with the entry into force of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA referred here as Treaty), which has established a Multilateral System of Access and Benefit Sharing (ABS) that facilitates access to plant genetic resources of the most important crops for food security. In other words, this system enables countries that are parties to the Treaty to have access to seed collections (genetic materials) of other countries that are parties to the Treaty, according to a list of 64 crops, on the basis of a Standard Material Transfer Agreement (SMTA). As of August 2010, there were 125 parties to the Treaty. A clear summary of the history of the development and exchange of plant genetic resources can be found in the article by Esquinas-Alcázar in *Nature* (2005) entitled *"Protecting crop genetic diversity for food security: political, ethical and technical challenges"*⁴.

The total number of crop accessions conserved *ex situ* worldwide has increased by approximately 20 percent since 1996, reaching 7.4 million. While new collecting accounted for at least 240,000 accessions, and possibly considerably more, much of the overall increase is the result of exchange and unplanned duplication. It is estimated that less than 30 percent of the total number of accessions are distinct. The creation of the Global Crop Diversity Trust and the Svalbard Global Seed Vault, a secure seedbank located on a Norwegian island in the remote Arctic Svalbard archipelago which preserves a wide variety of plant seeds (duplicate samples of seeds held in genebanks worldwide) in an underground cavern, both represent major recent achievements in support to *ex situ* collections.

The issues of *in situ* and *ex situ* conservation of genetic resources are dealt in-depth elsewhere and will not

⁴ Additional information on genetic resources is available in the background papers of the Commission on Genetic Resources for Food and Agriculture – 12th Regular Session and in the "Draft second report on the world's plant genetic resources for food and agriculture" 2009.



be the subject in this paper. It is important to note, however, that while maintaining *ex situ* collections has received serious attention and support from the international community, with a special fund specifically devoted to the conservation of the collections (the Global Crop Diversity Trust), supporting the *in situ* conservation on farmers' fields has been a much harder struggle with a practical implementation that has yet to become a reality.

Nature and people

As human beings, we represent part of nature, part of the “complexity of nature” as one farmer rightly said.⁵ Agriculture, intimately connected with nature, is fully dependent on the health of ecosystems, and in its most sustainable forms, mimics ecological principles. It is seldom understood that today's financial, fuel and food crises are the expression of a profound ecological crisis of the earth. Most of our present conflicts are related to access to resources. This section deals with the interconnection between nature and people, on how our use of ecosystem services has impacted the resources of the earth to the extent of changing the climate, and how our evolving models of production have resulted in an agrarian crisis.

The Millennium Ecosystem Assessment

The Millennium Ecosystem Assessment (MA) was called for by United Nations Secretary-General Kofi Annan in 2000 in a report to the General Assembly entitled “We the Peoples: The Role of the United Nations in the 21st Century”. Initiated in 2001, the objective of the MA was to assess the consequences of ecosystem change for human wellbeing and the scientific basis for actions needed to enhance the conservation and sustainable use of those systems and their contribution to human wellbeing. The MA has involved the work of more than 1360 experts worldwide

5 Olav Randen, Norwegian farmer. 2010.

KEY MESSAGES FROM THE MILLENNIUM ECOSYSTEM ASSESSMENT

(Statement of the Board of the MA)

- Everyone in the world depends on nature and ecosystem services to provide the conditions for a decent, healthy, and secure life.
- Humans have made unprecedented changes to ecosystems in recent decades to meet growing demands for food, fresh water, fiber, and energy.
- These changes have helped to improve the lives of billions, but at the same time they weakened nature's ability to deliver other key services such as purification of air and water, protection from disasters, and the provision of medicines.
- Among the outstanding problems identified by this assessment are the dire state of many of the world's fish stocks; the intense vulnerability of the 2 billion people living in dry regions to the loss of ecosystem services, including water supply; and the growing threat to ecosystems from climate change and nutrient pollution.
- Human activities have taken the planet to the edge of a massive wave of species extinctions, further threatening our own well-being.
- The loss of services derived from ecosystems is a significant barrier to the achievement of the Millennium Development Goals to reduce poverty, hunger, and disease.
- The pressures on ecosystems will increase globally in coming decades unless human attitudes and actions change.
- Measures to conserve natural resources are more likely to succeed if local communities are given ownership of them, share the benefits, and are involved in decisions.
- Even today's technology and knowledge can reduce considerably the human impact on ecosystems. They are unlikely to be deployed fully, however, until ecosystem services cease to be perceived as free and limitless, and their full value is taken into account.
- Better protection of natural assets will require coordinated efforts across all sections of governments, businesses, and international institutions. The productivity of ecosystems depends on policy choices on investment, trade, subsidy, taxation, and regulation, among others.



The following statement and the key messages, are from the board governing the MA process, whose membership includes representatives from UN organisations, governments through a number of international conventions, nongovernmental organisations, academia, business and indigenous peoples.

“Running down the account—The bottom line ...

At the heart of this assessment is a stark warning. Human activity is putting such strain on the natural functions of Earth that the ability of the planet’s ecosystems to sustain future generations can no longer be taken for granted. The provision of food, fresh water, energy, and materials to a growing population has come at considerable cost to the complex systems of plants, animals, and biological processes that make the planet habitable. As human demands increase in coming decades, these systems will face even greater pressures—and the risk of further weakening the natural infrastructure on which all societies depend. Protecting and improving our future well-being requires wiser and less destructive use of natural assets. This in turn involves major changes in the way we make and implement decisions. We must learn to recognize the true value of nature—both in an economic sense and in the richness it provides to our lives in ways much more difficult to put numbers on. Above all, protection of these assets can no longer be seen as an optional extra, to be considered once more pressing concerns such as wealth creation or national security have been dealt with. This assessment shows that healthy ecosystems are central to the aspirations of humankind.”

Biocapacity of the planet Earth

The Global Footprint Network published the *Ecological Wealth of Nations* in April 2010, bringing forward a new framework for calculating the earth’s biocapacity – a framework with great potential for international cooperation. This section is based on this publication.

Ecological footprint accounting, which measures society’s use of nature’s assets, is based on data from the United Nations, as well as in-country statistical sources. It compares humanity’s ecological footprint (the demand human consumption places on the biosphere) with biocapacity (the biosphere’s ability to meet this demand), providing a kind of bank statement for the planet.

“The biosphere is made up of complex, interactive systems that are often unpredictable. Air, water, land, and life -- including human life -- combine forces to create a constantly changing world. If these changes

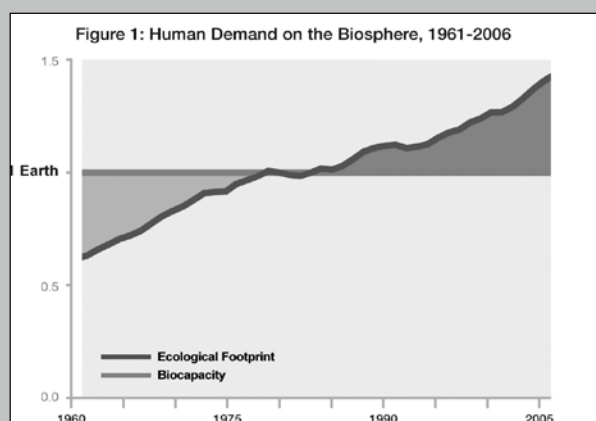
Human demand on the biosphere, 1961-2006

In 1961 we used a little more than half of the Earth’s biocapacity.

In 2006 we used 44% more than was available.

The ecological footprint helps clarify risks and opportunities, laying the foundation for ecologically-sound decision making and a new global collaboration, one based on the sharing of ecological assets, without their depletion or degradation. The publication demonstrates the growing need for nations to recognize the value of their own ecological assets, as well as the need to find a way for humanity to live well, within the means of our planet.

The *Ecological wealth of nations* presents the graphs of the ecological footprint and biocapacity of nations



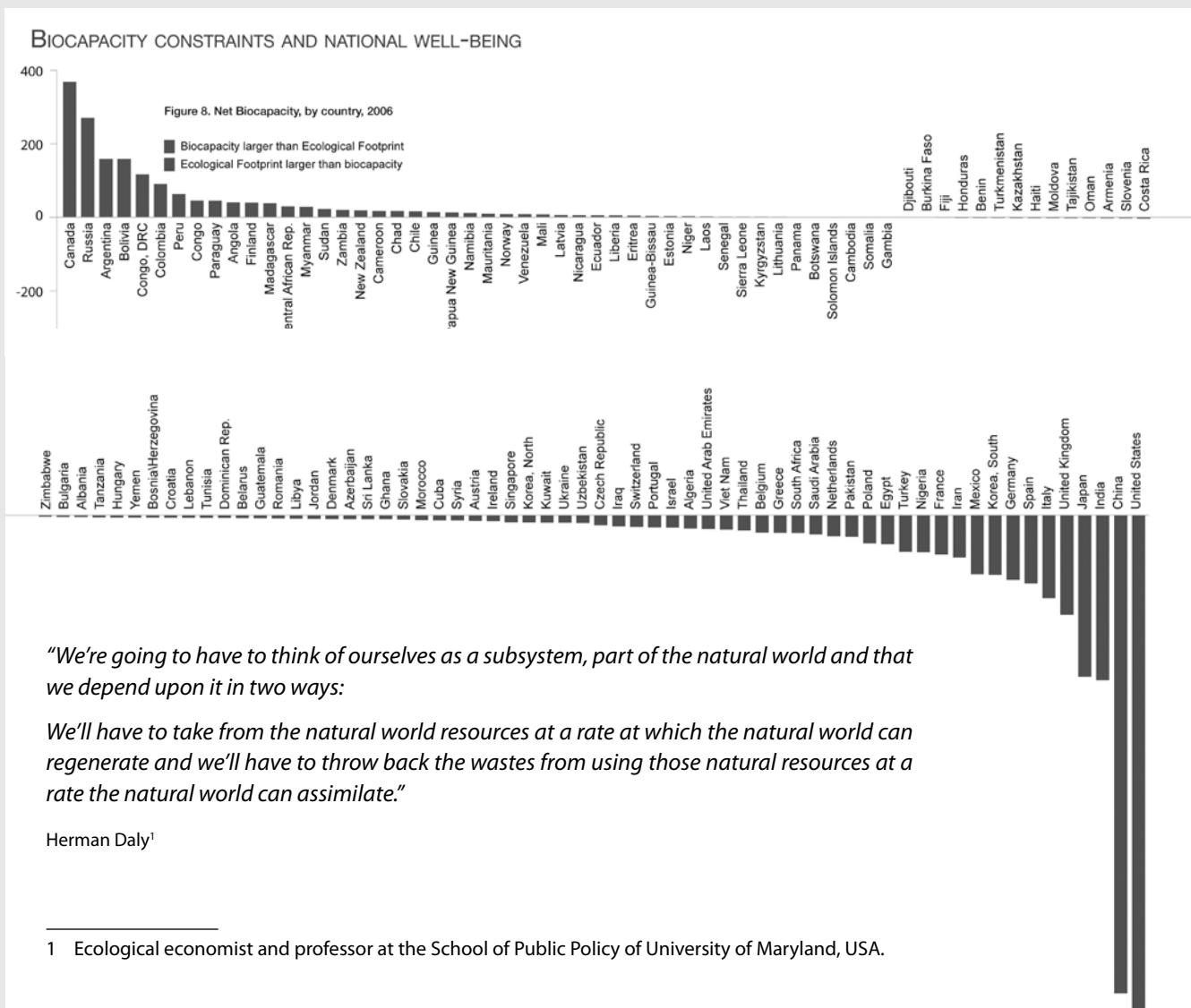
and takes the UNDP human development index as the basis to measure “living well”. It stresses humanity’s challenge to live well, while living within the capacity of the planet, and not degrading ecological assets to the detriment of future generations.



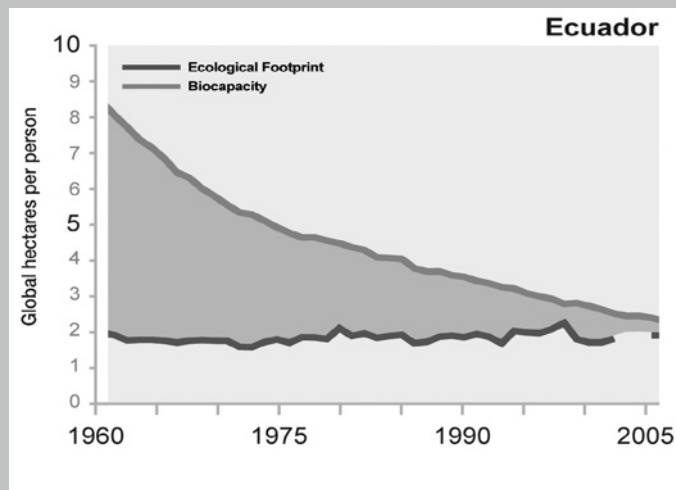
exceed certain thresholds conditions could depart from those that were present during the course of human evolution, making the planet a less hospitable place for us to live” (The Global Footprint Network, 2010).

In the Forward of to *The Ecological Wealth of Nations*, Mathis Wackernagel, President of the Global Footprint Network, says that our Footprint now overshoots the Earth’s biocapacity by more than 40 percent. Overshoot is possible only for a limited time. Similar to the financial world, we can temporarily eat into our ecological savings by drawing down our resource stocks. By the late 2030s humanity will need the equivalent of two Earths to keep up with our demands. With demand so far out of synchrony with supply, and ecological debt accumulating from decades of ecological overspending, it is unrealistic to assume we can even reach this level of consumption. There just are not that many fisheries to overfish, forests to deforest, or atmospheres to fill up with CO2 before climate change wreaks havoc with food and water supplies. We have a choice: maintaining the ‘right to develop’ means moving away from our current course, one which all too often seems to be more about maintaining the right to collapse. We must work with nature’s budget, not against it, if we are to secure human well-being for both current and future generations.

Net biocapacity by country, 2006.



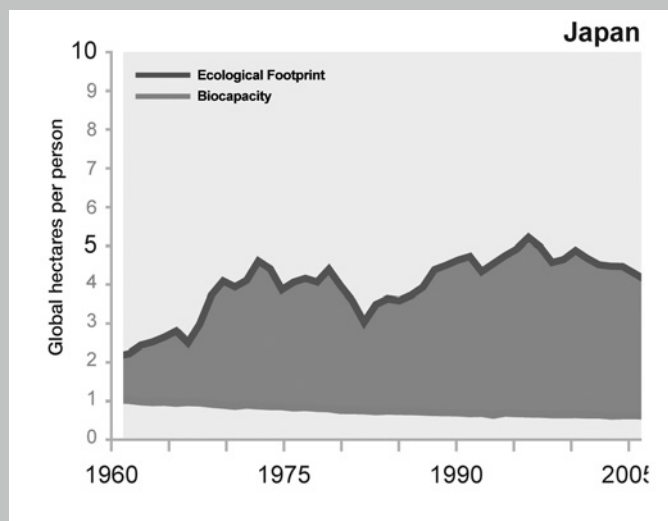
Ecuador



Ecuador. Sierra region. Fields near Quito- Yann Arthus-Bertrand.

In 1961, Ecuador's biocapacity was more than four times its footprint, meaning the consumption demand of Ecuador's residents could be met, in net terms, using less than one-quarter the capacity of its own ecosystem. But by 2006, the country's footprint was almost as large as its biocapacity. Of all the South American countries, Ecuador is the closest to running an ecological deficit. In December 2009, Ecuador's President announced a Presidential mandate with a goal of no ecological deficit by 2013.

Japan



Japan. Rice field near Oukura

In 1961, Japan's footprint was about twice its biocapacity, in 2006, its footprint was seven times its biocapacity. In 1961, Japan had the seventh highest footprint to biocapacity ratio of any country, and in 2006 it ranked fifth. Its ecological deficit was not just a reflection of carbon emissions to the global atmosphere. Even without the carbon component, Japan's footprint was more than twice its biocapacity. Running an ecological deficit is possible for Japan because of its purchasing power. But this deficit also indicates a potential risk for the Japanese economy as the world enters ever further into a resource-constrained future.

Climate change

The challenge of addressing climate change has given rise to many alternative strategies that are often presented as – or assumed to be – equivalent. However, there are clear and important differences between fossil fuel emission reductions, carbon sequestration and simply avoiding biotic emissions by reducing forest clearance which would mean that the biotic carbon remains undisturbed.⁶

When biotic carbon emissions occur in addition to fossil fuel emissions, it further aggravates the challenge of reversing climate change. Land-use change stimulated by the expansion of industrial agriculture is the most significant source, contributing more than 15 percent of global greenhouse gas emissions. If its destruction of communities and biodiversity were not reason enough, then this huge contribution of land-use change to global warming gives even more impetus to stopping large-scale forest clearances. Biotic emissions differ from fossil fuel emissions, as they can open up equivalent opportunities for sequestration. For example, as soils degrade they emit greenhouse gases, but as they rebuild, they draw in carbon in from the atmosphere; similarly, replanting cleared forests rapidly takes up carbon from the atmosphere. No such option exists for fossil fuel emissions.

Sequestration refers to the capacity to capture emissions that have already been released into the atmosphere. Soils in particular have a huge potential to store carbon. Significant benefits can be gained in dryland areas in particular, where the historic loss of carbon from soils through desertification offers great potential for sequestration when soil management practices are implemented. However, in agriculture debates, sequestration is often presented as the solution to climate change: it is not. Unless we also stop using fossil fuels, CO₂ will continue to accumulate in the atmosphere, sooner or later leaving us with catastrophic climate change. There is simply not enough sequestration potential to allow us to use all the fossil fuels that are stored in the ground.

Agriculture can contribute to reducing climate change in three different ways:

- reducing its fossil fuel usage – for example in transport or fertilizer production;
- slowing the release of biotic carbon and addressing methane emission from livestock and rice cultivation;
- sequestering carbon, which has vast potential, particularly in soils.

But the latter two approaches will only buy time to achieve rapid and drastic reductions in fossil fuel use throughout the global economy.

In these three categories, GRAIN (2009) has calculated that:

- by distributing food mainly through local markets instead of transnational food chains, total GHG emissions can be reduced by 10–12 percent;
- by decentralising livestock farming and integrating it with crop production, total GHG emissions can be reduced by 5–9 percent;
- by stopping land clearing and deforestation for plantations, total GHG emissions can be reduced by 15–18 percent;
- by using agroecological practices to rebuild the organic matter in soils lost from industrial agriculture, sequestration equivalent to 20–35 percent of current GHG emissions can be achieved.

Clearly, then, there is significant potential for agriculture to reduce fossil carbon emissions, and to undertaken sequestration of atmospheric carbon. GRAIN notes that the expansion of the industrial food system is the leading cause of climate change. Through its reliance on fossil fuels, massive exports, market concentration, erosion of soils and expansion of plantations, it generates 44–57 percent of the

⁶ Agriculture releases three main types of GHG into the atmosphere: carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O). There is consistent agreement over global emissions estimates, although the different means of expression can make it somewhat confusing. Emissions of nitrous oxide and methane are usually expressed as the equivalent units of carbon dioxide in terms of their global warming potential in 100 years: nitrous oxide has 296 times the warming potential of carbon dioxide, and methane 23 times, as both are more efficient in trapping heat (Bellarby et al, 2008).



total global GHG emissions. The most devastating consequence of this industrial food system is that it is destroying other food systems that could turn climate change around and provide for the world's food needs.

In the same line, "Small Scale Sustainable Farmers are Cooling the Earth", published in 2009 by the peasant movement, *Via Campesina* highlights that industrial agriculture is a major contributor to global warming and climate change by transporting food all around the world, by imposing industrial forms of production, by destroying biodiversity and its capacity to absorb carbon, by converting land and forests into non-agricultural areas and by transforming agriculture from an energy producer into an energy consumer. The publication proposes food sovereignty⁷ as the key to providing decent livelihoods to millions and protect life on earth.

False solutions

In the ongoing climate negotiations, there has been growing emphasis on carbon credits for agriculture and the inclusion of soil carbon sequestration into the Clean Development Mechanism (CDM) and other mechanisms including Reducing Emissions from Deforestation and Forest Degradation (REDD). Soil carbon sequestration was initially explicitly excluded from the CDM because of major uncertainties in measuring and verifying the permanence of soil carbon stores. But there is now a major push to change this. If soil carbon sequestration is included in a climate change agreement, as experience with carbon trading in general and the CDM in particular has shown, the benefits will go to large companies who can afford specialist carbon consultants, not to small-scale farmers, their communities and sustainable, local ecological food provision.

Including soil carbon sequestration in carbon markets is the worst of all worlds. Carbon credits are traded to "offset" fossil fuel emissions from industrial processes, but there is no equivalence between fossil fuel emissions – which are irreversible – and soil carbon sequestration. Trading fossil carbon with soil sequestration simply wastes the sequestration potential while sustaining fossil carbon emissions. Just as seriously, creating a market in soil carbon poses real risks for poor farmers whose livelihoods depend on their lands.

Incentivising land acquisition for "carbon farming" activities – such as burying "biochar" and establishing large-scale, no-till agriculture to promote soil carbon storage – is likely to displace and impoverish local communities. Lands in developing countries should be specifically protected from global markets to ensure protection for farmers who have access to neither the knowledge nor legal representation to defend their interests. Climate change is a problem created by the resource use patterns of the richest nations on the earth, and the potential for sequestration in the poorest nations must not become a stimulus for carbon market and land use policies that may penalise their poorest communities.

Dietary trends

Concerns over dietary trends tend to focus on livestock and meat production. A vegetarian diet produces fewer GHG emissions over a lifetime: an average of 25 kcals of fossil energy are used per kcal of meat produced, compared with 2.2 kcal for plant-based products (Pimentel and Pimentel, 2003). 385 kcal of fossil fuel per person per day could be saved by substituting 5 percent of meat in the (USA.) diet with vegetarian products (Bellarby *et al.*, 2009). Stehfest *et al.* (2009) used an integrated assessment model to analyse the relationship between meat consumption and climate change. They found that a global food transition to less meat – a fall from the current 245g per person per day to 102g per day – would have a dramatic effect on land use, freeing up pasture and cropland for carbon sequestration uses and substantially reducing nitrous oxide and methane emissions. This global transition to a low meat diet would reduce GHG mitigation costs by 50 percent compared to other dietary approaches, to achieve a 450 ppm CO₂ eq⁸ stabilisation target by 2050. Actually, the goal for most environmental movements and

⁷ Defined as the right of peoples and sovereign states to democratically determine their own agricultural and food policies. IAASTD Synthesis Report.

⁸ part per million CO₂ equivalent corresponding to CO₂ concentration.



many countries is not 450 ppm but 350 ppm. In industrialised countries, animals consume more than five calories of feed for every one calorie of meat or dairy produced. But animals also can be fed grasses or by-products that humans cannot consume, so that in the case of Kenya, livestock produce more calories than they consume (De Schutter, 2009).

Whole-farm systems analyses

The best defined bodies of intentionally sustainable, whole farm systems are the certified and non-certified organic, agro-ecological and biodynamic farming movements. Farmers within these movements follow specific, transparent principles or guidelines on sustainability across the whole farm system, or share a belief system that drives their decision-making toward a style of agriculture that works with nature (biomimicry).

A comparative analysis of energy inputs on long-term trials at the Rodale Institute found that organic farming systems used 63 percent of the energy required on conventional farms, largely because of the savings made in the energy input of synthetic nitrogen fertiliser (Pimentel *et al.*, 2005). Organic farms have been criticised as playing into the industrialised, high-fossil energy dependent, food system, and organic commodities may be similarly associated with a high overall GHG footprint. Nevertheless, the majority of mitigation activities are cornerstones of organic agricultural practice, and therefore these production systems arguably serve as the best widespread examples of low emissions agriculture to date. Numerous examples of reviews on whole-farm systems analyses are available in the literature, in particular in the thorough literature review undertaken by Wright (2010).

Climate change adaptation

Our ability to understand much of what climate change will bring in a particular location is hampered by uncertainty in climate projections. Future rainfall patterns are least well understood, presenting a significant challenge for food production. This uncertainty, coupled with the likely increase in extreme rainfall or drought events and the emergence of unfamiliar pests and diseases, demands a form of agriculture that is resilient, and a system of food production that supports knowledge transfer and experimentation on farm through building the adaptive capacity of farmers (Ensor and Berger, 2009).

The compartmentalisation of institutions and disciplines disguises the fact that measures to reduce emissions, capture carbon and support adaptation to climate change can be combined. But the reality is that some agricultural systems – too often the unknown, unnoticed and marginalised systems – do exactly this. Concrete examples can be seen in traditional forms of agriculture and in the infinitely diverse sustainable forms of production. These systems are being developed around the globe, focussing on cultural practices that have the potential to reduce emissions and increase carbon capture by soil and vegetation, while at the same time adapting to transformations of the climate. Practical examples range along the spectrum of what could be referred to as millennia-tested to modern state-of-the art practices.

Building soil quality is a prime example of the inter-linkages between adaptation and mitigation in agriculture. Long-term scientific studies have established the importance of soil quality to resilience, demonstrating that higher levels of soil organic matter - the non-living decomposed and partially decomposed plant and animal tissues that are found in soils - conserve the soil itself and, critically, water resources within the soil (Pimentel *et al.* 2005). However, soil composition is not static. Soil organic matter and the biodiversity of organisms within the soil in agro-ecosystems vary, meaning that the approach to agriculture is critical in maintaining or diminishing the productivity and resilience of the agro-ecosystem.

A side-by-side comparison of organic and non-organic conventional farms that has run continuously since 1948 demonstrates the impact of farming practice. It found that organic methods, in which crop rotations, manuring, organic fertilizers and biological pest controls are employed in place of chemical inputs, reduce soil erosion and maintain productivity over the long term. The study found that the organically farmed soils had “significantly higher levels of organic carbon” concluding that organic farmers



“can, and generally do, achieve higher organic matter levels in their soils than do conventional farmers”. Moisture contents were *“significantly higher”* in the organically farmed soils, while *“the amount of productive topsoil was dramatically less on the conventionally farmed soil”* (Reganold *et al.*, 1987). A similar study, based on a 22-year continuous field-scale trial, found that *“high levels of soil organic matter helped conserve soil and water resources and proved beneficial during drought years”* (Pimentel, 2005), with significantly higher yields resulting from organically farmed soils during the most severe drought (Lotter *et al.*, 2003).

A 21-year Swiss study comparing organic and conventional farm systems demonstrated that soil quality and microbial biomass activity were both increased by the use of manure compost in place of chemical inputs (Fließbach, 2006). In particular, soil components that play a crucial role in nutrient acquisition and soil fertility are known to be maintained under organic farming methods but severely depressed in conventional industrial agriculture, reducing soil fertility (Oehl, 2004). The scientific literature also provides evidence that soils with high organic matter and biodiversity render crops less susceptible to pest attack and infection by disease-causing organisms, due to the presence of beneficial organisms and microbes within the food web supported by the soil. This ability to cope with pests and diseases will form an important element of resilience as their distribution changes in response to the modification of regional and local temperature and moisture profiles by climate change. As Pimentel and colleagues pointed out, *“abundant biomass both above and below the ground (soil organic matter) also increases biodiversity, which helps in the biological control of pests and increases crop pollination by insects”* (Pimentel *et al.*, 2004). Recent research in China illustrated the significance of above-ground biodiversity, finding that farmers who grew four different varieties of rice “suffered 44 per cent less blast incidence and exhibited 89 per cent greater yield than homogeneous fields without the need to use fungicides” (Altieri, 2002).

Adaptive capacity refers to the ability of individuals or communities to actively engage in processes of change. It is the capacity to respond to anticipated and experienced climate change, enabling adjustments or transformations in lifestyles or livelihoods that reduce vulnerability to climate hazards, increase resilience or capitalise on opportunities. Where resilience is the capacity to absorb or cope with shocks and stresses, adaptive capacity is defined by overlapping resources and abilities that can be employed to respond to and create changes.

Ecological agriculture encourages and requires farmers, fishers and herders to be responsive to their environment, engendering flexibility and experimentation in breeding and management practices. It is this ability to experiment and innovate in order to maximise the productive capacity of the available resources that underpins adaptive capacity. Methods for coping with harsh environments exist within different communities, and tend to be knowledge intensive rather than input intensive, creatively applying agro-ecological principles to a particular context. The combination of responsive management strategies and technologies with agricultural biodiversity is witnessed in “millions of hectares under traditional agriculture in the form of raised fields, terraces, polycultures, agroforestry systems” (Holt *et al.*, 2006). Indigenous knowledge, then, is as significant to adaptive capacity as the biodiversity that it works with.

Creativity, innovation and experimentation are inherent in agro-ecological methods as employed by farmers, fishers and herders worldwide. The promotion of adaptive capacity requires mechanisms to support the sharing of this existing knowledge and for on-farm, community-based experimentation as environmental challenges shift across regions and continents in a changing climate. Institutional support is necessary for climate information dissemination, as climate change science and predictions will be beyond the reach of many communities. It is the responsibility of national governments to assimilate and communicate short- and long-term weather and climate change information, and to identify and facilitate the filling of gaps in knowledge where they exist. Moreover, these tasks should be grounded in the livelihood context of those farmers, fishers and herders who are most vulnerable to climate change: information should be targeted at these groups in a form and with content that is appropriate to their needs (Ensor and Berger, 2009).



Finite resources

We have now, in particular through the Millennium Assessment, scientific evidence of the severe decline of the natural resources and ecosystems of the earth. A global transformation towards sustainability must begin in the near future and accelerate quickly if we want to tackle the overwhelming challenge of these finite resources and the consequences of climate change. Our future foods will depend on this shift. The growing body of analytical work examining scenarios at the global and regional level suggests this is feasible, economically affordable and profitable, especially if the costs of inaction are considered (Wright, 2010).

Some of these resources are presented here, listing a few key points: first water, a precondition for life and a limiting factor of agricultural production, secondly soil biology, still widely unknown, with complex synergies still to be unveiled, having significant implications for our food systems. A description follows on the growing concern among citizens of the earth about the use and misuse of the planet's resources and the need for a different outlook.

Spending the capital

The Millennium Assessment has shown that nearly two thirds of the services provided by nature to humankind are found to be in decline worldwide. In effect, the benefits reaped from our engineering of the planet have been achieved by running down natural capital assets.

As highlighted by the Millennium Board, *“in many cases, it is literally a matter of living on borrowed time. By using up supplies of fresh groundwater faster than they can be recharged, for example, we are depleting assets at the expense of our children. The cost is already being felt, but often by people far away from those enjoying the benefits of natural services. Shrimp on the dinner plates of Europeans may well have started life in a South Asian pond built in place of mangrove swamps—weakening a natural barrier to the sea and making coastal communities more vulnerable.*

Unless we acknowledge the debt and prevent it from growing, we place in jeopardy the dreams of citizens everywhere to rid the world of hunger, extreme poverty, and avoidable disease—as well as increasing the risk of sudden changes to the planet's life-support systems from which even the wealthiest may not be shielded. We also move into a world in which the variety of life becomes ever more limited. The simpler, more uniform landscapes created by human activity have put thousands of species under threat of extinction, affecting both the resilience of natural services and less tangible spiritual or cultural values.” (Millennium Ecosystem Assessment, 2003).

Water

A few figures:

- The world contains an estimated 1400 million cubic km of water. Only 0.003 percent of this vast amount, about 45,000 cubic km, are what is called “fresh water resources” – water that theoretically can be used for drinking, hygiene, agriculture and industry. But not all of this water is accessible.
- In fact, only about 9000–14,000 cubic km are economically available for human use.
- Globally, rainfed agriculture is practised on 80 percent of cultivated land and supplies more than 60 percent of the world's food.
- Agriculture is by far the biggest user of water, accounting for almost 70 percent of all withdrawals, and up to 95 percent in developing countries.
- The water needed for crops amounts to 1000–3000 cubic metres per tonne of cereal harvested. Put another way, it takes 1–3 tons of water to grow 1 kg of cereal.
- The daily drinking water requirements per person are 2–4 litres. However it takes 2000–5000 litres of water to produce a person's daily food.



A Comprehensive Assessment of Water Management in Agriculture (IWMI, 2007), produced by a broad partnership of practitioners, researchers and policy makers (FAO, CGIAR, EU etc.), recommended a list of policy actions which stress the need to think differently about water in agriculture and to view rain as the ultimate source of water that can be managed. It also stresses that the era of rapid expansion of irrigated agriculture is over, and emphasizes the need to secure water rights.

Several other reports such as *Water at a Glance* from FAOWATER, *Water Footprint Manual- State of the Art 2009* from the Water Footprint Network, *Value of Virtual Water in Food: Principles and Virtues* and *Virtual Water I Food Production and Global Trade* from Daniel Renault *et al.*, and *Water and the Rural Poor* an FAO-IFAD publication, all conclude along the same lines.

The policy proposals suggested are a clear illustration of this shift in thinking about water resources and the need for holistic perspectives which take account of the various actors involved, the need for consultation and balance between often competing needs and the ecosystem services involved. Some extracts are presented as follows:

Policy action 1. Change the way we think about water and agriculture.

Thinking differently about water is essential for achieving our triple goal of ensuring food security, reducing poverty and conserving ecosystems. Instead of a narrow focus on rivers and groundwater, view rain as the ultimate source of water that can be managed. Instead of isolating agriculture as a production system, view it as an integrated multiple-use system and as an agro-ecosystem, providing services and interacting with other ecosystems.

Policy action 2. Fight poverty by improving access to agricultural water and its use.

Target livelihood gains of smallholder farmers by securing water access through water rights and investments in water storage and delivery infrastructure where needed.

Policy action 3. Manage agriculture to enhance ecosystem services.

Good agricultural practice can enhance other ecosystem services. Agricultural production does not have to be at the expense of other services that water provides in rivers and wetlands.

Policy action 4. Increase the productivity of water.

Gaining more yield and value from less water can reduce future demand for water, limiting environmental degradation and easing competition for water. A 35 percent increase in water productivity could reduce additional crop water consumption from 80 percent to 20 percent. More food can be produced per unit of water in all types of farming systems, with livestock systems deserving attention.

Policy action 5. Upgrade rainfed systems—a little water can go a long way.

Rainfed agriculture is upgraded by improving soil moisture conservation and, where feasible, providing supplemental irrigation.

Policy action 6. Adapt yesterday's irrigation to tomorrow's needs.

The era of rapid expansion of irrigated agriculture is over. A major new task is adapting yesterday's irrigation systems to tomorrow's needs.

Policy action 7. Reform the reform process – targeting state institutions.

Following a realistic process to suit local needs, a major policy shift is required for water management investments important to irrigated and rainfed agriculture. A wider policy and investment arena needs to be opened by breaking down the divides between rainfed and irrigated agriculture and by better linking fishery and livestock practices to water management. Reform cannot follow a blueprint. It takes time. It is specific to the local institutional and political context. And it requires negotiation and coalition building. Civil society and the private sector are important actors. But the state is often the critical driver, though state water institutions are often the most in need of reform.



Policy action 8. Deal with tradeoffs and make difficult choices.

Because people do not adapt quickly to changing environments, bold steps are needed to engage with stakeholders. Informed multistakeholder negotiations are essential to make decisions about the use and allocation of water. Reconciling competing demands on water requires transparent sharing of information. Other users—fishers, smallholders without official title, and those dependent on ecosystem services—must develop a strong collective voice.

Views diverge sharply on the competing choices for water for food and for ecosystems. Some emphasize developing more water through large infrastructure to relieve scarcity. At the other end of the spectrum are calls for a halt to agricultural and hydraulic infrastructure expansion—and for practices that restore ecosystems. A major reason for the diverging views is divergent understanding of some basic premises. How much water is used in agriculture? How much irrigation is there? What is the contribution of groundwater? And what is the present use and future potential of rainfed agriculture? Different people place different values on water use. There is also a lack of knowledge and awareness of past impacts and the current situation of water use.

How much more water?

Without further improvements in water productivity or major shifts in production patterns, the amount of water consumed by evapotranspiration in agriculture will increase by 70 percent – 90 percent by 2050. The total amount of water evaporated in crop production would amount to 12,000–13,500 cubic kilometres, almost doubling the 7130 cubic kilometres of today. This corresponds to an average annual increase of 100–130 cubic kilometres, almost three times the volume of water supplied to Egypt through the High Aswan Dam every year.

Can upgrading rainfed agriculture meet future food demands?

Today, 55 percent of the gross value of our food is produced under rainfed conditions on nearly 72 percent of the world's harvested cropland. In the past, many countries focused their “water attention” and resources on irrigation development. The future food production that should come from rainfed or irrigated agriculture is the subject of intense debate, and the policy options have implications that go beyond national boundaries. An important option is to upgrade rainfed agriculture through better water management practices. Better soil and land management practices can increase water productivity adding a component of irrigation water through smaller scale interventions such as rainwater harvesting. Integrating livestock in a balanced way to increase the productivity of livestock water is important in rainfed areas.

At the global level the potential of rainfed agriculture is large enough to meet present and future food demand through increased productivity. An optimistic rainfed scenario assumes significant progress in upgrading rainfed systems while relying on minimal increases in irrigated production, by reaching 80 percent of the maximum obtainable yield. This leads to an average increase of yields from 2.7 metric tons per hectare in 2000 to 4.5 in 2050 (1 percent annual growth). With no expansion of irrigated area, the total cropped area would have to increase by only 7 percent, compared with 24 percent from 1961 to 2000, to keep pace with rising demand for agricultural commodities.

What can irrigated agriculture contribute?

Under optimistic assumptions about water productivity gains, three-quarters of the additional food demand can be met by improving water productivity on existing irrigated lands. In South Asia – where more than 50 percent of the cropped area is irrigated and productivity is low – additional food demand can be met by improving water productivity in irrigated agriculture rather than by expanding the area under production. But in parts of China and Egypt and in developed countries, yields and water productivity are already quite high, and the scope for further improvements is limited. In many rice-growing areas, water savings during the wet season make little sense because they will not be easily available for other uses.



Soil

As described in the European Commission latest publication on the subject (EC, 2010), soils are home to over one-fourth of all living species on earth. Just one teaspoon of garden soil may contain thousands of species, millions of individuals, and 100 metres of fungal networks (in other words, very fine threads also called hyphae). Bacterial biomass is particularly impressive and, in a temperate grassland soil, can amount to 1–2 tonnes per hectare, which is roughly equivalent to the weight of one or two cows. (See box)

Most of the species in soil are microorganisms, such as bacteria, fungi and protozoans, which are the soil's *chemical engineers*, responsible for the decomposition of plant organic matter into nutrients readily available for plants, animals and humans. Soils also comprise a large variety of small invertebrates, such as nematodes, pot worms, springtails and mites, which act as predators of plants, other invertebrates or microorganisms, by regulating their dynamics in space and time. Most of these so-called *biological regulators* are relatively unknown to a wider audience. Earthworms, ants, termites and some small mammals are *ecosystem engineers*, since they modify or create habitats for smaller soil organisms by building resistant soil aggregates and pores.

The decomposition of soil organic matter by soil organisms releases nutrients in forms usable by plants and other organisms. The residual soil organic matter forms humus, which serves as the main driver of soil quality and fertility. As a result, soil organisms indirectly support the quality and abundance of plant primary production. It should be underlined that soil organic matter as humus can only be produced by the diversity of life that exists in soils – it cannot be human-made. When the soil organic matter recycling and fertility service is impaired, all life on earth is threatened, as all life is either directly or indirectly reliant on plants and their products, including the supply of food, energy, nutrients (e.g. nitrogen produced by the rhizobium bacteria in synergy with the legumes), construction materials and genetic resources.

Every year, soil organisms process 25,000 kg of organic matter (the weight of 25 cars) in soil in a surface area equivalent to a soccer field.

Pest control

Soil biodiversity promotes pest control, either by acting directly on belowground pests, or by acting indirectly on aboveground pests. Pest outbreaks occur when microorganisms or regulatory soil fauna are not performing efficient control. Ecosystems presenting a high diversity of soil organisms typically present a higher natural control potential, since they have a higher probability of hosting a natural enemy of the pest. Interestingly, in natural ecosystems, pests are involved in the regulation of biodiversity. Soil-borne pathogens and herbivores control plant abundance, which enhances plant diversity.

The use of pesticides, for instance, can be the origin of a loss of more than USD 8 billion per year due to environmental and societal damages. In natural ecosystems, the loss of pathogenic and root-feeding soil organisms will cause a loss of plant diversity and increase the risk of exotic plant invasions.

Soil degradation

The majority of human activities result in soil degradation, which impacts the services provided by soil biodiversity. Soil organic matter depletion and soil erosion are influenced by inappropriate agricultural practices, over-grazing, vegetation clearing and forest fires. It has been observed, for example, that land without vegetation can be eroded more than 120 times faster than land covered by vegetation, which can thus lose less than 0.1 tonne of soil per ha/y. Inappropriate soil irrigation practices may also lead to soil salinisation. When salinity increases, organisms either enter an inactive state or die off. An important portion of European soils have high (28 percent) to very high (9 percent) risks of compaction. Soil compaction impairs the engineering action of soil ecosystem engineers, resulting in further compaction. This has dramatic effects on soil organisms, by reducing the habitats available for them, as well as their access to water and oxygen.



Land use management

Grassland soils are the soils that present the richest biodiversity, before forests and cropped or urban lands. Within rural lands, soil biodiversity tends to decrease with the increasing intensification of farming practices (e.g. use of pesticides, fertilisers, heavy machinery).

Chemical pollution and genetically modified organisms (GMOs)

The pollution of European soils is mostly a result of industrial activities and of the use of fertilisers and pesticides. Toxic pollutants can destabilise the population dynamics of soil organisms, by affecting their reproduction, growth and survival, especially when they are bio-accumulated. In particular, accumulation of stressing factors is devastating for the stability of soil ecosystem services. Pollutants may also indirectly affect soil services, by contaminating the belowground food supply and modifying the availability of soil organic matter.

Holistic approaches that investigate the impacts of chemical pollutants on soil ecosystem functioning as a whole are still lacking and only recently started to be covered in ecological risk assessments. However, significant impacts can be expected on nutrient cycling, fertility, water regulation and pest control services. Genetically modified crops may also be considered as a growing source of pollution for soil organisms. Most effects of GMOs are observed on chemical engineers (or microorganisms such as bacteria, fungi and Protozoans), by altering the structure of bacterial communities, bacterial genetic transfer, and the efficiency of microbial-mediated processes. GMOs have also been shown to have effects on earthworm physiology.

Several knowledge gaps exist on components of soil biodiversity, and new groups of soil organisms with potentially high ecological significance (e.g. Archaea) have only recently been considered as having specific functions in soil ecosystems.

Another factor of uncertainty is that sometimes even the mechanisms underlying one specific service are not perfectly understood. For instance, it is not yet known exactly how biodiversity can control pest spread or how to quantify the final impacts of soil biodiversity disturbance to human health,

Agricultural diversity

Biodiversity co-evolving in farmers' fields

The FAO first State of the World on plant diversity (FAO, 1997f), describes the importance of small farmers who have nurtured biodiversity during millennia. It found that the inherent variation within farmers' varieties, or landraces, is especially high for cross-pollinated species such as maize and millet. This is particularly important for optimizing output from highly variable environments. For self-pollinated crops such as rice, wheat and barley, and for vegetatively propagated crops such as potatoes and bananas, the number of varieties developed may also be very high. For example, the Arguarana Jivaro community in the Peruvian Amazon grows 61 distinct cultivars of cassava, while some small communities in the Andes grow as many as 178 locally named potato varieties.

The complex use of diversity in farming systems is further illustrated by bean production in Malawi by small-scale farmers. Farmers in Malawi typically grow a large number of varieties (an average of 12 seed types), some in pure stands, some in mixtures and some interplanted with local or hybrid maize. Some are planted during the main growing season, others during the off-season. Each is valued for different reasons. Farmers attach high importance not only to yield, but also to various other attributes including taste, cooking ability, marketability, early maturity, ability to utilize residual soil moisture, and storability.

Farming systems based on diversity also provide a range of products with multiple uses, including varied food and other products, fuel, medicines, construction material, etc. The use of a wide diversity of crops and crop varieties can also be very important from a nutritional perspective. Traditional vegetables, often grown in gardens, provide valuable minerals, vitamins and amino acids, making a substantial contribution to household food security. The contribution of such plants to alleviating micronutrient



DID YOU KNOW THAT...?

- 1 ha of soil contains the equivalent in weight of one cow of bacteria, two sheep of protozoa, and four rabbits of soil fauna.
- 1 billion bacterial cells and about 10,000 different bacterial genomes are typically found in 1 gram of soil.
- Every year, soil organisms process an amount of organic matter equivalent in weight to 25 cars on a surface area as big as a soccer field.
- Only 1% of soil microorganism species are known.
- Some nematodes hunt for small animals by building various types of traps, such as rings, or produce adhesive substances to entrap and to colonise their prey.
- Some fungi are extremely big and can reach a length of several hundred metres.
- Some species of soil organisms can produce red blood to survive low oxygen conditions.
- Some crustaceans have invaded land.
- Termites have air conditioning in their nests.
- Bacterial population can double in 20 minutes.
- The fact to be ingested by earthworms or small insects can increase the activity of bacteria.
- Soil bacteria can produce antibiotics.
- Bacteria can exchange genetic material.
- Soil microorganisms can be dispersed over kilometres.
- Some soil organisms can enter a dormant state and survive for several years while unfavourable environmental conditions persist.
- Fungal diversity has been conservatively estimated at 1.5 million species.
- Earthworms often form the major part of soil fauna biomass, representing up to 60% in some ecosystems.
- Several soil organisms can help plants to fight against aboveground pests and herbivores.
- Ninety per cent of the energy flow in the soil system is mediated by microbes.
- The elimination of earthworm populations can reduce the water infiltration rate in soil by up to 93%.
- Moles are very common, and can be found everywhere in Europe, except in Ireland.
- Moles need to eat approximately 70% to 100% of their weight each day.
- Moles can paralyse earthworms thanks to a toxin in their saliva. They then store some of their prey in special 'larders' for later consumption – up to 1,000 earthworms have been found in such larders.
- The improper management of soil biodiversity worldwide has been estimated to cause a loss of 1 trillion dollars per year.
- The use of pesticides causes a loss of more than 8 billion dollars per year.
- Soils can help fight climate change.

European Commission – DG ENV-Soil biodiversity: functions, threats and tools for policy makers
February 2010



deficiencies is greatly underappreciated. In addition, complex farming systems based on diversity tend to support a wider range of animal and fish life which also make a valuable contribution to local diets.

Women farmers are particularly aware of the usefulness of plant genetic diversity as in many parts of the world they are the ones with primary responsibility for the production of subsistence crops that are essential to household food security. Women are often a reservoir of traditional knowledge of cultivation, maintenance and use of traditional varieties.

While improved varieties will usually have a higher potential yield than traditional varieties, such yield potential often cannot be achieved in resource poor environments and may involve risks to people's livelihoods. By using locally adapted farmers' varieties, or mixtures of varieties, farmers are able to spread the risk of crop failure resulting from pest and disease epidemics or adverse environmental effects such as drought. Often, farmers' varieties are well adapted to poor conditions. The countries of West Africa report, for example, local varieties of fonio which grow in low-fertility soils in arid zones.

In highly variable environments, higher total household production may be obtained from employing a range of crop varieties, each specifically adapted to the micro-environment in which it grows. Farmers also often use intercropping and agroforestry techniques that employ mixtures of species with complementary requirements, such as cereals with pulses. Intercropping is the norm for maize, millet, cowpea and many bean varieties in small farming systems. In some cases, crop varieties have become adapted to each other as a result of intercropping.

Efforts to measure genetic diversity within production systems have ranged from the evaluation of plant phenotypes using morphological characters, to the use of new tools of molecular biology. Considerable variation exists among production systems and at the highest levels of crop genetic diversity occur most commonly in areas where production is particularly difficult, such as in desert margins or at high altitudes, where the environment is extremely variable and access to resources and markets is restricted.

A study of the richness and evenness of traditional crop variety diversity of crops maintained by farming communities by Jarvis *et al.* (2007), drew varietal data from 27 crop species from five continents to determine overall trends in crop varietal diversity on farm. Measurements of richness, evenness and divergence confirmed that considerable crop genetic diversity continues to be maintained on farm, in the form of traditional crop varieties. The authors explained the importance of taking into account both key notions of biological diversity: richness and evenness. Richness refers to the number of different kinds of individuals. Evenness, however, measures how similar the frequencies are, with low evenness indicating dominance by one or a few types. These simple but powerful concepts of diversity are often forgotten when small-scale or single studies are conducted. Over the last 10 years, a coordinated global partnership of researchers in eight countries and on five continents has measured the amount and distribution of genetic diversity present in farmers' fields of 27 crop species⁹. The study encompassed an area of 63,600 ha. Traditional varieties dominated the planting at most of the sites (from 80 percent to 100 percent of the total crop area). The exception was rice, where the range was from 7 percent to 100 percent across six sites. The on-farm richness of traditional varieties ranged from 1.38 to 4.25 per household. At the community level, the richness indices indicated that communities harboured a large number of varieties. The mean number of varieties per community ranged from 4 (durum wheat) to 60 (cassava).

In general, farm evenness statistics indicated that farm diversity is not made up of one dominant and other very rare varieties. Instead, evenness at the community level was impressively high with a mean of 0.70. The study also found that communities having smaller farm-field areas are more differentiated in varietal composition than those with larger areas. In addition, community richness is eight fold that of farm richness, a result that underscores the importance of the difference between farms within the local

⁹ Based on Simpson indices. The greater the Simpson value the greater the evenness – i.e. that the frequency of varieties is more even, thus farmers are not devoting most of their land to one dominant variety, instead high evenness means that the area planted to each variety is evenly distributed.



community. The study emphasizes the fact that farmer management of the diversity is a self-adapting system, and that a powerful selection routine works to improve populations for the farmers' preferred trait and lead to a self-sustaining system.

Shifting science towards the development of eco-agricultural concepts

In discussing the utilization and conservation of agrobiodiversity in agricultural landscapes, Jackson *et al.*, (2007), emphasized the need for more research on agrobiodiversity and its ecosystem services, both for agrobiodiversity conservation in traditional agricultural systems, and as a potential source of innovation for sustainable agriculture.

The authors highlighted, in a table adapted from S. Scherr, the ecological science needed to develop eco-agriculture concepts, i.e. strategies to increase agricultural productivity and save the biodiversity of wild species and their ecosystem services. Critical issues requiring scientific research are compared to the eco-agriculture challenges (See Box).

Diversity and the evolution of agrarian systems

In *A History of World Agriculture*, Mazoyer and Roudart (2006) provide a body of analytical knowledge and a theory of historical transformations and geographical differentiations of agrarian systems. Just as a physician would not legitimately listen to a person's heart, make a diagnosis and prescribe a treatment without pre-existing knowledge of anatomy and physiology, it is not "legitimate" to analyse a given agricultural system, formulate a diagnostic and propose projects and policies without being grounded in knowledge of the dynamics of the different agriculture systems.

Every form of agriculture practiced in a given place and time appears, first of all, as a complex ecological and economic object, composed of several categories of production units that exploit different types of terrains and diverse species of cultivated plants and animals. Over time, every agricultural system is transformed, and in a given region of the world different species of agriculture can succeed one another, forming the stages of an evolutionary series characteristic of the history of this region.

An "agrarian system" is an intellectual tool that makes it possible to comprehend the complexity of each form of agriculture through a methodical analysis of its structure and its functions. Analyses and theorisation of the same type have been developed in response to the need to study other complex, varied, living and evolving objects, such as the systematic classification and theorisation of evolution of living species (Linnaeus¹⁰, Darwin), classification and theory of the formation and differentiation of the main types of soil in different regions (Dokoutchaev¹¹), and classification and theory of the relation among languages (Saussure¹²).

The following contains a snapshot of the systems that form humanity's agrarian heritage. *A History of World Agriculture* describes them further in great detail.

Systems of slash-and-burn agriculture in forest environments

Slash-and-burn agriculture is practiced in diverse forest environments. It is established on terrains previously cleared by cutting and then burning trees without removing the stumps. The parcels thus cleared are only cultivated one, two or three years, after which they are left for the forest to grow again, for a period of ten to 50 years. Most often a cereal such as rice, millet, or maize, a tuber such as yam or a root such as manioc or taro is planted to provide a staple diet rich in starch. The rest of the diet comes from gardens or animal breeding, hunting, fishing and gathering. This system can also be followed by one or two secondary cultivations of legumes rich in proteins and lipids such as peas, beans, groundnuts and soya, as well as various fruits, vegetables and condiments used for sauces including tomatoes, okra, squash and peppers. The primary cultivation is done immediately after the clearing and preparation of the soil to benefit from the best fertility conditions.

10 Carl Linnaeus, 18th century was a Swedish botanist, physician and zoologist. He is the father of modern taxonomy

11 Dokoutchaev early 20th century, Russian, father of soil science.

12 Saussure, Swiss, father of 20th century linguistics.



THE ECOLOGICAL SCIENCE NEEDED TO DEVELOP ECOAGRICULTURE CONCEPTS (adapted from S. Scherr)

determine geographic priorities for investment in biodiversity conservation

- mapping and documenting existing species populations, distribution and behaviour within agricultural landscapes,
- conservation of biodiversity resources in landscapes where ecosystems are especially productive and most converted to agriculture,

analyzing the tradeoffs and synergies involved in managing for agriculture productivity vs. for biodiversity conservation

- valuation of biodiversity in agricultural landscapes from biophysical and socioeconomic perspectives on short- and long-term time scales,

how to keep natural areas in agricultural landscapes, design networks of natural areas in agricultural landscapes to achieve effective habitat and biodiversity functions

- habitat requirements for wild species within different types of ecosystems within agricultural landscapes, especially in response to agricultural intensification,
- flows of genes, diseases, and other associated biota between wild and domesticated species,

assess progress towards achieving biodiversity conservation objectives in agricultural landscapes

- methods for measuring biodiversity within dynamic, highly fragmented landscapes (including interaction effects with key types of agricultural patches),

determine minimum size, type and configuration of natural areas required to achieve conservation of different species and ecological communities within agricultural landscapes

- degree and type of ecological disturbances that can be tolerated by different species and ecological communities,

achieve sustainable harvest of wild species from natural areas

- species tolerance and viability under diverse types of management and harvest,

how to manage agriculturally productive areas for biodiversity conservation, mobilize resources for habitat protection through ecosystem service payments, to farmers and farming communities

- contribution of wild and domestic biological resources to maintaining or increasing agricultural productivity, resilience and sustainability,
- substitution of off-farm inputs with agrobiodiversity-derived ecosystem services,

determine where reduction of agrochemicals are especially important for biodiversity conservation

- tolerance of wild species and ecological communities to agrochemical exposure,

decide where changes in crop, tree and livestock management are especially important for biodiversity conservation

- response of wild species to agricultural management, practices (e.g., cultivation, timing of practices, soil management),
- interaction of wild species with different types of agricultural crops and livestock,

maintain adequate levels of both livestock and wildlife health

- interrelationships of disease vectors for domestic stock and wildlife, develop best management practices to conserve wild species critical for agricultural production
- species population dynamics, behaviour and interactions with agricultural species and landscapes for soil microorganisms, crop pollinators,

determine parameters for irrigation system design and management to minimize threats to wild species and habitats

- impact of hydrological regimes on species and habitats.

Utilizing and conserving agrobiodiversity in agricultural landscapes. L. E. Jackson, U. Pascual and T. Hodgkin. Science Direct, Agriculture, Ecosystems and Environment 121 (2007) 196-210



The hydraulic agrarian systems in arid regions

The Nile Valley provides a good example of this type of system. Enclosed in the middle of an immense desert, within the narrow limits of the carefully organized and cultivable lands of a slender valley and delta that are submerged each summer by the Nile flood, Egyptian civilisation has always relied on hydraulic agriculture. For nearly 5000 years, the predominant system has been winter cultivation using basins and the receding floodwaters which coexists with a system of irrigated cultivation at different seasons.

Terraced mountain system

The Inca agrarian system is an example of a terraced mountain system. In fact, the first hydro-agricultural civilisations in the Andes were formed by a civilisation of peasant maize farmers in 1000 BC, on the desert coastal plain along the Pacific Ocean. Remarkable for its large stone edifices, sculptures and bas-relief, the Incas were one of a string of agrarian societies practicing cultivation on irrigated lands centred on magnificent city states (Lima, Nazca, Tiahuanaco etc.).

The Andes have always been a discontinuous agrarian world, an archipelago composed of populated and cultivated islands, and islets dispersed along the coast and the Andean and Amazonian rivers. These very heterogeneous agricultural lands are affected by mixed climates and unstable meteorological conditions. In the *suní* zone lying between 3600 and 4200 metres in altitude, both cooler and wetter, the ecosystem included non-irrigated cultivated lands, pastures, and lands left to the wild. The principal crop was the potato, transformed into *chuno* in order to preserve it. It was dehydrated by alternately exposing it to nightly freezes and daily sunshine. Thus it could be preserved for two or three years and easily transported to other regions.

Systems of animal-drawn cultivation based on rotation fallowing and accompanying animal herding

These are systems based on fallowing and animal-drawn cultivation with the ard – a simple tool that preceded the plough and biannual rotation. It consists of a single cereal crop that alternates with one year of fallow grassland. Typically this is a winter cereal crop that occupies the land for around nine months, sown in autumn and harvested in summer of the following year. The winter cereal is often wheat on good land, rye on less fertile lands, or a mixture of the two (mixed crop). It can also be winter barley or oats. In the fallow period, the land is not sown for several months, subjected to grazing by domestic animals and then ploughed. This unsown land is called uncultivated. However, far from being deserted, it is land where cereal stubble and residual weeds dominate after the harvest, a land where a natural vegetation develops.

The fallow is exploited as a pasture, when possible ploughed with a spade or hoe. Thus the widespread idea that fallowing is a period of rest for the soil, allowing it to “restore its strength” after a period of cultivation, is false. The soil does not have strength, it does not tire, and it does not rest. Another misconception is that fallowing is aimed at reproducing fertility. In little more than one year, the vegetation does not have the time to root itself strongly enough and this production of biomass would not be sufficient. The idea that by simply having livestock grazing on the fallow, the fertility will be improved is also a misconception. Nothing of the sort occurs because, as long as the animals do not eat elsewhere, their excrement cannot contain organic matter and minerals other than those absorbed in the fallow itself.

Systems of animal-drawn cultivation based on the plough, fallowing and accompanying animal herding in the cold temperate regions

This cultivated ecosystem is characterized by widespread use of the scythe and carts, hay meadows and hay making, along with pastures, henceforth occupied a large part of the old *saltus*, or pastures. The development of animal raising, stabling, manure production and the new plough gave rise to more extensive arable lands that were both better manured and better prepared. The growth in the size of herds and the development of stabling led to an enormous increase in the availability of organic fertilizer, compared to what was available in systems of cultivation based on the ard.

Systems of animal-drawn cultivation using the plow and without fallowing

From the sixteenth to the nineteenth century, most of Europe was the scene of a new agricultural revolution – referred to as a “revolution” because of its close relationship with the first industrial revolution. The



fallow lands were replaced by either pastures seeded with grass, such as ryegrass, or fodder legumes such as clover or sainfoin, or fodder roots and tubers such as turnips. In the new rotations, fodder crops alternated with cereals with almost no break, enabling the arable lands to produce as much fodder as the pastures and meadows combined in the old system. The development of these new rotations went hand in hand with the possibility to have more cattle which in turn supplied more animal products, draft power and manure. This led to a strong growth in cereal yields and made possible the introduction of other cereal crops with high fertility requirements, such as the turnip, cabbage, potato and corn as well as flax, hemp, sugar beets.

Motorized, mechanized, specialized systems using mineral fertilizers resulting from the second agricultural revolution.

Up to the end of the eighteenth century, industry primarily provided consumer goods. However at that time it also began to produce new machines and with the use of the steam engine, industrial mechanisation took on great importance. In the nineteenth century a rapidly growing iron and steel industry produced all sorts of new machines. The use of these machines, which were more effective, saved time in particular during the heaviest periods of work in the agricultural calendar. Gradually they formed a new comprehensive system of equipment.

As we can see, each agrarian system is the theoretical expression of a historically forged and geographically localized type of agriculture, composed of a characteristic cultivated ecosystem and a specific social production system. The latter makes the long-term exploitation of the fertility of the corresponding cultivated ecosystem possible. The production system is characterized by the types of tools and energy used to prepare the soil of the ecosystem in order to renew and exploit its fertility. The types of tools and energy used are themselves conditioned by the division of labour dominant in a society of a particular epoch.

An agrarian system cannot then be analyzed independently of the upstream activities that provide it with the means of production, any more than it can be analyzed independently of the utilisation of its products by downstream activities and by the consumers, nor can it be analyzed independently of other agrarian systems that contribute to satisfying a society's needs.

Other descriptions of farming systems

Farming systems have been given different classifications by various authors but always with a common ground: the fascination of the extraordinary diversity and richness of the endless variety of evolving modes of cultivations around the earth.

In his book, *Agricultures and peasantries of third worlds*, Dufumier (in French-2004) describes the historical evolution of agricultures in different parts of the world: Near-East, Magreb, Sahel-Sudan, plantation areas in Africa, South Africa, South-Asia, North-East Asia, South-East Asia, Mexico, Andes, Brazil, Central America and Caribbean as well as Haiti. The detailed description again reflects the very distinct trajectories that different parts of the world have followed, depending on the historical, agro-ecological and socio-economic conditions in which they evolved.

The FAO–World Bank farming system classification

John Dixon and Aidan Gulliver with David Gibbon in a FAO-World Bank publication (2001), defined more than 70 major farming systems throughout the six developing regions of the world, and looks in detail at some 20 systems, as a useful framework for understanding the needs of those living within a system, the likely challenges and opportunities that they will face over the next 30 years and the relative importance of different strategies for escaping from poverty and hunger. It differentiates between smallholder irrigated, wetland rice based, smallholder rainfed humid including forest based, rice-tree crop, root crop, cereal-root crop mixed, maize mixed, and smallholder rainfed highland with highland perennial, highland temperate mixed. Then smallholder rainfed dry/cold including agropastoral millet/sorghum, pastoral, sparse (arid), dualistic (tree crop, large commercial and smallholder), coastal artisanal fishing and urban based.



The authors state that they are “*convinced that the key to eradicating current suffering is to focus upon the creation of dynamic rural communities founded upon prosperous farming.*” A decade later, this is more true than ever.

To further understand how the safeguarding and development of the agriculture of the poor, which is by far the most widespread in the world today, can contribute to resolving the contemporary crisis, it is important to understand the root causes of the agrarian crisis that is increasingly threatening our future.

Agrarian crisis and general crisis

To further understand how the safeguarding and development of the agriculture of the poor, which is by far the most widespread in the world today, can contribute to resolving the contemporary crisis, it is important to understand the root causes of the agrarian crisis that is increasingly threatening our future.

Since the end of the nineteenth century, agrarian systems of the world have progressively confronted each other and their disparities in productivity and income. Confronted with harsh competition and hit by lower prices, the least well-equipped and productive farmers have seen their incomes collapse. Having become incapable of investing and developing, they were condemned to regression and elimination. In this way, tens of millions of small and medium farms in the developed countries have disappeared since the beginning of the century. For the past decades, hundreds of millions of small peasant farms in the developing countries plunged into crisis and were eliminated, adding to the growing rural exodus, unemployment, and rural and urban poverty.

This immense wave of global unemployment and poverty limits the growth of solvent world demand and leads to mass migration. Even if the archipelago of prosperity formed by the large industrial centres and their satellites continues to develop and expand, it finds itself stifled by the lack of outlets and overwhelmed and threatened by poverty growing a little more every day. The drivers of the agrarian crisis are poorly understood, and practically ignored in most development strategies. Condescending programmes are usually geared solely towards proposing the adoption of “improved” technologies to increase yields. The following provides a more detailed analysis of the roots and causes of the present crisis.

The hunger paradox

Most of the world’s hungry are not urban consumers but, instead, the very producers of foods, the peasants themselves. This stands as a contradictory and unacceptable paradox, not a simple heritage from the past but the result of an ongoing process that has led hundreds of millions of peasants to extreme poverty.

To explain this process, Mazoyer and Roudart answer the following questions:

- How large are the inequalities between different agricultures in the world?
- How has the contemporary agricultural revolution, carried out by a minority of farmers in the developed countries and in some developing countries, greatly increased these inequalities?
- Why has the Green Revolution increased inequalities?
- How has the tendency for real agricultural prices to fall blocked development and led to extreme poverty for more than one-third of the planet’s peasants?

The key is to understand the concept of labour productivity. Not crop productivity per hectare, but instead what can actually be produced by farmers during a year, given their means of production. We can measure the productivity of agricultural labour by looking at the production of cereals or cereal-equivalent per agricultural worker per year. In little more than half a century, the difference in labour productivity between the least equipped agriculture in the world, practiced exclusively with manual implements (hoe, spade, digging stick, machete, harvest knife, sickle) and the most-equipped, has increased dramatically. The gap has widened from 1 to 10 in the interwar period, to 1 to 2000 at the end of the twentieth century.



The contemporary Agricultural Revolution

In the course of the second half of the twentieth century, the contemporary agricultural revolution (large-scale motorisation and mechanisation, selection of high yields plant varieties and animal species, widespread use of synthetic fertilizers and herbicides, concentrated feed for livestock, and pesticides for plants and domestic animals) has greatly progressed in the developed countries and in some limited sectors of developing countries.

Developed countries. In the developed countries, farmers who were already relatively productive have benefited from policies that support agricultural development, as well as from real agricultural prices, which, at the beginning of the period under consideration, were much higher than today, thereby enabling maximum opportunities for investment and progress. But ultimately, fewer than 10 percent of the farms have succeeded in going through every stage of this revolution. Today, the best equipped, the best proportioned, the best situated among them attain a raw productivity on the order of 2000 tonnes of cereal-equivalent per worker per year (200 ha, 10 tonnes/ha). As a result, there has been a dramatic drop in real agricultural prices. Depending upon the products, these prices have been reduced by 2, 3 or 4 times in the course of the second half of the twentieth century. Consequently, during this time, more than 90 percent of the farms, the least advantaged, have been blocked in their development and impoverished by the lowering of prices to the extent that, one after the other, they disappeared and thereby provided a labour force for expanding industry and services.

Developing countries. In the developing countries, the immense majority of peasants have not accessed costly large-scale motorisation and mechanisation of agriculture. However, in a few regions (Latin America, the Middle East, South Africa), some large agricultural entrepreneurs who have thousands of hectares of land and poorly paid day labourers at their disposal have profited from inflation and the relatively high international agricultural prices since the first half of the 1970s, as well as advantageous credit terms, to equip themselves. Today, the most successful of these large farms have labour productivity as high as the best-equipped North American or western European farms, but with a much smaller labour cost.

The Green Revolution

Beginning in the 1960s, the Green Revolution, a variant of the contemporary agricultural revolution but without the large-scale motorisation and mechanisation, developed widely in the developing countries. Based on the selection of varieties of rice, maize, wheat and soya, a heavy utilisation of synthetic fertilizers and pesticides, and, if necessary, firm control over water for irrigation and drainage, the Green Revolution was adopted by farmers capable of acquiring these new means of productions in regions where it was possible to realize a return on their investment. In several countries, the public powers have greatly favoured the diffusion of this revolution by adopting policies of agricultural price supports, subsidies for inputs, preferential interest rates for borrowing, and investments in the infrastructures for irrigation, drainage, and transport. Today, a farmer fully utilizing the means of the Green Revolution can attain raw labour productivity on the order of 10 tonnes of cereal equivalent if that farmer has only manual tools (1 ha/worker 10 tonnes/ha), or on the order of 50 tonnes if they have equipment which uses animal power (5ha/worker) and even more if the farmer can make several harvests per year.

The social and environmental problems of the Green Revolution have been widely documented (Holt and Patel, 2009), including: increased inequality in rural incomes; concentration of land and resources; increasing pest problems; loss of agrobiodiversity; massive farm worker poisonings; salinisation; depleted and contaminated aquifers; and the erosion of fragile tropical soils. Initially the Green Revolution failed to incorporate poor and middle peasants and rural women. This accentuated existing gender and socio-economic disparities in the countryside. The high cost of its purchased inputs deepened the divide between the large farmers and smallholders.

In India, since 1997 a quiet emergence of debt-driven suicides directly attributed to the Green Revolution, has been estimated at 199,132 farmers, according to the National Crime Records Bureau (NCRB), 2009.



And, 40 percent of the farmers want to opt out of farming¹³. In 2001, with granaries so full of surplus that Indian authorities proposed dumping them into the sea, hunger deaths were reported in 12 Indian states; deaths unheard of since the 1960s. Farmer's suicides have been reported by the Ministry of Home Affairs, Government of India in "Accidental Deaths and suicides in India". In 2008 India ranked 66th out of 88 countries on the International Food Policy Research Institute's Hunger Index (IFPRI 2008).

It is calculated that while the total food available per person in the world increased by 11 percent during the two decades of the Green Revolution (1970-1990), the number of hungry people in South America went up by 19 percent, in South-Asia by 9 percent, and (if China is left out of the equation) the number of hungry people in the world actually increased by more than 11 percent (from 536 to 597 million). When the Green Revolution stagnated in the 1990s, cereal yield increases dropped by half and the number of hungry people ballooned to 800 million (World Bank, 2003).

Orphan agricultures

A very large number of peasants in the developing countries have never had access to the means of production for either one of these agricultural revolutions. Motorisation and mechanisation are practically absent, and specially selected seeds, and pesticides are used only a little or not at all in large cultivated areas in the intertropical forests, savannas, and steppes of Africa, Asia and Latin America. And even in regions fully influenced by one or the other of these revolutions, numerous peasants have never been in a position to acquire the new means of production and increase profitability and productivity. They too have been impoverished by the lowering of agricultural prices and, moreover, have often been affected by the ill consequences resulting from these two revolutions (diverse pollutions, lowering the ground water table, increasing salinity of irrigated and poorly drained soils).

As a consequence, hundreds of millions of peasants continue to work with strictly manual tools, without synthetic fertilizers or pesticides, and with plant varieties that have not been the object of research and systematic selection (tef, finger millet, fonio, millet, quinoa, sweet potato, oca, taro, yam, plantain, manioc). The yields obtained in these conditions are less than 1 tonne of cereal-equivalent per hectare (for example average yield of millet in the world is 0.8 tonnes/ha). Since manual tools hardly allow a single worker to cultivate more than 1 ha, the productivity does not surpass 1 tonne of cereal-equivalent per active worker per year (1 ha/worker 1 ton/ha).

Current reasons for the extreme impoverishment of hundreds of millions of peasants

The increases in productivity and global production resulting from the industrial agricultural revolution and from the Green Revolution have not only provoked a sharp drop in real agricultural prices in the countries concerned, they have also allowed certain countries to unload exportable surpluses at low prices. International trade in basic agricultural products involves only a small fraction of world agricultural production and consumption (12 percent in the case of cereals). The corresponding markets are residual markets, which consist of surpluses difficult to sell except at particularly low prices. At such prices, even the producers who have benefited from the agricultural revolution or the Green Revolution can win part of the market, or simply preserve their position, only if they have additional competitive advantages. Such is the case for certain South American, South African, Zimbabwean, and now Ukrainian and Russian, large farm-based agro-exporters, who are not only well equipped but have access to huge areas of land at low cost and to some of the lowest paid workers in the world. Today, on this type of latifundia, an agricultural worker making less than USD1000 per year can produce more than 1000 tonnes of cereals, which reduces the labour cost per kilo of cereal to less than a thousandth of dollar. Consequently, the price of one tonne of exportable cereal from these regions is less than USD 100.

At this price, a number of American or European farmers would have a nil or negative income. Consequently they would not be able to win a share of the market nor withstand imports nor persist in

¹³ Reported at the 59th Round of National Sample Survey Organisation, Government of India, 2005.



their business if they did not live in high-income, developed countries and benefit from important public assistance.

Finally, in certain developing countries, notably in Southeast Asia (Thailand, Vietnam, Indonesia), the increase in production due to the Green Revolution is combined with local incomes and wages so low that these countries have become exporters of rice, while under nourishment is rife in the countryside.

For the immense majority of the world's peasants, the international prices of basic food products are far too low for them to support themselves and renew their means of production, let alone to allow them to invest and grow. As a result of the lowering of transport costs and the growing liberalisation of international agricultural exchanges, the always renewed strata of under-equipped peasantry, with unsecured access to resources, in particular land, are confronted with competition from commodities sold at very low prices in international markets. This competition blocks their development, leading ultimately to extreme poverty and hunger.

In these conditions, it is easy to understand why development policies that consist of pushing the industrial agricultural revolution and Green Revolution further in favoured regions, and food policies that are designed to provide cities and towns with food products at always lower prices are particularly contraindicated in the fight against hunger. In fact, these policies impoverish the most destitute peasants even more, who, as has been explained, form the majority of the world's undernourished people.

Proponents of industrial agriculture fail to understand that large-scale motorisation and mechanisation are not in themselves means to reduce poverty. The cost is so high that it is out of the reach of the great majority of the peasants in the developing countries, while its adoption by the large estates that employ wage labour will reduce by 90 percent the need for that labour power, thereby increasing rural poverty, migration and unemployment in the same proportion. Neither GMO nor improved seeds can, in themselves, eradicate the extreme poverty and hunger of poorly equipped peasants. At the prices paid for agricultural products today, these peasants are less than ever able to benefit from such means.

A concrete example: a farmer in the US

A snapshot of the same reality is given through a practical example in the most industrialised context. The fast transformation towards a highly mechanised production system, witnessed in just one generation, is illustrated by Pollan in his magnificent book *The omnivore's dilemma* (2006).

The author describes the experience of pulling a spidery eight-row planter through an Iowa corn field, which he compares to trying to steer a boat through a softly rolling sea of dark chocolate. He tells us the

IN PRACTICE

In order to understand this impoverishment process better, consider a Sudanese, Andean or Himalayan cultivator of cereal, using manual tools and producing 1000 kg net of grain (seeds deducted), without fertilizer or pesticides. Around 50 years ago, such a farmer received the equivalent of USD 50 for 100 kg of grain. The farmer had to sell 200 kg in order to renew tools, clothes, etc, retaining 800 kg to feed four persons modestly. By cutting back on consumption a little, the farmer could even sell 100 kg more in order to buy some new and more effective tools. Twenty years ago, the same farmer received no more than the equivalent of USD 20 for 100 kg. Thus the farmer had to sell around 400 kg in order to renew tools and retained only 600 kg for food, this time insufficient for four persons. It was no longer possible to buy new tools. Finally today, if this farmer receives no more than USD 10 for 100 kg of grain, more than 600 kg must be sold in order to renew the equipment, which is well nigh impossible since one cannot feed four persons with 400 kg of grain. In fact, at this price, the farmer can neither completely renew the tools, however pitiable, nor eat properly and renew his/her labour power. This farmer is condemned to indebtedness and an exodus toward under-equipped and under-industrialized shantytowns where unemployment and low wages hold sway.



story of the Naylor farm, starting in 1919, when George Naylor bought it. The farm tracks the twentieth century story of American agriculture, its achievements as well as its disasters.

“It begins with a farmer supporting a family on a dozen different species of plants and fruits and other vegetables, as well as oats, hay, and alfalfa to feed the pigs, cattle, chicken, and horses—horses being the tractors of that time. One of every four Americans lived on a farm when Naylor’s grand-father arrived here in Churdan; his land and labour supplied enough food to feed his family and twelve other Americans besides. Less than a century after, fewer than 2 million Americans still farm—and they grow enough to feed the rest of us. What that means is that Naylor’s grandson, raising nothing but corn and soybeans on a fairly typical Iowa farm, is so astoundingly productive that he is, in effect, feeding some 129 Americans. Measured in terms of output per worker, American farmers like Naylor are the most productive humans who have ever lived. ...

For though this farm might feed 129, it can no longer support the four who live on it: The Naylor farm survives by the grace of Peggy Naylor’s paycheck (she works for a social services agency in Jefferson) and an annual subsidy payment from Washington, D.C. Nor can the Naylor family literally feed the Naylor family, as it did in grandfather Naylor’s day. George’s crops are basically inedible—they’re commodities that must be processed or fed to livestock before they can feed people. Water, water everywhere and not a drop to drink: like most of Iowa, which now imports 80 percent of its food, George’s farm (apart from his hedges, his laying hens, and his fruit trees) is basically a food desert.

The 129 people who depend on George Naylor for their sustenance are all strangers, living at the far end of a food chain so long, intricate, and obscure that neither producer nor consumer has any reason to know the first thing about the other. ...

So the plague of cheap corn goes on, impoverishing farmers (both here and in the countries to which we export it) degrading the land, polluting the water, and bleeding the federal treasury, which now spends up to \$5 billion a year subsidizing cheap corn. But though those subsidy checks go to the farmer (and represent nearly half of net farm income today), what the Treasury is really subsidizing are the buyers of all that cheap corn. “Agriculture’s always going to be organized by the government; the question is organized for whose benefit? Now it’s for Cargill and Coca-Cola. It’s certainly not for the farmer.”

One long tale: the kingdom of soils

The arbuscular mycorrhizal (AM) fungi – knowledge still to be unveiled

A lot has been written about Mycorrhizae, the symbiotic relationship between the mycelium (or threads also called hyphae) of a fungus and the roots of a plant, but research is still in its infancy. Here is a summary of the latest information, taken from the work of José-Miguel Barea.¹⁴

Agricultural productivity depends on soil quality. From an agronomical point of view, “soil quality” is expressed as “soil fertility” or the ability of a given soil to support sustainable plant health and productivity. Agricultural fertility is determined by the interaction of chemical, physical and biological components, as modulated by the prevalent environmental climatic conditions. The biological component of soil fertility is based on the activities of soil microbial populations which are particularly relevant at the root-soil interface microhabitats, known as the rhizosphere, where microorganisms interact with plant roots and soil constituents.

In spite of diverse microbial forms usually developed in the rhizosphere, most studies on rhizosphere microbiology have focussed their attention on bacteria and fungi. The prokaryotic¹⁵ bacteria and the

14 D. José Miguel Barea Navarro. University of Granada, Spain. Coordinador-Director del Curso Internacional de Edafología, Fertilidad de Suelos y Biología Vegetal.

15 An organism of the kingdom Monera (or Prokaryotae), comprising the bacteria and cyanobacteria, characterized by the absence of a distinct, membrane-bound nucleus or membrane-bound organelles, and by DNA that is not organized into chromosomes. Also called moneran.



eukaryotic¹⁶ fungi can carry out a variety of either saprophytic¹⁷ or symbiotic relationships, either detrimental (pathogens) or beneficial for the plant. Certain microbes establish so-called mutualistic symbiosis (two organisms intimately associated to live together with mutual benefit for both of them). Three main types of beneficial microbes can be distinguished: (i) the saprophytic root colonist rhizosphere bacteria, which are known as plant growth promoting rhizobacteria (PGPR); (ii) the microsymbionts arbuscular mycorrhizal (AM) fungi; and (iii) the microsymbionts N₂-fixing bacteria. The PGPR are involved in growth promotion, nutrient cycling and plant protection against diseases, the N₂-fixing bacteria are responsible for great N inputs to the biosphere, and the AM fungi, which associate with plant roots to form the so-called arbuscular mycorrhiza, are described here in more detail.

Research has mainly focused in the past on understanding the plant growth promoting rhizobacteria, those around the roots, and the ones that fix nitrogen. The arbuscular mycorrhizal fungi, the AM ones, those that look like trees and expand their mycelium deep in the plant and in the soil have kept their secrets to themselves. Now suddenly we are awakening to these intricate multifunctional complex interactions. The facts are here: AM symbiosis improves plant growth, nutrient acquisition, plant water relations, plant health (as bioprotectants against pathogens and abiotic stresses), and soil quality. AM fungi are a key component of soil fertility, perhaps the most important one.

How does it work? First of all terminology: mycorrhiza comes from the Greek “fungus-roots”. Mycorrhizal fungi are those around and inside the roots (in average 1 m of hyphae per cm of colonized root). The plant gets the food (mineral nutrients), the fungus gets the carbon which it is unable to obtain through photosynthesis. When they come close to each other, the plant recognises the fungus as a friend and allows it to develop without launching any defence mechanism. The fungus will connect with the plant's extended mycelium to the surrounding soil going beyond the roots. This happens to more than 80 percent of plant species, including almost all agricultural crops. The way young children in school learn the design of a plant or tree with stem or trunk and roots is just a fraction of what roots are. The reality is an intricate mix of threads intertwined in a continuum where it is difficult to know where one starts and where the other one ends. Fungi and their hyphae are specialised and efficient, they have been around for 450 million years – fossils showing that they were present at very early stages of plant evolution.

Since cyanobacteria able to fix atmospheric carbon (C) and nitrogen (N) were present in the primitive soil before colonisation of the land by plants, a biological system capable of facilitating phosphate (P) acquisition for plant nutrition appears to have been critical to the early evolution of land plants. The AM symbiosis, among many other key ecosystem activities, helps plants to acquire phosphate from soil, particularly under conditions of P-limitation. Therefore, through their association with AM fungi, primitive roots developed a biological system specialized in P acquisition.

How does that happen? The hypha, or fungi threads, build a pressure organ which will punch its way through the host using turgor pressure. Once inside the root there is an intense proliferation of the fungal mycelium which forms arbuscules, highly specialized and extremely branched with very fine tips to exchange nutrients and signals. Once it is inside, it can now spread outside into the soil. It will spread over long distances (several cm) longer than root hairs. The fungi will absorb the phosphate and “translocate” from external to internal mycelium and to the plant. This can be so efficient that the plant will “relax” and no longer directly absorb phosphate, letting the fungi work by itself and absorb all nutrients for the plant. The plant “knows” the fungus even has enzymes that will allow the release of phosphate from some organic sources it would not have access to. It also “knows” that beyond phosphate the fungus will absorb other nutrients and take care of her health by protecting against stresses which can be biotic (pathogen attack) or abiotic (salinity, heavy metals, organic pollutants) and enhance soil structure by forming aggregates.

16 Any of the single-celled or multicellular organisms, of the taxonomic domain Eukaryota, whose cells contain at least one distinct nucleus.

17 Obtaining food osmotically from dissolved organic material.



The potential of these on-going discoveries on the micro dynamics of interactions is enormous. An increasing demand for low-input agriculture means increased interest in the manipulation and use of beneficial soil microorganisms, including AM fungi, able to benefit soil fertility. A good management of soil microbes can reduce the use of chemicals and energy in agriculture leading to a more economical and sustainable production, while minimizing environmental degradation. But in spite of the general recognition of the positive influence on crop productivity of the AM symbiosis, there are still very few examples of inoculation and management of AM colonisation in agronomical practices.

Inoculation of seedlings could be used for establishing selected fungi in roots, before potting on or planting-out into the field. Inoculation is appropriate where transplanting is part of the normal production system, as is the case with horticulture, including plantation crops. Farmers can also produce 'home-grown' inoculum of highly colonized roots and soil to be applied to plots immediately before planting a crop could make a valuable contribution to food production in many relatively small, low input systems. Management strategies for inoculum build-up include the use of pastures and sequential cropping, where two or more crops are grown each year, or intercropping, where two crops are grown simultaneously.

Bringing to the surface the knowledge on the intricate mycorrhizal mycelium web and its fabulous ability to feed the plants and thereby, to feed us as well, is a good example of the need to reorient financial support and research towards more viable practices, awakening to a new outlook on the living systems of the earth (see also Annex 2 on the Rights of Mother Earth).



Where we are going

Models of development

This third section of Part II of *A viable food future* looks at development models, describes the potential effects of current practices, and the latest knowledge on sustainable practices, bringing to the forefront the dichotomy of two possible paths ahead, one based on democratic processes of those primarily concerned, one based on gambling-with-the-future technologies. It also includes a tale of viruses, which, as in the case of the root tale, is also real, and also appears almost like science fiction.

This section is about what could be if we realize the wealth we have at hand. It is also about what it can become if we do not care.

Industrial agriculture

Issues related to unsustainable practices in agriculture have been discussed in *A Viable Food Future* Part I. In this section we first review the repercussions these practices have on human health and then describe the Haber-Bosh process, the nitrogen fixation reaction of nitrogen gas and hydrogen gas, used to produce ammonia essential for the production of fertilizers and explosives. Unsustainable practices in agriculture are reviewed and the risks of genetically engineered crops discussed.

The impacts of industrial agriculture on human health

Industrial meals are increasingly all around us. They make up the food chain from which more and more people eat most of the time and have become the inescapable product of the industrial agricultural chain. Processing food increases the shelf life of food products, which makes it easier to market them away from the place of production and for longer time. From childhood, people get used to the high fat and sugar fast-foods and it is believed that these carbohydrates relieve stress and give a sensation of wellbeing.

Pollan (2006) describes how humans have inherited a preference for energy dense foods. Natural selection has predisposed us to the taste of sugar and fat. This is why processing food is such a good strategy for getting people to eat more. Yet, it is the increased energy density of processed foods that will affect humans' health. Type II diabetes typically occurs when the body's mechanism for managing glucose simply wears out from over-use. Type II diabetes and obesity are exactly what you would expect to see in a mammal whose environment has overwhelmed its metabolism with energy-dense foods.

According to WHO (2006), 1.6 billion people are currently overweight and 400 million obese. And, according to FAO (2009e), there is already a global food surplus, yet over 1 billion go hungry. Overall, 2.7 million deaths annually are attributable to low fruit and vegetable intake which causes 19 percent of gastrointestinal cancer, 31 percent of ischemic heart disease and 11 percent of strokes (WHO, 2003). Wright (2010) stresses the fact that this dietary-related ill-health is not included in food costs, but instead is paid for by governments and society. In 1996, for example, these health costs amounted to USD 81–117 per ha in Germany and USD 343 per ha in the UK. Indeed, in 2002, the FAO estimated that achieving the goal of halving the number of hungry people would generate global annual incremental benefits of USD 120 billion during the period up to 2010 (2009e).

At the other end of the spectrum of industrial meals, there has been much discussion and deep interest in finding the diet that will improve the health of human beings. Ever since antiquity, the traditional diet of Cretans was found to be the best example. The Greek island of Crete has always been identified with healing and regeneration. Following scientific research and statistical analyses, the Cretan nutrition and diet has been proven to promote health and longevity. It consists almost exclusively of products that the people of Crete produce locally without external inputs. It is not only the unique taste and quality of Cretan products but also their combination which gives great nutritional value and can be found in every Cretan dish.

A comparative study among seven developed countries, which began in 1960, included a group of about 700 Cretans from the countryside under medical observation, regularly checking the state of their



health. So far this group has had the lowest percentage of deaths caused by heart attacks and different kinds of cancer. The study has also shown the Cretan population to be the one with higher longevity. In 1991, 31 years after the study began, the Social Health Sector of the University of Crete undertook the medical checkup of the group, and found about 50 percent were found to be still alive as opposed to the other six participating countries that did not have a single survivor. Until recently the diet was simple and wholesome: olive oil, which counted for a third of the individual's daily need in energy, cereals principally bread, pulses, vegetables and fruit and, to a lesser degree, cheese, milk, eggs, fish and red wine. The following are the basics:

- olive oil as the principal fat, replacing other fats and oils;
- a moderate consumption of wine, normally with meals; about one to two glasses per day;
- fresh fruit as a typical daily dessert; limited sweets with much sugar and saturated fat;
- an abundance of food from plant sources, including fruits and vegetables, breads and grains, beans, nuts, and seeds;
- minimally processed and seasonally fresh and locally grown foods;
- total dietary fat should range from less than 25 percent to over 35 percent of energy, with saturated fat not exceeding 7 to 8 percent of total calories;
- low to moderate amounts of cheese and yoghurt daily;
- low to moderate amounts of fish and poultry weekly; limiting eggs from zero to four per week;
- red meat from time to time or just once a month.

Unfortunately local foods, local diets and local recipes are on the decline, increasingly being replaced by standardised chain consumption of processed foods.

In the case of industrial agriculture, human health is affected not only by the type of foods available in the market but also by the residues that are still present in the food products being consumed and by the combination of toxic substances that are released in the environment. A short snapshot is provided below based on Gauker (2009).

Heavy use of pesticides is associated with elevated cancer risks. Unsanitary conditions in factory farms and industrial slaughterhouses cause high levels of meat contamination which has resulted in recurrent epidemics of food-borne illness. Each year in the USA, food-borne illness sickens 76 million people, causes 325,000 hospitalisations, and kills 5,000 people. The high level of nitrates in industrial crops are also a major cause of concern both for human health and for the environment. A 1998 study by Consumer Reports revealed that 71 percent of store-bought chicken contaminated with *Campylobacter* and/or *Salmonella*, bacterial contaminants were responsible for thousands of deaths and millions of sicknesses in the USA.

Chemicals commonly used in industrial agriculture are pesticides, insecticides, herbicides, fungicides and antimicrobials. These chemicals are known to cause endocrine disruptions and cancer in humans. The use of antibiotics is another practice used to keep livestock healthy, but it contributes to antibiotic resistance among humans. Antibiotic-resistant microbes cause known treatment methods to be less effective in humans. Synthetic growth hormones given to livestock are used to promote unnaturally fast rates of growth. This in turn alters normal human hormone levels and functions. Preservatives used by manufactures in processed food help lengthen product shelf life but exacerbate asthma symptoms. In addition to the chemicals used to grow food, processed foods often contain unhealthy amounts of sugar, salt and fat, which cause improper cell metabolism and obesity. Finally, high fructose corn syrup found in almost all processed foods causes fatty tumours and cirrhosis.

Beyond the human health factors, environmental burdens from industrial agriculture are monoculture production, and the fact that toxic herbicides, insecticides and chemical fertilizers accumulate in the water and pollute water supplies. Massive amounts of faecal waste create toxic chemicals in large scale



manure holding pits seeping poisons into the soil and air near our water and food sources. This causes streams, rivers, and groundwater to gather pollutants. Foul odours, dust, and small airborne particles are absorbed affecting human health causing asthma and other related diseases.

Exposure to pesticides: currently, over 400 chemicals can be regularly used in conventional farming as biocides to kill weeds and insects. For example, apples can be sprayed up to 16 times with 36 different pesticides. In the span of the five-month growing season, chemicals are found in the air, soil, water, and food we eat. The short-term health impacts of pesticide drift – the movement of pesticides through erosion, migration, volatility or windblown soil particles on any unintended area – are multiple. Eye, nose, throat and skin irritation, difficulty breathing, skin rashes, headaches, stomach aches, diarrhoea, nausea, vomiting, dizziness, tremors, muscle weakness, blurred vision, excessive sweating or fever can occur a few minutes to a few days after exposure to pesticides.

Long-term (chronic) health impacts of pesticide exposure include brain cancer, birth defects, Parkinson's disease, leukaemia, miscarriage, non-Hodgkin's lymphoma, infertility, asthma, and sterility. Individuals who work with pesticides have a significantly elevated risk for all short and long-term health effects. Even though they take precautionary protective measures, chemicals still seep into their skin and they inhale more particles. People who live near farms using pesticides get exposure by the drift of the pesticides through the contaminated air and are at an increased risk to the short and long-term health effects as well. The United Nations has estimated two million poisonings and 100,000 deaths occur each year in developing countries from pesticides that affect human immune, endocrine and nervous systems.

Pesticides affect how the human body is able to develop and reproduce. They injure the nervous and reproductive systems, cause obesity, diabetes, miscarriages, birth defects, and cancers. Other environmental associated health risks of pesticides include solid tumours, neuroblastoma, reduced testosterone concentrations, reduced sexual organ growth, childhood cancers, brain cancer, non-Hodgkin's lymphoma, Wilms' tumour, and Ewing's sarcoma. Evidence indicates the biggest risk to a foetus is the amount of pesticides and herbicides the mother consumes. The Environmental Protection Agency has noted children receive half of their lifetime cancer risk in the first two years of life. Scientists have found exposure to pesticides increased the risk of spontaneous abortions and exposures to pesticides during pregnancy and early life increases the risk of a child developing leukaemia and non-Hodgkin's lymphoma.

Pesticides interfere with the normal development of the endocrine system, which aids in regulating metabolism and tissue function. A specific type of pesticide – organophosphate insecticide (OP) – poses the most significant developmental risks. OPs are specifically associated with increased risks of reproductive problems, childhood abnormalities and developmental changes that can last multiple generations. Vinclozolin, a fungicide used by the wine industry, blocks cell receptors normally activated by the hormone androgen. Fungicides decrease sperm counts and mobility in males when exposed in utero for three subsequent generations. Herbicides are a main source of chemicals farmers use in their fields to produce crops. Atrazine is one of the most widely used herbicides in the United States commonly applied to corn, sugarcane, pineapple, and sorghum.

Pesticide exposure in the first year of life has been associated with a significantly higher risk for asthma. There is an increased risk for asthma when there is exposure to farm animals, crops or dust.

A point Wright (2010) notes in light of awareness of health and dietary implications, is that feeding 9 billion people is not simply a question of increasing food availability from current levels in proportion with population growth. Global projections are inadequate to ensure food security at the level of the human being, as all these projections focus on two food components: cereals and livestock. This should be compared with standard dietary recommendations that promote an intake of at least 33 percent of fruit and vegetables, with another 33 percent coming from carbohydrates (cereals but also roots and tubers), and the other 33 percent comprising limited amounts of protein, dairy, fats and sugars (FSA, 2001).

Srinivasan *et al.* (2006) looked at the implications for production if everyone ate a more healthy diet. Based on WHO/FAO nutritional guidelines, their study concluded that this would require substantial



changes in production and consumption, to reduce meat, vegetable oils, eggs and dairy, and increase more cereal-based products, pulses, fruit and vegetables.

The need to apply the Precautionary Principle

The IAASTD report stresses the need for a systematic redirection of Agricultural knowledge, science and technology (AKST) that includes a rigorous rethinking of biotechnology, and especially modern biotechnology, in the decades to come. It highlights the fact that no long-term environmental and health monitoring programs exist to date in the countries with the highest areas planted to gene modified (GM) crops. Hence, long-term data on environmental implications of GM crop production are at best deductive or simply missing and speculative.

Biotechnology is defined as “*any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for a specific use.*” Broadly, biotechnology can include anything from fermentation technologies (e.g., for beer making) to gene splicing. It includes traditional and local knowledge and the contributions to cropping practices, selection and breeding of plants and animals made by individuals and societies for millennia. It also includes the application of tissue culture and genomic techniques and marker-assisted breeding, or to augment conventional breeding. Modern biotechnology is a term adopted by multilateral agreements to refer to biotechnological techniques for the manipulation of genetic materials and the fusion of cells beyond natural breeding barriers. The most obvious example is genetic engineering to create genetically modified/engineered organisms (GMOs/GEOs) through “transgenic technology” involving the transfer, insertion or deletion of genes. The word “modern” does not mean that these techniques are replacing other, or less sophisticated, biotechnologies. Conventional biotechnologies, such as breeding techniques, tissue culture, cultivation practices and fermentation remain widely accepted and used. Between 1950 and 1980, prior to the development GMOs, modern varieties of wheat may have increased yields up to 33 percent through the use of conventional biotechnologies even in the absence of fertilizers. Even modern biotechnologies used in containment are widely adopted. For example, the industrial enzyme market reached US\$1.5 billion in 2000. Overall, biotechnologies in general have made profound contributions in agriculture that continue to be relevant to both big and small farmers. The more controversial techniques in modern biotechnology are those that involve releases to the environment, such as the cultivation of GM crops. The controversy over environmental releases of products of modern biotechnology involve technical, social, legal, cultural and economic issues. The IAASTD report outlines the three most hotly-debated issues on modern biotechnology:

1. Lingering doubts about the adequacy of efficacy and safety testing, or regulatory frameworks for testing GMOs;
2. Suitability of GMOs for addressing the needs of most farmers while not harming others, at least within some existing intellectual property rights (IPR) and liability frameworks; and
3. Ability of modern biotechnology to make significant contributions to the resilience of small and subsistence agricultural systems.

Some of the most important risks cited in the literature are presented here to illustrate the need for applying the precautionary principle and the fact that, in the present state of affairs and in view of the existing potential in sustainable practices, GM crops are not compatible with diversified agriculture that could at the same time feed the earth, protect the environment and cool the climate.

The cultivation of GM crops has been increasing since 1996, particularly in a handful of countries with huge industrial agricultural production, such the USA, Canada, Brazil, Argentina, China and India. Worldwide, the areas planted to transgenic crops have reached 134 million hectares in 2009¹⁸. In the USA, 85 percent of national areas planted to maize are GM varieties, and 90 percent of national cotton areas

18 Clive James, ISAAA Brief No. 41, “Global Status of Commercialized Biotech/GM Crops in 2009”,



were planted to GM varieties. Herbicide-tolerant crops accounted for 62 percent of the total hectareage worldwide planted to GM crops, while stacked trait crops (those with combined insect resistance and herbicide-tolerant traits) and insect resistant crops (*Bt* crops) accounted for 21 percent and 15 percent, respectively, of the total global area of all transgenic crops in 2009¹⁹.

Proponents of GM crops, argue that the introduction of these crops will reduce or even eliminate the enormous crop losses due to weeds, insect pests, and pathogens²⁰. They claim that the use of such crops will have added beneficial effects on the environment by significantly reducing the use of agrochemicals. However, many sectors have expressed their concerns regarding the possible environmental risks of genetically engineered organisms and contend that there are several widely accepted environmental drawbacks associated with the rapid deployment and widespread commercialization of such GM crops in large monocultures.

Risks posed by GM Crops

The major risks surrounding GM crops often cited in the literature are as follows:

- the spread of transgenes to related weeds or conspecifics via crop-weed hybridization,
- reduction of the fitness of non-target organisms through the acquisition of transgenic traits via hybridization,
- the rapid evolution of resistance of insect pests such as Lepidoptera to Bt,
- accumulation of the insecticidal Bt toxin, which remains active in the soil after the crop is ploughed under and binds tightly to clays and humic acids,
- disruption of natural control of insect pests through intertrophic-level effects of the Bt toxin on predators,
- unanticipated effects on non-target herbivorous insects (i.e., monarch butterflies) through deposition of transgenic pollen on foliage of surrounding wild vegetation,
- vector-mediated horizontal gene transfer and recombination to create new pathogenic organisms.

Altieri et al. have studied the effects of the two dominant types of GM crops: herbicide tolerant crops and insect resistant crops (Bt), and have put forward the following conclusions:

Farmers have many choices, other than biotechnology, that work.

Many scientists think that herbicide-tolerant crops and Bt crops have been a poor choice of traits to feature the technology, given predicted environmental problems and the issue of resistance evolution. In fact, there is enough evidence to suggest that both traits are not really needed to address the problems they were designed to solve. On the contrary, they tend to reduce the pest management options available to farmers. There are many alternative approaches, (e.g., rotations, polycultures, cover crops, biological control, etc.) that farmers can use to effectively regulate the insect and weed populations that are being targeted by the biotechnology industry. To the extent that transgenic crops further entrench the current monocultural system, they impede farmers from using a plethora of alternative methods.

Ecological and Agronomic effects of GM Crops

Gene flow

Just as it occurs between conventionally improved crops and wild relatives, pollen mediates gene flow between GM crops and wild relatives or conspecifics despite all possible efforts to reduce it. Little is known about the long-term persistence of crop genes in wild populations or about the impact of fitness-related crop genes on the population dynamics of weedy relatives. The main concern with transgenes that confer significant biological advantages such as tolerance to herbicides is that they may transform wild/

¹⁹ *ibid.*

²⁰ Sales of biotechnology products are reaching \$60 billion/year.



weed plants into new or “super” weeds. Hybridization of herbicide-tolerant GM crops with populations of weedy relatives will make these plants increasingly difficult to control, especially if they are already recognized as agricultural weeds and if they acquire resistance to widely used herbicides. Experiences on development of weedier weeds have already been studied:

- Transgenic resistance to glufosinate can be passed on from *Brassica napus* to populations of weedy *Brassica napa*, and persist under natural conditions.
- In Europe there is a major concern about the possibility of pollen transfer of herbicide tolerant genes from *Brassica* oilseeds to *Brassica nigra* and *Sinapis arvensis*.

Development of insect resistance

Based on the fact that more than 500 species of pests have already evolved resistance to conventional insecticides, pests can also evolve resistance to Bt toxins present in transgenic crops. No one questions if Bt resistance will develop, the question is how fast it will develop. Susceptibility to Bt toxins can therefore be viewed as a natural resource that could be quickly depleted by inappropriate and massive use of Bt crops. Cautious restriction on the use of these crops may delay the evolution of resistance, but it does not look viable given the commercial pressures that have resulted to the cultivation of insect-resistant GM crops in 21.7 million hectares worldwide in 2009.

Questions on viability of insect refuge strategies

The insect refuge strategy of setting aside 20-30 percent of land area to non-Bt crops to delay resistance is very difficult to implement, especially in countries where average landholding of farmers is small and regulatory systems are weak. Data from the US Midwest shows that Bt corn saves on some insecticide use and yields are 2.4 Bu/acre higher than conventional corn but only under high European corn borer infestations (USDA 1999). On the other hand organic corn growers use no insecticides and obtain yields (4.8-9 t/ha) which is similar or slightly higher than conventional farmers (5.0-7.1 t/ha).

Majority of GM crops have been engineered to repel unwanted plants or weeds

Worldwide in 2009, transgenic herbicide-resistant crops were planted on 62 percent of the 134 million hectares devoted to transgenic GM crops. Of the total areas planted to GM crops worldwide in 2009, 52 percent were planted to herbicide-tolerant soybeans alone.²¹

Transgenic herbicide-resistance in crops simplifies chemically- and mechanically-based weed management because it typically involves compounds that are active on a very broad spectrum of weed species. Proponents also claim that post-emergence application timing for these materials fits well with reduced or zero-tillage production methods, which may conserve soil and reduce fuel and tillage costs. However, herbicide-tolerant crops also have significant problems:

- Dependence on herbicide-tolerant crops perpetuates the weed resistance problems and species shifts that are common to conventional herbicide-based approaches.
- Herbicide resistance becomes more of a problem as the number of herbicide modes of action to which weeds are exposed becomes fewer and fewer, a trend that herbicide-tolerant crops may exacerbate due to market forces.
- Given industry pressures to increase herbicide sales, areas treated with broad-spectrum herbicides are expected to expand further, exacerbating the resistance problem. Although glyphosate is considered less prone to weed resistance, the increased use of the herbicide will result in weed resistance, even if more slowly, as it has been already documented with Australian populations of annual ryegrass, quackgrass, birdsfoot trefoil and *Cirsium arvense*.
- The use of herbicide-tolerant crops steer efforts away from crop diversification and help to maintain cropping systems dominated by one or two annual species, resulting to increased crop uniformity.

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In contrast, crop diversification can reduce the need for herbicides, improve soil and water quality, minimize requirements for synthetic nitrogen fertilizers, regulate insect pest and pathogen populations, and increase crop yields and reduce yield variance.

GM Crops may have unintended victims, such as beneficial insects

Bacillus thuringiensis proteins are becoming ubiquitous, highly bioactive substances in agroecosystems. Most non-target herbivores colonizing *Bt* crops in the field ingest plant tissue containing *Bt* protein which they can pass on to their natural enemies in a more or less processed form. Polyphagous (e.g., subsisting on many kinds of foods) natural enemies that move between crop cultures are found to frequently encounter *Bt*-containing non-target herbivorous prey in more than one crop. This is a major ecological concern given previous studies that documented that genetically engineered *Cry1 Ab* protein from *Bt* adversely affected the predaceous lacewing *Chrysoperla carnea* reared on *Bt* corn-fed prey larvae.

These findings are problematic for small farmers in developing countries who rely on natural insect pest control, which involves a complexity of predators in their mixed cropping systems. Research shows that natural enemies can be affected directly through inter-trophic level effects of the toxin present in *Bt* crops. This raises serious concerns about the potential disruption of natural pest control, as polyphagous predators will encounter *Bt*-containing, non-target prey that moves within and between crop cultivars throughout the crop season. Disrupted biocontrol mechanisms will likely result in increased crop losses due to pests or to the increased use of pesticides by farmers with consequent health and environmental hazards.

Effects on the soil ecosystem

The possibilities for soil biota to be exposed to transgenic products are very high. The little research conducted in this area has already demonstrated that:

Toxins from GM crops remain active in the soil, decreasing soil fertility.

- There is long-term persistence of insecticidal products (*Bt* and proteinase inhibitors) in soil.
- The insecticidal toxin produced by *Bacillus thuringiensis subsp. kuruskatki* remain active in the soil, where it binds rapidly and tightly to clays and humic acids.
- The bound toxin retains its insecticidal properties and is protected against microbial degradation by being bound to soil particles, persisting in various soils for at least 234 days.
- The presence of the toxin in exudates from *Bt* corn and verified that it was active in an insecticidal bioassay using larvae of the tobacco hornworm.

Given the persistence and the possible presence of exudates, there is potential for prolonged exposure of the microbial and invertebrate community to such toxins, and therefore studies should evaluate the effects of transgenic plants on both microbial and invertebrate communities and the ecological processes they mediate.

If transgenic crops substantially alter soil biota and affect processes such as soil organic matter decomposition and mineralization, this would be of serious concern to organic farmers and most poor farmers in the developing world. These farmers cannot afford or do not want to use expensive chemical fertilizers. They rely instead on local residues, organic matter and especially soil organisms for soil fertility (e.g., key invertebrate, fungal or bacterial species) which can be affected by soil-bound toxins. Soil fertility could be dramatically reduced if crop leachates inhibit the activity of the soil biota and slow down natural rates of decomposition and nutrient release.

Economic Implications

Threats to organic production

A major economic impact of environmental releases of GM crops is the contamination of organic crops by transgenes from GM crops which could result to reduced or loss of income for organic farmers.



Certification systems of organic products in most countries prohibit the use of GM crops and can only tolerate very low threshold limits of GM content, if at all. Already, some organic farmers in the USA and Canada have suffered economic losses due to contamination by GM crops in neighbouring fields, with a few cases raised to the courts demanding redress and compensation.

Promotion of GM crops generally targets large and medium-scale farmers who can afford the high costs of seeds, associated technologies and required inputs.

Diversification of resources from ecological agriculture

Pressures from commercial interests behind GM crops result in massive promotion of these products among farmers by government institutions. In the Philippines, for example, the Department of Agriculture and its extension network at the local level actively promotes the adoption of GM corn by farmers. There are even local government units that extended direct subsidies to farmers who shift to GM corn seeds amounting to as much as 50 percent of the costs of seeds, plus extension services to assist farmers on the proper cultivation of GM crops. This is an obvious diversion of meager financial and human resources to the production of GM crops sold by corporations, at the expense of ecological production systems.

General Conclusions and Recommendations

Available independently-generated scientific information suggests that:

The long-term impacts of GMCs are not yet known.

- the massive use of transgenic crops poses substantial potential risks from an ecological point of view – the ecological effects are not limited to pest resistance and creation of new weeds or virus strains¹¹
- transgenic crops can produce environmental toxins that move through the food chain and also may end up in the soil and water, affecting invertebrates and probably disrupting ecological processes such as nutrient cycling³
- no one can really predict the long-term impacts that will result from such massive deployment of such crops.

Not enough research has been done to evaluate the environmental and health risks of transgenic crops, an unfortunate trend in view of the commercial introduction and massive promotion of GM crops in many parts of the world. Most scientists believe that such knowledge is crucial to have before innovations in modern biotechnology are implemented, released into the environment, or commercially deployed. There is a clear need to further assess the severity, magnitude and scope of risks associated with the massive field deployment of transgenic crops. Much of the evaluation of risks must go beyond comparing fields planted with GM crops with conventionally-managed systems, and should also include alternative cropping systems featuring crop diversity and low-external input approaches. This will allow real risk/benefit analysis of transgenic crops in relation to known and effective alternatives.

The loss of agricultural diversity may lead to disaster in developing countries

Moreover, the large-scale landscape homogenization with transgenic crops will exacerbate the ecological problems already associated with monoculture agriculture. Unquestioned expansion of this technology into developing countries may not be wise or desirable. Biological diversity and local knowledge are the very foundation of agriculture in most developing countries, and these should not be inhibited or reduced by extensive monoculture, especially when consequences of doing so result in serious social and environmental problems.

The repeated use of transgenic crops in an area may result in cumulative effects such as those resulting from the build-up of toxins in soils. For this reason, risk assessment studies not only have to be of an ecological nature in order to capture effects on ecosystem processes, but also of sufficient duration so that probable cumulative effects on the environment and ecosystems can be detected. The application



of multiple diagnostic methods will provide the most sensitive and comprehensive assessment of the potential ecological impact of transgenic crops.

Conclusion: Apply the Precautionary Principle, Moratorium on Field Releases of GM Crops

A recent report *Failure to Yield*, by UCS expert Doug Gurina Sherman, released in March 2009 is the first report to closely evaluate the overall effect genetic engineering has had on crop yields in relation to other agricultural technologies. It reviewed two dozen academic studies of corn and soybeans, the two primary genetically engineered food and feed crops grown in the United States. Based on those studies, the UCS report concluded that genetically engineering herbicide-tolerant soybeans and herbicide-tolerant corn has not increased yields. Insect-resistant corn, meanwhile, has improved yields only marginally. The increase in yields for both crops over the last 13 years, the report found, was largely due to traditional breeding or improvements in agricultural practices. This report, among others, has shown that whatever little, if any, benefits that GM crops may have brought to agricultural production are not commensurate the serious risks that it poses to the environment, biodiversity and livelihood.

While modern biotechnology may potentially be an important tool in agriculture, there are alternative solutions that exist to address the problems that current GM crops are intended to solve. The dramatic positive effects of rotations, multiple cropping, and biological control on crop health, environmental quality and agricultural productivity have been confirmed repeatedly by scientific research. Biotechnology should be considered as one more tool that may be used by farmers, provided the ecological risks and socio-economic implications are investigated indepth and deemed acceptable, in conjunction with a host of other approaches to move agriculture towards sustainability. In the absence of independent scientific studies that establish the safety of GM crops on the environment, biodiversity and human health, the Precautionary Principle embodied in the Rio Declaration adopted universally by states in 1992 should be invoked.

The story of chemical fertilisers

Synthetic fertilisers are often referred to in this paper without having explained the why and how of their development. Here is a short summary based on Pollan (2006), which gives a better understanding of the context in which they have been developed and used.

“The great turning point in the modern history of corn, which in turn marks a key turning point in the industrialization of our food, can be dated with some precision to the day in 1947 when the huge munitions plant at Muscle Shoals, Alabama, switched over to making chemical fertilizer. After the war the government had found itself with a tremendous surplus of ammonium nitrate, the principal ingredient in the making of explosives. Ammonium nitrate also happens to be an excellent source of nitrogen for plants. Serious thought was given to spraying America’s forests with the surplus chemical, to help out the timber industry. But agronomists had a better idea: spread the ammonium nitrate on farmland as fertilizer. The chemical fertiliser industry (along with that of pesticides which are based on poison gases developed for the war) is the product of the government’s effort to convert its war machine to peacetime purposes. As the Indian farmer activist Vandana Shiva says in her speeches, *“we’re still eating the leftovers of World War II.”*

“Hybrid corn turned out to be the greatest beneficiary of this conversion. Hybrid corn is the greediest of plants, consuming more fertilizer than any other crop. ...

The discovery of synthetic nitrogen changed everything- not just for the corn plant and the farm, not just for the food system, but also for the way life on earth is conducted. All life depends on nitrogen; it is the building block from which nature assembles amino acids, proteins and nucleic acids; the genetic information that orders and perpetuates life is written in nitrogen ink But the supply of usable nitrogen on earth is limited. Although earth’s atmosphere is about 80 percent nitrogen, all those atoms are tightly paired, nonreactive and therefore useless; the nineteenth-century chemist Justus von Liebig spoke of atmospheric nitrogen’s *“indifference to all other substances.”* To be of any value to plants and animals, these self-involved nitrogen atoms must be split and then joined to atoms of hydrogen. Chemists call



this process of taking atoms from the atmosphere and combining them into molecules useful to living things “fixing” that element. Until a German Jewish chemist named Fritz Haber figured out how to turn this trick in 1909, all the usable nitrogen on earth had at one time been fixed by soil bacteria living on the roots of leguminous plants ... or, less commonly, by the shock of electrical lightening, which can break nitrogen bonds in the air, releasing a light rain of fertility.

Vaclav Smil, a geographer who has written a fascinating book about Fritz Haber called *Enriching the Earth*, pointed out that “*there is no way to grow crops and human bodies without nitrogen*”. Before Fritz Haber’s invention the sheer amount of life earth could support (the size of crops and therefore the number of human bodies) was limited by the amount of nitrogen that bacteria and lightning could fix. By 1900, European scientists recognized that unless a way was found to augment this naturally occurring nitrogen, the growth of the human population would soon grind to a very painful halt. ... This is why it may not be hyperbole to claim, as Smil does, that the Haber-Bosch process (Carl Bosch gets the credit for commercializing Haber’s idea) for fixing nitrogen is the most important invention of the twentieth century. He estimates that two of every five humans on earth today would not be alive if not for Fritz Haber’s invention. We can easily imagine a world without computers or electricity, Smil points out, but without synthetic fertilizer billions of people would never have been born ...

When humankind acquired the poser to fix nitrogen, the basis of soil fertility shifted from a total reliance on the energy of the sun to a new reliance on fossil fuel. For the Haber-Bosch process works by combining nitrogen and hydrogen gases under immense heat and pressure in the presence of a catalyst. The heat and pressure are supplied by prodigious amounts of electricity, and the hydrogen is supplied by oil, coal, or, most commonly today, natural gas (fossil fuels).

On the day in the 1950s (...when a US farmer...) spread his first load of ammonium nitrate fertilizer, the ecology of his farm underwent a quiet revolution. What had been a local, sun-driven cycle of fertility, in which the legumes fed the corn which fed the livestock which in turn (with their manure) fed the corn, was now broken. Now he could plant corn every year on as much of his acreage as he chose, since he had no need for the legumes or the animal manure. He could buy fertility in a bag, fertility that had originally been produced a billion years ago halfway around the earth. ...

It takes more than a calorie of fossil fuel to produce a calorie of food. ... From the standpoint of industrial efficiency, it’s too bad we can’t simply drink the petroleum directly. Ecologically this is a fabulously expensive way to produce food (but “ecologically” is no longer the operative standard). As long as fossil fuel energy is so cheap and available, it makes good economic sense to produce corn this way.

What happens to the ... synthetic nitrogen that ... corn plants don’t take up? Some evaporate into the air, where it acidified the rain and contributes to global warming Some seeps down to the water table. When nitrogen runoff is at its heaviest, cities issue “blue baby alerts”, warning parents it’s unsafe to give children water from the tap.

The flood of synthetic nitrogen has fertilized not just the farm fields but the forests and the oceans too, to the benefit of some species (corn and algae) and to the detriment of countless others.”

Unsustainable practices

Much has been written about the unsustainable practices in industrial agriculture and the related social and environmental externalities. The expansion of monocultures and their ecological implications are summarised as follows (Altieri, 2000).

Until about four decades ago, in the USA, crop yields in agricultural systems depended on internal resources, recycling of organic matter, built-in biological control mechanisms and rainfall patterns. Inputs of nitrogen were gained by rotating major field crops with legumes. In turn, rotations suppressed insects, weeds and diseases by effectively breaking the life cycles of these pests. Most of the labour was done by the family with occasional hired help and no specialized equipment or services were purchased



from off-farm sources. In these types of farming systems, the link between agriculture and ecology was quite strong and signs of environmental degradation were seldom evident.

But as agricultural modernisation progressed, the ecology-farming linkage was often broken as ecological principles were ignored and/or overridden. Evidence has accumulated showing that whereas the present capital- and technology-intensive farming systems have been extremely productive and competitive, they also have brought a variety of economic, environmental and social problems.

Evidence also shows that the very nature of the agricultural structure and prevailing policies have led to an environmental crisis by favouring large farm size, specialized production, crop monocultures and mechanisation. Today as more and more farmers are integrated into international economies, imperatives to diversity disappear and monocultures are rewarded by economies of scale. In turn, lack of rotations and diversification take away key self-regulating mechanisms, turning monocultures into highly vulnerable agro-ecosystems dependent on high chemical inputs.

From an ecological perspective, the regional consequences of monoculture specialisation are many-fold:

- a. Most large-scale agricultural systems exhibit a poorly structured assemblage of farm components, with almost no linkages or complementary relationships between crop enterprises and among soils, crops and animals.
- b. Cycles of nutrients, energy, water and wastes have become more open, rather than closed as in a natural ecosystem. Despite the substantial amount of crop residues and manure produced in farms, it is becoming increasingly difficult to recycle nutrients, even within agricultural systems. Animal wastes cannot economically be returned to the land in a nutrient-recycling process because production systems are geographically remote from other systems which would complete the cycle. In many areas, agricultural waste has become a liability rather than a resource.
- c. Part of the instability and susceptibility to pests of agro-ecosystems can be linked to the adoption of vast crop monocultures, which have concentrated resources for specialist crop herbivores and have increased the areas available for immigration of pests. This simplification has also reduced environmental opportunities for natural enemies. Consequently, pest outbreaks often occur when large numbers of immigrant pests, inhibited populations of beneficial insects, favourable weather and vulnerable crop stages happen simultaneously.
- d. As specific crops are expanded beyond their “natural” ranges or favourable regions to areas of high pest potential, or with limited water, or low-fertility soils, intensified chemical controls are required to overcome such limiting factors.
- e. Commercial farmers witness a constant parade of new crop varieties as varietal replacement due to biotic stresses and market changes has accelerated to unprecedented levels. A cultivar with improved disease or insect resistance makes a debut, performs well for a few years (typically 5-9 years) and is then succeeded by another variety when yields begin to slip, productivity is threatened, or a more promising cultivar becomes available.
- f. The need to subsidize monocultures requires increases in the use of pesticides and fertilizers, but the efficiency of use of applied inputs is decreasing and crop yields in most key crops are levelling off. In some places, yields are actually in decline. There are different opinions as to the underlying causes of this phenomenon. Some believe that yields are levelling off because the maximum yield potential of current varieties is being approached, and therefore genetic engineering must be applied to the task of redesigning crop. Agroecologists, on the other hand, believe that the levelling off is because of the steady erosion of the productive base of agriculture through unsustainable practices.

The first wave of environmental problems

The specialisation of production units has led to the image that agriculture is a modern miracle of food production. Evidence indicates, however, that excessive reliance on monoculture farming and



agroindustrial inputs, such as capital-intensive technology, pesticides, and chemical fertilizers, has negatively impacted the environment and rural society. Most agriculturalists had assumed that the agroecosystem/natural ecosystem dichotomy need not lead to undesirable consequences, yet, unfortunately, a number of “ecological diseases” have been associated with the intensification of food production. They may be grouped into two categories: diseases of the ecotope, which include erosion, loss of soil fertility, depletion of nutrient reserves, salinisation and alkalisation, pollution of water systems, loss of fertile croplands to urban development, and diseases of the biocoenosis, which include loss of crop, wild plant, and animal genetic resources, elimination of natural enemies, pest resurgence and genetic resistance to pesticides, chemical contamination, and destruction of natural control mechanisms. Under conditions of intensive management, treatment of such “diseases” requires an increase in the external costs to the extent that, in some agricultural systems, the amount of energy invested to produce a desired yield surpasses the energy harvested.

The loss of yields due to pests in many crops (reaching about 20–30 percent in most crops), despite the substantial increase in the use of pesticides (about 500 million kg of active ingredient worldwide) is a symptom of the environmental crisis affecting agriculture.

It is well known that cultivated plants grown in genetically homogenous monocultures do not possess the necessary ecological defence mechanisms to tolerate the impact of pest population outbreaks. Modern agriculturists have selected crops for high yields and high palatability, making them more susceptible to pests by sacrificing natural resistance for productivity. On the other hand, modern agricultural practices negatively affect pest natural enemies, which in turn do not find the necessary environmental resources and opportunities in monocultures to effectively and biologically suppress pests. Due to this lack of natural controls, an investment of about USD 40 billion in pesticide control is incurred yearly by USA farmers, which is estimated to save approximately USD 16 billion in USA crops. However, the indirect costs of pesticide use to the environment and public health have to be balanced against these benefits.

Based on the available data, the environmental impacts on wildlife, pollinators, natural enemies, fisheries, water and development of resistance, and the social costs of human poisonings and illnesses resulting from pesticide use reach about USD 8 billion each year. What is worrisome is that pesticide use is on the rise. Data from California shows that from 1941 to 1995, pesticide use increased from 161 to 212 million pounds of active ingredients. These increases were not due to increases in planted acreage – statewide crop acreage remained constant during this period. Crops such as strawberries and grapes accounted for much of this increased use, which includes toxic pesticides, many of which are linked to cancers.

Synthetic fertilizers, on the other hand, have been praised as being highly associated with the temporary increase in food production observed in many countries. National average rates of nitrate applied to most arable lands in the USA fluctuate between 120–550 kg N/ha. But the bountiful harvests created, at least in part through the use of chemical fertilizers, have associated, and often hidden, costs. A primary reason why chemical fertilizers pollute the environment is due to wasteful application and the fact that crops use them inefficiently. The fertilizer that is not recovered by the crop ends up in the environment, mostly in surface water or in ground water. Nitrate contamination of aquifers is widespread and in dangerously high levels in many rural regions of the world. In the USA, it is estimated that more than 25 percent of the drinking water wells contain nitrate levels above the 45 parts per million safety standard. Such nitrate levels are hazardous to human health and studies have linked nitrate uptake to methaemoglobinemia in children and to gastric, bladder and oesophageal cancers in adults.

Fertilizer nutrients that enter surface waters, such as rivers, lakes and bays, can promote eutrophication, characterized initially by a population explosion of photosynthetic algae. Algal blooms turn the water bright green, prevent light from penetrating beneath surface layers, therefore killing plants living on the bottom. Such dead vegetation serves as food for other aquatic microorganisms which soon deplete water of its oxygen and inhibit the decomposition of organic residues, which accumulate on the bottom.



Eventually, such nutrient enrichment of freshwater ecosystems leads to the destruction of all animal life in the water systems. In the USA it is estimated that about 50–70 percent of all nutrients that reach surface waters is derived from fertilizers.

Chemical fertilizers can also become air pollutants and have recently been implicated in the destruction of the ozone layer and in global warming. Their excessive use has also been linked to the acidification and salinisation of soils and to a higher incidence of insect pests and diseases through mediation of negative nutritional changes in crop plants.

It is clear that the first wave of environmental problems is deeply rooted in the prevalent socio-economic system which promotes monocultures, and the use of high input technologies and agricultural practices that lead to natural resource degradation. Such degradation is not only an ecological process, it is also a social and political-economic process. This is why the problem of agricultural production cannot be regarded only as a technological one. It is also crucial to pay attention to social, cultural and economic issues.

The second wave of environmental problems.

Despite that awareness of the impacts of modern technologies on the environment increased, as we traced pesticides in food chains and crop nutrients in streams and aquifers, there are those who, when confronted with the challenges of the twenty-first century still argue for further intensification to meet the requirements of agricultural production. It is in this context that supporters of “status-quo agriculture” celebrate the emergence of biotechnology as the latest magic bullet that will revolutionize agriculture with products based on nature’s own methods, making farming more environmentally friendly and more profitable for the farmer. Clearly, certain forms of non-transformational biotechnology hold promise for improving agriculture, given its present orientation and control by multinational corporations. However it also holds promise for environmental harm, for the further industrialisation of agriculture and for the intrusion of private interests too far into public interest sector research.

What is ironic is the fact that the biorevolution is being brought forward by the same interests (Monsanto, Novartis, DuPont, etc.) that promoted the first wave of agrochemically-based agriculture, but this time, by equipping each crop with new “insecticidal genes”, they are promising the world safer pesticides, reduction of chemically intensive farming and a more sustainable agriculture.

However, as long as transgenic crops follow the pesticide paradigm, such biotechnological products will do nothing but reinforce the pesticide treadmill in agro-ecosystems, thus legitimizing the concerns that many scientists have expressed regarding the possible environmental risks of genetically engineered organisms.

So far, field research as well as predictions based on ecological theory, indicate that the major environmental risks associated with the release of genetically engineered crops can be summarized as follows.

- Corporations seek to create broad international markets for a single product, thus creating the conditions for genetic uniformity in rural landscapes. History has repeatedly shown that a huge area planted to a single cultivar is very vulnerable to a new matching strain of a pathogen or pest.
- The spread of transgenic crops threatens crop genetic diversity by simplifying cropping systems and promoting genetic erosion.
- There is potential for the unintended transfer to plant relatives of the “transgenes”, with unpredictable ecological effects. The transfer of genes from herbicide resistant crops (HRCs) to wild or semidomesticated relatives can lead to the creation of super weeds.
- Most probably insect pests will quickly develop resistance to crops with Bt toxin (insect resistant). Several Lepidoptera species have reportedly developed resistance to Bt toxin in both field and laboratory tests, suggesting that major resistance problems are likely to develop in Bt crops which, through the continuous expression of the toxin, creates a strong selection pressure.



- Massive use of Bt toxin in crops can unleash potential negative interactions affecting ecological processes and non-target organisms. Evidence from studies conducted in Scotland suggested that aphids were capable of sequestering the toxin from Bt crops and transferring it to its coccinellid predators, in turn affecting reproduction and longevity of the beneficial beetles.
- Bt toxins can be incorporated into the soil through leaf materials and litter, where they may persist for 2–3 months, resisting degradation by binding to soil clay particles while maintaining toxic activity, in turn negatively affecting invertebrates and nutrient cycling.
- A potential risk of transgenic plants expressing viral sequences derives from the possibility of new viral genotypes being generated by recombination between the genomic RNA of infecting viruses and RNA transcribed from the transgene.
- Another important environmental concern associated with the large-scale cultivation of virus-resistant transgenic crops relates to the possible transfer of virus-derived transgenes into wild relatives through pollen flow.

Although there are many unanswered questions regarding the impact of the release of transgenic plants and micro-organisms into the environment, it is expected that biotechnology will exacerbate the problems of conventional agriculture and, by promoting monocultures will also undermine ecological methods of farming such as rotations and polycultures.

Because transgenic crops developed for pest control emphasize the use of a single control mechanism, which has proven to fail over and over again with insects, pathogens and weeds, transgenic crops are likely to increase the use of pesticides and to accelerate the evolution of “super weeds” and resistant insect pest strains. These possibilities are worrisome, especially when considering that during the period 1986–1997, approximately 25,000 transgenic crop field trials were conducted worldwide on more than 60 crops with 10 traits in 45 countries. By 1997 the global area devoted to transgenic crops reached 12.8 million hectares. Seventy-two percent of all transgenic crop field trials were conducted in the USA and Canada, although some were also conducted in Europe, Latin America and Asia.

In most countries, biosafety standards to monitor such releases are absent or are inadequate to predict ecological risks. In the industrialized countries from 1986–1992, 57 percent of all field trials to test transgenic crops involved herbicide tolerance pioneered by 27 corporations, including the world’s eight largest pesticide companies. As Roundup and other broad spectrum herbicides are increasingly deployed into croplands, farmers’ options for a diversified agriculture will become even more limited.

To conclude, clearly the nature of modern agricultural structure and contemporary policies have decidedly influenced the context of agricultural technology and production, which in turn has led to environmental problems of a first and second order. In fact, policies discourage resource-conserving practices and in many cases such practices are not profitable for farmers. So the expectation that a set of policy changes could be implemented for a renaissance of diversified or small-scale farms may be unrealistic, because it negates the existence of scale in agriculture and ignores the political power of agribusiness corporations and current trends set forth by globalisation.

A more radical transformation of agriculture is needed, one guided by the notion that ecological change in agriculture cannot be promoted without comparable changes in the social, political, cultural and economic arenas that also conform agriculture. In other words, change toward a more socially just, economically viable, and environmentally sound agriculture should be the result of social movements in the rural sector in alliance with urban organisations. This is especially relevant in the case of the new biorevolution, where concerted action is needed so that biotechnologies are re-orienting for the overall benefit of society and nature.

Similarly, the IAASTAD (2008) concluded in its synthesis report that current ways of organizing technology generation and diffusion will be increasingly inadequate to address emerging environmental challenges, the multifunctionality of agriculture, the loss of biodiversity, and climate change. Focusing



Agriculture Knowledge, Science and Technology (AKST) systems and actors on sustainability requires a new approach and worldview to guide the development of knowledge, science and technology as well as the policies and institutional changes to enable their sustainability. It also requires a new approach in the knowledge base. There is a need for the revalorisation of traditional and local knowledge and their interaction with formal science, and for interdisciplinary (social, biophysical, political and legal), holistic and system-based approaches to knowledge production and sharing.

IAASTAD emphasises the need to embrace sustainable practices to reduce agrochemical inputs (particularly pesticides and synthetic fertilizers); use energy, water and land more efficiently (not only as in precision agriculture, but also as in agro-ecology); diversify agricultural systems and use agro-ecological management approaches. It stresses the need to coordinate biodiversity and ecosystem service management policies with agricultural policies and to internalize the environmental cost of unsustainable practices and to avoid those that promote the wasteful use of inputs (pesticides and fertilizers).

In particular it calls for the fair compensation of ecosystem services, the regulation of environmentally damaging practices and for the development of capacities for institutional changes that ensure monitoring and evaluation of compliance mechanisms.

Private investment detrimental to nature and societies: the case of land grabs

The following is taken from the paper from S. Daniel with A. Mittal, “(Mis)investment in agriculture” (2010), on the issue of land grabs. The eloquent foreword by H. Buffet states: *“There is no disguising what is happening right now, on our watch. It is estimated that 50 million hectares have already been leased to foreign entities with at least 20 African countries considering similar deals. Some of these leases (99 years at \$1 per hectare) are unbelievable deals. But they are only available to a select few. Local farmers (people who struggle to feed their families (...)) are not eligible for the deals being promoted in countries where millions of people remain dependent on food aid.”* And recalling: *“I will never forget a trip to the Chad/Sudan border: an old man grasped my hand and with the little energy he could muster asked me not to forget him, not to let the world forget him and his people. I didn’t have the heart to tell him that most people had already forgotten.”*

The global land grab²², has been spurred by the events surrounding the food and financial crises of 2008. Fertile land is being offered to investors, often at giveaway prices, especially in Africa. These and other factors have ignited a global rush for the world’s farmland by investors in what has become known as the global “landgrab” phenomenon. The World Bank took the lead role on the international stage following the food and financial crises with the formation of programmes such as the Global Food Crisis Response Programme and has played a role in the global landgrab, enabling a trend that threatens global food security and livelihoods of small-scale farmers.

Making agriculture more sustainable

The idea of agricultural sustainability centres on food production that makes the best use of nature’s goods and services while not damaging these assets (Pretty, 2006).

Resource Efficiency

Towards viable and resilient farming systems

Throughout the developing world, there are countless experiences of sustainable and diverse forms of agriculture implemented at the local level by farmer’s organisations, NGOs, and other agencies. These experiences demonstrate the feasibility of intensifying production, regenerating and preserving soils, and maintaining biodiversity, based on sustainable technologies and locally available resources. A few concrete examples, based on field experience, will be given here to provide the latest knowledge and scientific evidence of what can realistically be proposed.

²² More information see GRAIN- land grabs: <http://www.grain.org/landgrab/>



It has now been demonstrated²³ that at least double digit increases in yields can be obtained while reducing synthetic fertilizers and that the performance of pest control can be substantially improved while cutting the use of chemical inputs drastically. Beyond yields *per se* and the amount of food that can be produced, these different forms of production touch upon a whole range of environmental and social benefits with a variety of measurable and non-measurable benefits for people and the ecosystems which go beyond the production of food *per se*.

The concept of sustainability in the context of agricultural and food production is central to any future challenges (Pretty 2008). It incorporates, as defined in Reaping the Benefits (UK Royal Society, 2009), four key principles:

- **Persistence:** the capacity to continue to deliver desired outputs over long periods of time (human generations), thus conferring predictability;
- **Resilience:** the capacity to absorb, utilise or even benefit from perturbations (shocks and stresses), and so persist without qualitative changes in structure;
- **Autarchy:** the capacity to deliver desired outputs from inputs and resources (factors of production) acquired from within key system boundaries;
- **Benevolence:** the capacity to produce desired outputs, such as food, fibre, fuel or oil, while sustaining the functioning of ecosystem services and not causing depletion of natural capitals such as minerals, biodiversity, soil or clean water.

Under these principles and measures, any system is unsustainable if it depends on non-renewable inputs, cannot consistently and predictably deliver desired outputs, can only do this by requiring the cultivation of more land, and/or causes adverse and irreversible environmental impacts which threaten critical ecological functions.

The primary aim of agriculture is the efficient conversion of solar energy into various forms of chemical energy for human use. This encompasses crops grown for food, fuel fibre and forage for animals. Agriculture involves the management of the interaction between crop genotypes or livestock breeds and their immediate agro-environment (physical and biological). The capacity of the system to deliver what is required and to do this consistently over generations demands a continuity of agro-ecosystem functions.

As agricultural and environmental outcomes are pre-eminent objectives, sustainable agricultural systems cannot be defined by the acceptability of any particular technologies or practices. If a technology improves production without adverse ecological consequences, then it is likely to contribute to the system's sustainability. Sustainable agricultural systems are less vulnerable to shocks and stresses and also contribute to the delivery and maintenance of a range of valued public goods, such as clean water, carbon sequestration, flood protection, groundwater recharge and landscape amenity value.

A sustainable production system exhibits most of the following attributes:

- utilises crop varieties and livestock breeds with high productivity per externally derived input;
- avoids the unnecessary use of external inputs;
- harnesses agroecological processes such as nutrient cycling, biological nitrogen fixation, allelopathy, predation and parasitism;
- minimises the use of technologies or practices that have adverse impacts on the environment and human health;
- makes productive use of human capital in the form of knowledge and capacity to adapt and innovate and social capital to resolve common landscape-scale problems;

²³ By various authors and organizations mentioned in this report. For further information see Report I and Pretty et al., (2006), UNEP-UNCTAD (2008), FAO (2007), Wright (2010), Parrot et al., (2002), Badget et al., (2007) etc.



- quantifies and minimises the impacts of system management on externalities such as GHG emissions, clean water availability, carbon sequestration, conservation of biodiversity, and dispersal of pests, pathogens and weeds.

Productive and sustainable agricultural systems thus make the best use of crop varieties and livestock breeds through their agro-ecological or agronomic management. Science focuses on understanding and improving crop and animal genotypes as well as the conditions for agro-ecological management. It also seeks to improve the capacities of people and their institutions to deliver inputs, manage systems and distribute and use outputs.

Resource conserving agriculture

Pretty *et al.*, have undertaken field research (2006) that demonstrates the extent to which 286 recent interventions in 57 poor countries covering 37 million ha (3 percent of the cultivated area in developing countries) have increased productivity on 12.6 million farms while improving the supply of critical environmental services. The average crop yield increase was 79 percent. All crops showed water use efficiency gains, with the highest improvement in rainfed crops. Potential carbon sequestered amounted to an average of 0.35 t C ha⁻¹ y⁻¹. If a quarter of the total area under these farming systems adopted sustainability enhancing practices, they estimate global sequestration could be 0.1 Gt C y⁻¹. Of projects with pesticide data, 77 percent pesticide use by 71 percent while yields grew by 42 percent.

Many novel initiatives emerged, demonstrating that agriculture in poor countries can be greatly improved. The idea of agricultural sustainability centres on food production that makes the best use of nature's goods and services while not damaging these assets. Many different terms have come to be used to imply greater sustainability in some agricultural systems over prevailing ones (both preindustrial and industrialized).

In this research the authors concentrated on projects that have made use of a variety of packages of resource-conserving technologies and practices. These included the following:

- integrated pest management, which uses ecosystem resilience and diversity for pest, disease, and weed control, and seeks only to use pesticides when other options are ineffective;
- integrated nutrient management, which seeks both to balance the need to fix nitrogen within farm systems with the need to import inorganic and organic sources of nutrients, and to reduce nutrient losses through erosion control;
- conservation tillage, which reduces the amount of tillage, sometimes to zero, so that soil can be conserved and available moisture used more efficiently
- agroforestry, which incorporates multifunctional trees into agricultural systems, and collective management of nearby forest resources;
- aquaculture, which incorporates fish, shrimps, and other aquatic resources into farm systems, such as into irrigated rice fields and fish ponds, and so leads to increases in protein production;
- water harvesting in dryland areas, which can mean formerly abandoned and degraded lands can be cultivated, and additional crops can be grown on small patches of irrigated land owing to better rainwater retention;
- livestock integration into farming systems, such as dairy cattle and poultry, including using zero-grazing.

The authors showed the extent to which recent successful interventions focusing on agricultural sustainability had increased total food crop productivity in developing regions. The questions are as follows: (i) To what extent can farmers increase per hectare and per farm food production by using low-cost and locally available technologies and inputs? (ii) What impacts do such methods have on environmental goods and services (in particular using the water use efficiency, carbon sequestration, and pesticide use as proxies to indicate changes in adverse effects on the environment)?



The projects were classified in 8 broad categories using the typology of farming systems developed by FAO for the World Bank, based on the following social, economic, and biophysical criteria: (i) the available natural resource base, including water, land, grazing areas, and forest; climate and altitude; landscape, including slope; farm size, tenure, and organisations; and access to services including markets; and (ii) the dominant patterns of farm activities and household livelihoods, including field crops, livestock, trees, aquaculture, hunting and gathering, processing, and off-farm activities; and the main technologies used, which determine the intensity of production and integration of crops, livestock and other activities.

Impact on yields

The authors were able to sample some projects once in time and others twice over a four-year period to assess temporal changes. They were able to show that agricultural sustainability is spreading to more farmers and hectares. In the 68 randomly re-sampled projects from the original study, there was a 56 percent increase over the four years in the number of farmers (from 5.3 to 8.3 million), and 45 percent in the number of hectares (from 12.6 to 18.3 million). For the 360 reliable yield comparisons from 198 projects, the mean relative increase in yields was 79 percent across the very wide variety of systems and crop types. The mean and spread was largest in cassava and sweet potato crops. Soybean and groundnut showed mean increases of about 50 percent. Maize, millet and sorghum, potatoes, and the other legumes group (beans, pigeon peas, cowpea, chickpea) all showed mean yield increases of >100 percent, significantly higher than those for cotton, rice, and groundnut.

For most of the main field crops that were well represented in the survey, those with low yields before intervention often showed larger relative improvements, either because of growth limiting environments, or perhaps reduced investment in developing these crops, although potato showed large increases across the range. Though many technologies and practices were used in these projects, three types of technical improvement are likely to have played substantial roles in food production increases: (i) more efficient water use in both dryland and irrigated farming; (ii) improvements in organic matter accumulation in soils and carbon sequestration; and (iii) pest, weed, and disease control emphasizing in-field biodiversity and reduced pesticide (insecticide, herbicide, and fungicide) use.

Impact on farm water use efficiency

Water productivity gains were high in rainfed systems, and moderate in irrigated systems. Variability was high due to the wide variety of practices represented in the dataset, but indicated that gains in water productivity were possible through adoption of sustainable farming technologies in a variety of crops and farm systems. The results, demonstrated that the greatest opportunity for improvement in water productivity is in rainfed agriculture. Better farm management, including supplemental irrigation and fertility management can significantly reduce uncertainty, and thus avoid chronic low productivity and crop failure that are characteristic of many rainfed systems.

Impact on carbon sequestration

Farmers can increase carbon sinks in soil organic matter and above-ground biomass. The projects were potentially sequestering 11.4 Mt C y⁻¹ (11.4 mega tonnes of carbon per year), on 37 million ha. If scaled up, assuming that 25 percent of the areas under the different farming system categories globally adopted these same sustainability initiatives, this would result in sequestration of 100 Mt C y⁻¹. In other words, if 25 percent of smallholder/artisanal farmers and gardeners worldwide adopted sustainable agriculture techniques, 100 mega tonnes of carbon per year ($= 100 \text{ Mt C y}^{-1} = 0.1 \text{ Gt C y}^{-1}$) would be sequestered. To put this in context, in 2005, global emissions totalled 51,000 mega tonnes of carbon dioxide equivalents (IPCC AR4), thus smallholder farmers would be sequestering 1/500th of all carbon emissions.

Impacts on pesticide use

Integrated pest management (IPM) programmes are beginning to show how pesticide use can be reduced and modified without yield penalties in a variety of farm systems, such as in irrigated rice in Asia and rainfed maize in Africa. The authors analyzed the 62 IPM initiatives in 21 developing countries in the dataset. The evidence on pesticide use is derived from data on both the number of sprays per



hectare and the amount of active ingredient per hectare. Results showed pesticide use declined by 70.8 percent and yields increased by 41.6 percent. While pesticide reduction is to be expected, as farmers substitute pesticides by information, the cause of yield increases induced by IPM are complex. It is likely that farmers who receive good quality field training will not only improve their pest management skills but also become more efficient in other agronomic and ecological management practices. This analysis indicates considerable potential for avoiding environmental costs.

Farmer Field Schools (FFS) and Integrated Pest Management (IPM)

The latest practical and concrete examples providing additional convincing evidence in line with the above work are given by William Settle and Mohamed Hama Garba in their paper (in press) on sustainability, resilience and increased productivity in African food and agricultural systems (Settle and Garba, 2010, in press).

The case study reports on how the Farmer Field School (FFS) model has successfully developed community-based capacity building, optimized the use of available inputs including elimination of toxic pesticides, improved soil fertility, increased yields and net farm income, diversified farming systems, developed skills in economic management in the savannah zones of West Africa, and has been incorporated into national policies by some governments in the region.

The FFS model is a model based on non formal, adult educational or “discovery learning” methods, developed some 20 years ago in response to the weaknesses of the more “top-down” extension models of the time.

The FFS approach originated with the pioneering work on Farmer Field Schools (FFS) in South East Asia, started by FAO in the late 1980s. The Farmer Field School concept was originally conceived and implemented by FAO. The approach has since spread to nearly 90 countries worldwide.

The programme in West Africa started in Ghana in 1996, led by trainers from Indonesia and the Philippines and expanded to Senegal, Mali and Burkina Faso to later reach Benin. The West African programme has since grown to comprise a cluster of several projects, including a pesticide environmental and human health monitoring component, which in late 2009 brought in Guinea, Mauritania and Niger.

Key to the continued evolution of the approach is building the foundation for a strong knowledge network in which innovations are “harvested” for use elsewhere. One important development in this regard is the emergence of an independent NGO whose mandate is sharing the lessons learned globally and whose global list server is very active (global-ffs-l@farmerfieldschool.net).

Although the FFS was developed more than 20 years ago, the process of innovation is active, ongoing, diverse and occurs at all levels, from farmers to national and regional levels.

The principal elements of Farmers Field Schools (FFS)

- Each FFS consists of a group of approximately 25 farmers, working in small sub-groups of about five each. The training is field-based and season-long, usually meeting once per week.
- The season starts and ends with a ‘ballot box’ pre-test and post-test respectively to assess trainees’ progress.
- Each FFS has one training field, divided into two parts; one IPPM-managed (management decisions decided on by the group, not a fixed “formula”), the other with a conventional treatment regime, either as recommended by the agricultural extension service or through consensus of what farmers feel to be the “usual” practice for their area.
- In the mornings, the trainees go into the field in groups of five to observe and make careful observations on growing stage and condition of crop plants, weather, pests and beneficial insects, diseases, soil and water conditions, etc. Interesting specimens are collected, put into plastic bags and brought back for identification and further observation.



- On returning from the field to the meeting site (usually near the field, under a tree or other shelter), drawings are made of the crop plant which depict plant condition, pests and natural enemies weeds, water, and anything else worth noting. A conclusion about the status of the crop and possible management interventions is drawn by each sub-group and written down under the drawing (agro-ecosystem analysis).
- Each subgroup presents its results and conclusions for discussion in the entire group. In these discussions, as well as in the preceding field observations, the trainers remain as much as possible in the background, avoiding all lecturing, not answering questions directly, but stimulating farmer to think for themselves.
- Special subjects are introduced throughout the training. These include maintenance of ‘insect zoos’ where observations are made on introduced pests, beneficial insects, and their interactions. Other “classic” special subjects include leaf removal experiments to assess pest compensatory abilities, life cycles of pests and diseases, etc. (in recent years with expansion of the topics away from just IPM),
- Socio-dynamic exercises serve to strengthen group bonding and active trainees are encouraged in the interest of post-FFS farmer to farmer dissemination.

(The description is from Settle and Garba, 2010, in press).

The report provides detailed data and charts on the positive shifts in production approaches. For example data from Mali and from Senegal show 94 and 90 percent reductions in use of synthetic pesticides respectively, and large shifts towards the use of botanical and biological pesticides. In Mali, estimated median values for rice production from three irrigated polders (Selingé, Niono and Baguinda) represent a 38 percent increase in yield. In Senegal, differences between medians represent a 25 percent increase in yield. In Benin, there was a two fold increase in production accompanied by a 66 percent decrease in chemical fertilizer use.

The scope of the FFS has expanded over time to include improved agronomic practices across a growing diversity of agricultural systems. In addition to pest management, the initial work by the programme in West Africa brought a focus on soil fertility management with an emphasis on increasing the use of organic amendments as well as on practices related to better establishing nursery seed beds and employing improved transplanting techniques in both rice and vegetable systems. A recent survey of 150 post-FFS vegetable farmers in Burkina Faso shows that the benefits ranked most important by farmers were developing proper seed beds and nurseries, and techniques for building and using compost and making local pesticides from plant extracts.

Around 2000 facilitators have been trained in Benin, Burkina Faso, Mali and Senegal since the beginning of the programme in 2002. Roughly one-third of these are government agents and two-thirds are farmers. More than 3500 Field Schools have been conducted, dominated by the three principal cropping systems targeted by the programme (vegetables, rice, cotton) and also including mango, cowpea, sesame, millet and sorghum, carité and Jatropha.

As of December 2009, an estimated 80,500 farmers, farming 100,000 ha were trained in season-long FFS in the four countries, and most have participated in post-training follow-up activities. Roughly 45 percent are vegetable producers, followed by rice producers (28 percent), cotton producers (20 percent) and others products (7 percent).

One of the most striking outcomes from surveys of FFS farmers is the report of large-scale increases in the use of organic amendments such as compost or rice straw. Savannah soils in West Africa are extremely fragile. High temperatures and stochastic rainfall patterns put soil carbon and water availability at a premium. Increased organic matter use by farmers is key to increasing the water penetration, water holding capacity and nutrient holding capacity of soils, as well as promoting important biological activities by soil micro organisms. Higher levels of organic matter in soils will reduce runoff from sporadic, but periodically heavy rain events, and reduce the loss of topsoil from erosion.



Incorporating compost into soils costs a farmer money, time and effort. The strong response by farmers to adopt these measures indicates farmers are seeing clear benefits. Adoption rates, however, can be thwarted in communities where land tenure rules render ownership rights uncertain.

According to recent surveys, the FFS IPPM approach is generally perceived as a positive factor in strengthening the cohesion within existing working groups and as a safe learning environment that helps to develop practical skills. The FFS sessions motivate a more dynamic social organisation that can lead to the birth of other activities needed to meet the larger needs of the community. Following training, the farmers expressed a desire to connect to networks of other IPPM practitioners. Monitoring in the four IPPM countries reveals variable participation by women, depending on the cropping system

Government interest for these approaches has been growing increasingly over the years to the extent that the Ministry of Agriculture in Mali has established the FFS approach as the official extension approach for the Malian Direction of Agriculture, and has determined as their priority that 75 percent of the irrigated rice producers in Mali are to be trained through FFS in the next few years. Given the well established programme in Mali, this target of an estimated 125,000 rice farmers could be met within 4 years.

A similar analysis for other countries in the subregion across the two major savannah production systems suggests that 500,000 farmers could be trained in the next four to five years, assuming the resources are made available.

Some principles of agro-ecology

The prevalent philosophy in what could be called mainstream agriculture is that pests, nutrient deficiencies or other factors are the cause of low productivity, as opposed to the view that pests or nutrients only become limiting if conditions in the agro-ecosystem are not in equilibrium (Carrol *et al.*, 1990). The idea of agro-ecology is to go beyond the use of alternative practices and to develop agro-ecosystems with the minimal dependence on high agrochemical and energy inputs, emphasizing complex agricultural systems in which ecological interactions and synergisms between biological components provide the mechanisms for the systems to sponsor their own soil fertility, productivity and crop protection (Altieri and Rosset, 1995). Instead of focusing on one particular component of the agroecosystem, agroecology emphasizes the interrelatedness of all agro-ecosystem components and the complex dynamics of ecological processes (Vandermeer, 1995).

The design of such systems is based on the application of the following ecological principles (Reinjtjes *et al.*, 1992).

1. Enhance recycling of biomass and optimizing nutrient availability and balancing nutrient flow.
2. Securing favourable soil conditions for plant growth, particularly by managing organic matter and enhancing soil biotic activity.
3. Minimizing losses due to flows of solar radiation, air and water by way of microclimate management, water harvesting and soil management through increased soil cover.
4. Species and genetic diversification of the agro-ecosystem in time and space.
5. Enhance beneficial biological interactions and synergisms among agrobiodiversity components thus resulting in the promotion of key ecological processes and services.

Agroecologists are now recognizing that intercropping, agroforestry and other diversification methods mimic natural ecological processes, and that the sustainability of complex agro-ecosystems lies in the ecological models they follow. By designing farming systems that mimic nature, optimal use can be made of sunlight, soil nutrients and rainfall (Pretty 1994).

Diversity is of value in agro-ecosystems for a variety of reasons (Altieri, 1994; Gliessman, 1998).



- As diversity increases, so do opportunities for coexistence and beneficial interactions between species that can enhance agro-ecosystem sustainability.
- Greater diversity often allows better resource-use efficiency in an agro-ecosystem. There is better system-level adaptation to habitat heterogeneity, leading to complementarity in crop species needs, diversification of niches, overlap of species niches, and partitioning of resources.
- Ecosystems in which plant species are intermingled possess an associated resistance to herbivores as in diverse systems there is a greater abundance and diversity of natural enemies of pest insects keeping in check the populations of individual herbivore species.
- A diverse crop assemblage can create a diversity of microclimates within the cropping system that can be occupied by a range of non-crop organisms – including beneficial predators, parasites, pollinators, soil fauna and antagonists – that are of importance for the entire system.
- Diversity in the agricultural landscape can contribute to the conservation of biodiversity in surrounding natural ecosystems.
- Diversity in the soil performs a variety of ecological services such as nutrient recycling and detoxification of noxious chemicals and regulation of plant growth.

Diversity reduces risk for farmers, especially in marginal areas with more unpredictable environmental conditions. If one crop does not do well, income from others can compensate.

Altieri (2008), talks of small farmers as a planetary ecological asset and gives five key reasons why we should revitalize small farms in the Global South. He argues that the quality of life and food security of the populations in the North depends not only on the food products, but in the ecological services provided by small farms of the South. He describes the five reasons why small farmers should be supported:

“1. Small farmers are key for the world’s food security

While 91 percent of the planet’s 1.5 billion hectares of agricultural land are increasingly being devoted to agro-export crops, biofuels and transgenic soybean to feed cars and cattle, millions of small farmers still produce the majority of staple crops needed to feed the planet’s rural and urban populations. In Latin America, about 17 million peasant production units occupying close to 60.5 million hectares, or 34.5 percent of the total cultivated land with average farm sizes of about 1.8 hectares, produce 51 percent of the maize, 77 percent of the beans, and 61 percent of the potatoes for domestic consumption. Africa has approximately 33 million small farms, representing 80 percent of all farms in the region. Despite the fact that Africa now imports huge amounts of cereals, the majority of African farmers (many of them women) who are smallholders with farms below 2 ha, produce a significant amount of basic food crops with virtually no or little use of fertilizers and improved seed. In Asia, the majority of more than 200 million rice farmers, few farm more than 2 ha of rice make up the bulk of the rice produced by Asian small farmers.

2. Small farms are more productive and resource conserving than large-scale monocultures

Although the conventional wisdom is that small family farms are backward and unproductive, research shows that small farms are much more productive than large farms if total output is considered rather than yield from a single crop. Integrated farming systems in which the small-scale farmer produces grains, fruits, vegetables, fodder, and animal products out-produce yield per unit of single crops such as corn (monocultures) on large-scale farms. A large farm may produce more corn per hectare than a small farm in which the corn is grown as part of a polyculture that also includes beans, squash, potato, and fodder. In polycultures developed by smallholders, productivity, in terms of harvestable products, per unit area is higher than under sole cropping with the same level of management.

Yield advantages range from 20 percent to 60 percent, because polycultures reduce losses due to weeds, insects and diseases, and make more efficient use of the available resources of water, light and nutrients. In overall output, the diversified farm produces much more food, even if measured in dollars. Not only



do small to medium sized farms exhibit higher yields than conventional farms, but do so with much lower negative impact on the environment. Small farms are ‘multi-functional’– more productive, more efficient, and contribute more to economic development than do large farms. Communities surrounded by many small farms have healthier economies than do communities surrounded by depopulated, large mechanized farms. Small farmers also take better care of natural resources, including reducing soil erosion and conserving biodiversity.

The inverse relationship between farm size and output can be attributed to the more efficient use of land, water, biodiversity and other agricultural resources by small farmers. So in terms of converting inputs into outputs, society would benefit from small-scale farmers. Building strong rural economies based on productive small-scale farming can allow the people to remain with their families and help to stem the tide of migration. And as population continues to grow and the amount of farmland and water available to each person continues to shrink, a small farm structure may become central to feeding the planet.

3. Small traditional and biodiverse farms are models of sustainability

Despite the onslaught of industrial farming, the persistence of thousands of hectares under traditional agricultural management documents a successful indigenous agricultural strategy of adaptability and resiliency. These microcosms of traditional agriculture that have stood the test of time, and that can still be found almost untouched since four thousand years in the Andes, MesoAmerica, Southeast Asia and parts of Africa, offer promising models of sustainability as they promote biodiversity, thrive without agrochemicals, and sustain year-round yields even under marginal environmental conditions. The local knowledge accumulated during millennia and the forms of agriculture and agrobiodiversity that this wisdom has nurtured, comprise a Neolithic legacy embedded with ecological and cultural resources of fundamental value for the future of humankind.

Recent research suggests that many small farmers cope and even prepare for climate change, minimizing crop failure through increased use of drought tolerant local varieties, water harvesting, mixed cropping, opportunistic weeding, agroforestry and a series of other traditional techniques. Surveys conducted in hillsides after Hurricane Mitch in Central America showed that farmers using sustainable practices such as “mucuna” cover crops, intercropping, and agroforestry suffered less “damage” than their neighbors using less sustainable practices.

This demonstrates that a re-evaluation of indigenous technology can serve as a key source of information on adaptive capacity and resilient capabilities exhibited by small farms—features of strategic importance for world farmers to cope with climatic change. In addition, indigenous technologies often reflect a worldview and an understanding of our relationship to the natural world that is more sustainable for the planet as a whole.

4. Small farms represent a sanctuary of GMO-free agrobiodiversity

In general, traditional small scale farmers grow a wide variety of cultivars. Many of these plants are landraces grown from seed passed down from generation to generation, more genetically heterogeneous than modern cultivars, and thus offering greater defenses against vulnerability and enhancing harvest security in the midst of diseases, pests, droughts and other stresses. In a worldwide survey of crop varietal diversity on farms involving 27 crops, scientists found that considerable crop genetic diversity continues to be maintained on farms in the form of traditional crop varieties, especially of major staple crops. In most cases, farmers maintain diversity as an insurance to meet future environmental change or social and economic needs. Many researchers have concluded that this varietal richness enhances productivity and reduces yield variability.

Although there is a high probability that the introduction of transgenic crops will enter centres of genetic diversity, it is crucial to maintain areas of peasant agriculture free of contamination from GMO crops, as traits important to indigenous farmers (resistance to drought, quality of food or fodder, maturation, competitive ability, performance in intercropping, storage quality, taste or cooking properties, compatibility with household labour conditions, etc) could be traded for transgenic qualities



(i.e. herbicide resistance) which are of no importance to farmers who don't use agrochemicals. Under this scenario, risk will increase and farmers will lose their ability to produce relatively stable yields with a minimum of external inputs under changing biophysical environments. The social impacts of local crop shortfalls, resulting from changes in the genetic integrity of local varieties due to genetic pollution, can be considerable.

Maintaining pools of genetic diversity, geographically isolated from any possibility of cross fertilization or genetic pollution from uniform transgenic crops, will create "islands" of intact germplasm. These can act as extant safeguards against potential ecological failure derived from the second green revolution increasingly being imposed with programmes such as AGRA. These genetic sanctuary islands will serve as source of GMO-free seeds that will be needed to repopulate the organic farms inevitably contaminated by the advance of transgenic agriculture. The small farmers and indigenous communities, with the help of scientists and NGOs, can continue to create and guard biological and genetic diversity that has enriched the food culture of the whole planet.

5. Small farms cool the climate

While industrial agriculture contributes directly to climate change through no less than one third of total emissions of the major greenhouse gases — Carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O), small, biodiverse organic farms have the opposite effect by sequestering more carbon in soils. Small farmers usually treat their soils with organic compost materials that absorb and sequester carbon better than soils that are farmed with conventional fertilizers. Researchers have suggested that the conversion of 10,000 small- to medium-sized farms to organic production would store carbon in the soil equivalent to taking 1174400 cars off the road.

Further climate amelioration contributions by small farms accrue from the fact that most use significantly less fossil fuel in comparison to conventional agriculture mainly due to a reduction of chemical fertilizer and pesticide use, relying instead on organic manures, legume-based rotations, and diversity schemes to enhance beneficial insects. Farmers who live in rural communities near cities and towns and are linked to local markets, avoid the energy wasted and the gas emissions associated with transporting food hundreds and even thousands of miles.

To conclude, the great advantage of small farming systems is their high levels of agrobiodiversity arranged in the form of variety mixtures, polycultures, crop-livestock combinations and/or agroforestry patterns. Modeling new agroecosystems using such diversified designs are extremely valuable to farmers whose systems are collapsing due to debt, pesticide use, transgenic treadmills, or climate change. Such diverse systems buffer against natural or human-induced variations in production conditions. There is much to learn from indigenous modes of production, as these systems have a strong ecological basis, maintain valuable genetic diversity, and lead to regeneration and preservation of biodiversity and natural resources. Traditional methods are particularly instructive because they provide a long-term perspective on successful agricultural management under conditions of climatic variability.



One long tale: the kingdom of pandemics

At the other extreme of the wealth of nations, a second tale is related here, one of another seemingly science fiction world, after the one related earlier in this report on soil's biology (mycorrhizae). This is a darker world though, that may be just around the corner and which may very well be if we are not cautious enough. The text below is based on the fascinating research undertaken by Wallace presented in his different articles and in his blog²⁴.

The latest literature on potential pandemics ahead of us is shocking. The risk seems much more real than what we are prepared to accept and the possible effects more devastating than we can imagine. Industrial animal agriculture may bode disaster, in terms of landscape destruction but also and above all because of pandemic risk. It is currently estimated that a severe pandemic would cost around 3 trillion USD because of societal disruption, much worse than a combination of 10 severe earthquakes, tsunamis, cyclones or the melting of the North Pole taken together. Yet, relatively little is done about it (Jan Slingenberg, personal communication, 2010). When discussing these abysmal risks, the proposals are to find options in terms of hybridisation of local medium size approaches, avoiding globalisation of intensive animal production chains, giving it an ecoregional twist, with mixed farming rather than going back to the past.

According to Wallace (2009, 2010), the risk is very real. What is thrilling in his articles is the lens he uses in his analysis, moving away from the microscope and the scientific details, to the social, economical and political spheres, explaining how humans are actually forging these deadly living machines.

The latest publication by Wallace *et al.* (2010, in press) talks about the agro-ecological resilience and the conditions presently supporting livestock influenzas and, by extension, protopandemicity. Much of the latest research in influenza has been directed toward recently emergent H1N1 2009, or swine flu, the first new influenza pandemic virus in forty years. While researchers have already learned something of the history of the new H1N1's origins, very little has been learned about the circumstances that led to the virus's emergence. In contrast, bird flu, or more scientifically denominated highly pathogenic influenza A (H5N1) remains a remarkable source of data for characterizing the emergence of protopandemic influenza. Bird flu's (HPAI H5N1) extensive geographic spread over the past 12 years, with multiple exposures across multiple countries, has exposed the virus to an increasing variety of human-animal environments, allowing researchers to learn under which agricultural practices and natural and man-made conditions the spread and evolution of a multiple-host pathogen are accelerated or blocked.

In another paper (2009) on *the political virology of offshore farming*, Wallace relates the first panic on bird flu (H5N1) and stresses that "some of the most basic questions about bird flu's nature appear lost in the blizzard of micrographs, sequence alignments, tertiary solution structures, SIR models, antigenic cartograms, and phylogenetic dendrograms. What of the virus's greater context?" These issues were presented at a FAO workshop in Beijing early June 2010. The following is based from this article.

After its first strike in Hong Kong, bird flu (H5N1) slipped underground with outbreaks largely limited to birds in southern China. The virus underwent the first of a series of reassortment events, in which several genomic segments were replaced with those from other serotypes, before re-emerging as a human infection in 2002.

Unchecked transmission in vulnerable areas increases the genetic variation with which bird flu (H5N1) can evolve human-specific characteristics. In spreading over three continents fast-evolving bird flu (H5N1) also contacts an increasing variety of socioecological environments, including locale specific combinations of prevalent host types, modes of poultry farming, and animal health measures. In this way, by a type of escalating demic selection, bird flu (H5N1) can better explore its evolutionary options. A series of fit variants, each more transmissible than the next, can evolve in response to local conditions and subsequently spread. The more genetic and phenotypic variation produced across geographic space, the more compressed the time until a human infection evolves.

24 Farming Pathogens blog: www.farmingpathogens.wordpress.com



How did we get into this fix? Why this deadly disease now? Wallace explores the social origins of bird flu and connects these with the evolution and spread of the virus. He reviews influenza as a case study of the “inadvertent biotic fallout of efforts aimed at steering animal ontogeny and ecology to multinational profitability”.

Some mechanism must transform low pathogenic strains into more virulent ones (and, we should hope, back again). There was an outbreak of highly pathogenic H5N2 in Texas in 2002. A low pathogenic H6N2 outbreak in California, beginning in large farms outside San Diego, evolved greater virulence as it spread through California’s Central Valley. Another outbreak worthy of note is that of a low pathogenic strain of H5N1 in Michigan in 2002. H5N1, then, has already invaded the United States in a less deadly form, and with different internal genes, telling us that the molecular identity of a strain is insufficient for defining the danger of any single outbreak.

The damage caused by pathogenic influenza may be in part due to an antigenic shift to which susceptible populations presently have no immunity. Humans, for instance, have this past century been infected almost exclusively by H1, H2, and H3 strains to which we eventually developed antibody memory. When many of us are confronted by a seasonal variant of these same types we can slow down the infection. We have partial immunity at the individual level and herd immunity at the population level. But as we have never been exposed to H5 infections *en masse* we have nothing to slowdown infection within each person and nothing to keep it dampened down across the population. Simply put, to start, there is a cap on pathogen virulence. Pathogens must avoid evolving the capacity to incur such damage to their hosts that they are unable to transmit themselves. If a pathogen kills its host before it infects the next host it destroys its own chain of transmission. But what happens when the pathogen “knows” that the next host is coming along much sooner? The pathogen can get away with being virulent because it can successfully infect the next susceptible in the chain before it kills its host. The faster the transmission rate, the lower the cost of virulence. A key to the evolution of virulence is the supply of susceptibles. As long as there are enough susceptibles to infect, a virulent phenotype can work as an evolutionary strategy. When the supply runs out it does not matter what virulence a pathogen has evolved. Time is no longer on the particular strain’s side. A failed supply of susceptibles, drained by high mortality or rebound immunity, forces all influenza epidemics to ultimately burn out at some point. That is, of course, cold comfort if millions of people are left dead in a pandemic’s wake.

Even if these and other such strains first developed on smallholdings, industrial livestock appear ideal populations for supporting virulent pathogens. Growing genetic monocultures of domestic animals removes whatever immune firebreaks may be available to slow down transmission. Larger population sizes and densities facilitate greater rates of transmission. Such crowded conditions depress immune response. High throughput, a part of any industrial production, provides a continually renewed supply of susceptibles, the fuel for the evolution of virulence. There are additional pressures on influenza virulence on such farms. As soon as industrial animals reach the right bulk they are killed. Resident influenza infections must reach their transmission threshold quickly in any given animal, before the chicken or duck or pig is sacrificed. The quicker viruses are produced, the greater the damage to the animal. Increasing age-specific mortality in industrial livestock should select for greater virulence. With innovations in production, the age at which chickens are processed has been reduced from 60 to 40 days, increasing pressure on viruses to reach their transmission threshold—and virulence load—that much faster.

Industrial production has already been implicated in increasing the diversity of human-friendly influenza. Over the past 15 years an unprecedented variety of influenzas capable of infecting humans have emerged across the global archipelago of industrial farms. Along with H5N1 there are now swine flu H1N1, H7N1, H7N3, H7N7, H9N2, in all likelihood H5N2, and perhaps even some of the H6 serotypes. A feedback appears to have emerged in kind: the very efforts pursued to control pathogenic bird flu may in passing increase viral diversification and persistence. Factory practices provide what seems to be an amenable environment for the evolution of a variety of virulent influenzas. Swine flu H1N1, the most recent example arising early 2009 appears by definition industrial in origin. The closest ancestor for each



of this swine flu's (H1N1) eight genomic segments is of swine origin. The segments have been identified as originating from different parts of the world: neuraminidase and the matrix protein from strains circulating in Eurasia, the other six from North America. No small farmer has the industrial capacity necessary to export livestock across such long distances, nor the market entrée, livestock influenzas need, to spread through international commodity chains. If swine H1N1 or any subsequent human-specific influenza proves deadly, the epidemiological pollution, threatens the very existence of the livestock industry.

Wallace then cites in his article Richard Levins who summarizes some of the many adjustments a new agriculture anywhere may require:

"Instead of having to decide between large-scale industrial type production and a 'small is beautiful' approach a priori, we saw the scale of agriculture as dependent on natural and social conditions, with the units of planning embracing many units of production. Different scales of farming would be adjusted to the watershed, climatic zones and topography, population density, distribution of available resources, and the mobility of pests and their enemies. The random patchwork of peasant agriculture, constrained by land tenure, and the harsh destructive landscapes of industrial farming would both be replaced by a planned mosaic of land uses in which each patch contributes its own products but also assists the production of other patches: forests give lumber, fuel, fruit, nuts, and honey but also regulate the flow of water, modulate the climate to a distance about 10 times the height of the trees, create a special microclimate downwind from the edge, offer shade for livestock and the workers, and provide a home to the natural enemies of pests and the pollinators of crops. There would no longer be specialized farms producing only one thing. Mixed enterprises would allow for recycling, a more diverse diet for the farmers, and a hedge against climatic surprises. It would have a more uniform demand for labour throughout the year".

Rather than to the expectations of an abstract neoclassical model of production, the scale and practice of agriculture can be flexibly tailored to each region's physical, social and epidemiological landscapes on the ground. At the same time, it needs to be acknowledged that under such an arrangement not all parcels will be routinely profitable. As Levins points out, whatever reductions in income farms accrue in protecting the rest of the region must be offset by regular redistributive mechanisms. Transforming the business of farming so broadly, as outlined here or otherwise, is likely only one of many large steps necessary to stop influenza and other pathogens.

Wallace considers that new ways of thinking about basic biology, evolution, and scientific practice are required. In a world in which viruses and bacteria evolve in response to humanity's multifaceted infrastructure—agricultural, transportation, pharmaceutical, public health, scientific, political—our epistemological and epidemiological intractabilities may be in fundamental ways one and the same. Some pathogens evolve into population states in which we cannot or, worse, refuse to think (R. Wallace and R.G. Wallace 2004). None of the broader factors shaping influenza evolution and drug response can be found underneath the microscope, no matter how many more automated microplates can now be loaded or how much industrial computing power becomes available. A geography connecting relationships among living organisms and human production across scale and domain may help us make the mental transitions necessary to excavate those population states in which influenza is able to shield itself. It may be only then that we can better control a pathogen seemingly capable—by distributed epiphenomena—of a chilling premeditation.

Here is a more detailed description of what happens:

Panic in the City

"HongKong, March 1997. An outbreak of deadly bird flu sweeps through poultry on two farms. The outbreak fizzles out, but 2 months later a 3- year-old boy dies of the same strain, identified as a highly pathogenic version of influenza A (H5N1). Officials are shocked. This appears the first time such a strain has jumped the species barrier and killed a human. Shocking too, the outbreak proves persistent. In November a 6-year-old is



infected, recovering. Two weeks later, a teenager and two adults are infected. Two of the three die. Fourteen additional infections rapidly follow. The deaths spur panic in the city and, with the onset of the regular flu season, send many patients to the hospital worried their symptoms might be those of the new flu. By mid-December poultry begin to die in droves in the city's markets and it now seems most humans infected had handled birds. Hong Kong acts decisively on that information. Authorities order the destruction of all of Hong Kong's 1.5 million poultry.

Most worrisome for human health is this strain's capacity for broad xenospecific transmission. The Hong Kong outbreak, first alerting the world to H5N1, infected humans with an influenza much more pathogenic than the relatively mild infections of other avian outbreaks that have intermittently crossed over into human populations. If much of H5N1's morbidity is distressing, its associated mortality is alarming. Once infected, the lungs' vasculature becomes porous and fibrinogen—a protein involved in blood clotting—leaks into the lungs (de Jong et al., 2006). The resulting fibroblast exudates clog the lungs' alveolar sacs, where gas exchange takes place, and an acute respiratory disease syndrome results. In a desperate effort to save its charge, the immune system recruits such a storm of cytokines that the lungs suffer oedema. In effect, patients drown in their own fluid only days after infection.” (Wallace 2009)

After its first strike in Hong Kong, H5N1 slipped underground. The following year H5N1 again reemerged, this time with a vengeance. The Z genotype that surfaced as the dominant recombinant spread across China, into Vietnam, Thailand, Indonesia, Cambodia, Laos, Korea, Japan, and Malaysia. Two additional strains would subsequently materialize. Since 2005 the Qinghai-like strain (H5N1 hemagglutinin clade 2.2) has spread across Eurasia, as far west as England, and into Africa. The Fujian-like strain, emerging from southern China province, has spread regionally across Southeast Asia and, more recently, into Korea and Japan.

Mainly, H5N1 is finding the regions of the world where animal health surveillance remains underdeveloped. Rural landscapes of many of the poorest countries are also now characterized by unregulated agribusiness pressed against periurban slums. Unchecked transmission in vulnerable areas increases the genetic variation with which H5N1 can evolve human-specific characteristics. In spreading over three continents fast-evolving H5N1 also contacts an increasing variety of socioecological environments, including locale specific combinations of prevalent host types, modes of poultry farming, and animal health measures. A series of fit variants, each more transmissible than the next, can evolve in response to local conditions and subsequently spread. The Z reassortant, the Qinghai-like strain, and the Fujian-like strain all outcompeted other local H5N1 strains to emerge to regional and, for the Qinghai-like strain, continental dominance.

To understand why we are faced with this deadly disease now, the latest literature tracks the ways the present class of models of globalized finance and production, which structure so much of humanity's daily life, are embodied in the control and exploitation of nonhuman systems—water management, fisheries, logging, mining, plant and animal genomics, and greenhouse gas emissions—we can add agriculture, breeding programmes, and pharmaceutical excavation.

Exporting the Tyson Model

In Israel, researchers recently selected for a lineage of featherless chickens. At first glance one suffers a shock at how much the naked birds look like living groceries. Able to survive solely in warm climes, the chickens were developed in the interests of the producer, not the consumer. Consumers have long avoided plucking feathers, a step typically conducted at the factory. A featherless poultry will allow producers, on the other hand, to scratch off plucking from production. The bald bird offers the anatomical equivalent of the factory epidemiology agribusiness is imposing on poultry—generating artificial ecologies that could never persist in nature because of the disease costs they incur, but that allow more poultry to be processed faster. The resulting costs are shifted to the birds, of course, but also consumers, farm workers, taxpayers, local governments, and nearby wildlife.

The lengths to which agribusiness has changed livestock production are remarkable, including, more



recently, in the present bird flu zone. Southern China serves as a regional incubator for new methods in poultry breeding. Sun *et al.* (2007), for instance, describe a Guangdong programme in which geese were exposed to a counter-seasonal lighting schedule that induced out-of-season egg laying. The innovation helped double profits for local goose production and expanded the market, and Chinese appetite, for goose meat. The resulting market advantages forced smaller farms out of business and led to a consolidation of the province's agribusiness. The structural shift marks a perverse turn back toward the farm collectivisation the Chinese government abandoned in 1980, this time, though, under the control of far fewer hands. As the result of such innovations, millions more birds have been put into production there.

The problem about agribusiness changing its commodity – living, breathing organisms – to maximize productivity is that it has turned poultry into plague carriers. Does out-of-season goose production, for instance, allow influenza strains to avoid seasonal extirpation, typically a natural interruption in the evolution of virulence? Are the resulting profits defensible at such a rapidly accruing cost?

Mass commodification of poultry emerged in what is now called the “Livestock Revolution”. Before the shift, poultry was largely a backyard operation. In Boyd and Watts's map of poultry across the United States in 1929, each dot represents 50,000 chickens. We see wide dispersion across the country – 300 million poultry total at an average flock size of only 70 chickens. The production chain of that era shows local hatcheries sold eggs to backyard poultry producers and independent farmers, who in turn contracted independent truckers to bring live poultry to city markets.

Each of their map's dots now represents 1million broilers, 6 billion in total, with an average flock size of 30,000 birds. A 2002 map reproduced by Graham *et al.* (2008) shows a similar geographic distribution but 10 years later hosting 3 billion more broilers. USA hog and pig populations have similarly exploded in size, particularly over the past 15 years. By the 1970s the new production model was so successful it was producing more poultry than people typically ate. How many roasted chickens were families prepared to eat a week? With the assistance of food science and marketing the poultry industry repackaged chicken in a mind-boggling array of new products, including chicken nuggets, strips of chicken for salads, and cat food. Multiple market shares were developed large enough to absorb the value-added production both domestically and abroad. The USA was for many years the world's leading poultry exporter. Industrial poultry has since spread geographically. With production widespread, annual world poultry meat increased from 13 million tons in the late 1960s to about 62 million by the late 1990s, with the greatest future growth projected in Asia.

According to political economist David Burch (2005), the shift in the geography of poultry production has some interesting consequences. Yes, agribusinesses are moving company operations to the global South to take advantage of cheap labour, cheap land, weak regulation, and domestic production hobbled in favor of heavily subsidized agroexporting. But companies are also engaging in sophisticated corporate strategy. Agribusinesses are spreading their production line across much of the world. For example, the CP Group, now the world's fourth largest poultry producer, has poultry facilities in Turkey, China, Malaysia, Indonesia, and the USA. It has feed operations across India, China, Indonesia, and Vietnam. It owns a variety of fast food chain restaurants throughout Southeast Asia.

Multinationals can control local labour markets; hobbling unions, blocking organisation drives, and setting wages and working conditions. Unions are an important check on production practices that affect not only workers and consumers, but both directly and by proxy the animals involved in production. Vertical agribusiness acts as both poultry supplier and retailer. Fewer independent retailers exist to play suppliers of each other in a way that assures demands for better treatment of livestock are met. In this attempts to proactively change livestock production in the interests of stopping pandemic influenza can be met with severe resistance by governments and corporate sponsors alike. The very biology of influenza is enmeshed with the political economy of the business of food.

If multinational agribusinesses can parlay the geography of production into huge profits, regardless of the outbreaks that may accrue, who pays the costs? The costs of factory farms are routinely externalized.



As Peter Singer (2005) explains, the state has long been forced to pick up the tab for the problems these farms cause; among them, health problems for its workers, pollution released into the surrounding land, food poisoning, and damage to transportation and health infrastructure. A breach in a poultry lagoon, releasing a pool of feces into a Cape Fear tributary that causes a massive fish kill, is left to local governments to clean up.

With the spectre of influenza the state is again prepared to pick up the bill so that factory farms can continue to operate without interruption, this time in the face of a worldwide pandemic agribusiness helped cause in the first place. The economics are startling. The world's governments are prepared to subsidize agribusiness billions upon billions for damage control in the form of animal and human vaccines, Tamiflu, and clean-up operations. Along with the lives of millions of people, the establishment appears willing to gamble much of the world's economic productivity, which stands to suffer catastrophically if a deadly pandemic were to erupt, for instance, in southern China.

Why Guangdong? Why 1997?

In reorganizing its stockbreeding industries under the American model of vertically integrated farming, Chinese farming helped accelerate a phase change in influenza ecology, selecting for strains of greater virulence, wider host range, and greater diversity. For decades a variety of influenza subtypes have been discovered emanating from southern China, Guangdong included. In the early 1980s, with livestock intensification under way, University of Hong Kong microbiologist Kennedy Shortridge identified 46 of the 108 different possible combinations of hemagglutinin and neuraminidase subtypes circulating worldwide at that time in a single Hong Kong poultry factory.

Ending large livestock operations as we know them could make a great difference in Guangdong as elsewhere. Such politically protected operations appear to promote both pathogen virulence and transmission. Graham ,(2008) review a number of proximate environmental pathways by which pathogens can spread across and out of large confined animal feedlot operations, including via animal waste handling and use in aquaculture, workers' occupational exposure, open transport of animals between farms and processing plants, contamination of shipping containers, non-livestock animals such as rats and flies, and tunnel ventilation systems that blow animal materials out into the environment. It would appear "biosecure" operations are not so biosecure.

The new arrangements belie the superficial distinction that has been made between industrial farms exercising "biosecurity" on the one hand and small farmers whose flocks are exposed to the epidemiological elements. Factory farms ship day-old chicks to be raised piecemeal by contracted farmers. Once grown (and exposed to migratory birds), the birds are shipped back to the factory for processing. The violation of biosecurity appears built directly into the industrial model.

Clearly agribusiness, structural adjustment, global finance, environmental destruction, climate change, and the emergence of pathogenic influenzas are more tightly integrated than previously thought. The nest of dependencies requires fuller investigation.

To beat back industrial influenza, or at the very least promote some sort of sustainable epidemiological mitigation, a number of radically invasive changes are required, changes that challenge core premises of present political economy. Whether there exists the political will to change is an open question. Denial, jockeying and obfuscation are presently rampant. Chinese officials have expended much effort in denying responsibility for bird flu or, in the epidemiological equivalent of the practice of paying off the families of collateral damage without admitting guilt, offered small sums to affected countries. In 2007, China donated USD 500,000 to Nigeria's effort to fight bird flu. Never mind that Nigeria would never have needed the aid if China had not infected it – albeit indirectly – with bird flu in the first place. The Qinghai-like strain Nigeria now hosts first originated in southern China. Meanwhile, the USA and EU, criticizing a stubborn Indonesia unwilling to share H5N1 samples, have blocked Indonesian efforts to reform a system of worldwide vaccine production that rewards pharmaceutical companies and the richest populations at the expense of the poorest .



What must be done?

What must be done to stop panzootic influenza, if the political will is found by, or forced upon, governments worldwide? In the short term, small farmers must be fairly compensated for animals culled in an effort to control outbreaks. Livestock trade must be better regulated at international borders. Livestock disease surveillance, largely voluntary at this point, must be made mandatory and conducted by well funded governmental agencies. Frontline farm workers and the world's poor more generally must be provided epidemiological assistance, including vaccine and antiviral at no cost. Structural adjustment programmes degrading animal health infrastructure in the poorest countries must be terminated. For the long term, we must end the livestock industry as we know it. Influenzas now emerge by way of a globalized network of corporate feedlot production and trade, wherever specific strains first evolve. With flocks and herds whisked from region to region – transforming spatial distance into just-in-time expediency – multiple strains of influenza are continually introduced into localities filled with populations of susceptible animals. Such domino exposure may serve as the fuel for the evolution of viral virulence. In overlapping each other along the links of agribusiness's transnational supply chains, strains of influenza also increase the likelihood they can exchange genomic segments to produce a recombinant of pandemic potential. In addition to the petroleum wasted and the loss of local food sovereignty, there are epidemiological costs to the geometric increase in food miles.

We might instead consider devolving much of the production to regulated networks of locally owned farms. While the argument has been made that corporate food supplies the cheap protein many of the poorest need, the millions of small farmers who fed themselves (and many millions more) would never have needed such a supply if they had not been pushed off their lands in the first place. A reversal need not involve ending global trade or an anachronistic turn to the small family farm, but might include domestically protected farming at multiple scales. Farm ownership, infrastructure, working conditions, and animal health are inextricably linked. Once workers have a stake in both input and output – the latter by outright ownership, profit sharing, or the food itself – production can be structured in such a way that respects human welfare and, as a consequence, animal health. With locale-specific farming, genetic monocultures of domesticated animals which promote the evolution of virulence can be diversified back into heirloom varieties that can serve as immunological firebreaks. The economic losses influenza imposes upon global livestock can be tempered: fewer interruptions, eradication campaigns, price jolts, emergency vaccinations, and wholesale repopulations. Rather than jury-rigged with each outbreak, the capacity for restricting livestock movement is built naturally into the regional farm model.

For one, migratory birds, which serve as a font of influenza strains, must concomitantly be weaned off agricultural land where they cross-infect poultry. To do so, wetlands worldwide, waterfowl's natural habitat, must be restored. Global public health capacity must also be rebuilt. That capacity is only the most immediate bandage for the poverty, malnutrition, and other manifestations of structural violence that promote the emergence and mortality of infectious diseases, including influenza. Pandemic and inter-pandemic flu have the greatest impact on the poorest. As for many pathogens, particularly for such a contagious virus, a threat to one is a threat to all.



A way forward

Food Sovereignty

The concept of food sovereignty developed as a reaction and an alternative to the dominant trend of restructuring the global food systems where local people's control is being replaced by the power of transnational corporations, liberalisation of international trade is destroying production for local and national markets, and peasants are forced away from their land. The global peasants' movement, La Via Campesina, introduced the concept of food sovereignty on the international arena at the World Food Summit in Rome in 1996, and has been the main force in promoting and developing food sovereignty. However, a wide range of social movements, NGOs, institutions and governments are now supporting and promoting food sovereignty.

There is not one common definition of food sovereignty, but the different definitions do all go along the same lines. The IAASTD synthesis report (2008) has this short definition:

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

One of the most common definitions, used by peasants' organisations and other social movements and NGOs, was coined by the Peoples Food Sovereignty Network (2002):

"Food Sovereignty is the right of peoples to define their own food and agriculture; to protect and regulate domestic agricultural production and trade in order to achieve sustainable development objectives; to determine the extent to which they want to be self reliant; to restrict the dumping of products in their markets; and to provide local fisheries-based communities the priority in managing the use of and the rights to aquatic resources. Food Sovereignty does not negate trade, but rather it promotes the formulation of trade policies and practices that serve the rights of peoples to food and to safe, healthy and ecologically" (Windfuhr and Johnsen, 2005).

The Nyéléni 2007 Forum for Food Sovereignty was an important event for the food sovereignty movement. *Via Campesina* initiated the Forum, but many other organisations took part in organizing it – organisations of peasants and farmers, pastoralists, fisherfolk, women, youth, environmentalists and NGOs. Nyéléni was a legendary Malian peasant woman, and the forum was named after her. It brought together more than 500 delegates from more than 80 countries. The forum had three objectives: to develop the concept and understanding of food sovereignty, build alliances among different organisations and constituencies, and to develop action plans for promoting and implementation of food sovereignty. The Nyéléni Forum agreed on this description:

"Food sovereignty is the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems. It puts the aspirations and needs of those who produce, distribute and consume food at the heart of food systems and policies rather than the demands of markets and corporations. It defends the interests and inclusion of the next generation. It offers a strategy to resist and dismantle the current corporate trade and food regime, and directions for food, farming, pastoral and fisheries systems determined by local producers and users. Food sovereignty prioritises local and national economies and markets and empowers peasant and family farmer-driven agriculture, artisanal - fishing, pastoralist-led grazing, and food production, distribution and consumption based on environmental, social and economic sustainability. Food sovereignty promotes transparent trade that guarantees just incomes to all peoples as well as the rights of consumers to control their food and nutrition. It ensures that the rights to use and manage lands, territories, waters, seeds, livestock and biodiversity are in the hands of those of us who produce food. Food sovereignty implies new social relations free of oppression and inequality between men and women, peoples, racial groups, social and economic classes and generations." (Nyéléni Declaration, 2007).



SIX PRINCIPLES OF FOOD SOVEREIGNTY

The Nyéléni Forum agreed on six principles of food sovereignty

1. Focuses on Food for People:

Food sovereignty puts the right to sufficient, healthy and culturally appropriate food for all individuals, peoples and communities, including those who are hungry, under occupation, in conflict zones and marginalised, at the centre of food, agriculture, livestock and fisheries policies;

and *rejects* the proposition that food is just another commodity or component for international agri-business.

2. Values Food Providers:

Food sovereignty values and supports the contributions, and respects the rights, of women and men, peasants and small scale family farmers, pastoralists, artisanal fisherfolk, forest dwellers, indigenous peoples and agricultural and fisheries workers, including migrants, who cultivate, grow, harvest and process food;

and *rejects* those policies, actions and programmes that undervalue them, threaten their livelihoods and eliminate them.

3. Localises Food Systems:

Food sovereignty brings food providers and consumers closer together; puts providers and consumers at the centre of decision-making on food issues; protects food providers from the dumping of food and food aid in local markets; protects consumers from poor quality and unhealthy food, inappropriate food aid and food tainted with genetically modified organisms;

and *rejects* governance structures, agreements and practices that depend on and promote unsustainable and inequitable international trade and give power to remote and unaccountable corporations.

4. Puts Control Locally:

Food sovereignty places control over territory, land, grazing, water, seeds, livestock and fish populations on local food providers and respects their rights. They can use and share them in socially and environmentally sustainable ways which conserve diversity; it recognizes that local territories often cross geopolitical borders and ensures the right of local communities to inhabit and use their territories; it promotes positive interaction between food providers in different regions and territories and from different sectors that helps resolve internal conflicts or conflicts with local and national authorities;

and *rejects* the privatisation of natural resources through laws, commercial contracts and intellectual property rights regimes.

5. Builds Knowledge and Skills:

Food sovereignty builds on the skills and local knowledge of food providers and their local organisations that conserve, develop and manage localised food production and harvesting systems, developing appropriate research systems to support this and passing on this wisdom to future generations;

and *rejects* technologies that undermine, threaten or contaminate these, e.g. genetic engineering.

6. Works with Nature:

Food sovereignty uses the contributions of nature in diverse, low external input agroecological production and harvesting methods that maximise the contribution of ecosystems and improve resilience and adaptation, especially in the face of climate change; it seeks to "*heal the planet so that the planet may heal us*";

and *rejects* methods that harm beneficial ecosystem functions, that depend on energy intensive monocultures and livestock factories, destructive fishing practices and other industrialised production methods, which damage the environment and contribute to global warming.

These six principles are interlinked and inseparable: in implementing the food sovereignty policy framework all should be applied.

(Nyéléni synthesis report).



Food sovereignty and the policies developed by the movements supporting it, are described in “Towards Food Sovereignty” (Pimbert, 2009):

“So far, the food sovereignty movement has developed a broad policy vision and discourse. And rather than presenting a fixed menu of policy instruments, it identifies a range of policy shifts and directions for national governments and other actors who seek to implement food sovereignty within their societies. Some of these are listed below.

Enabling national policies and legislation

- Implement equitable land reform and redistribute surplus land to tenants, within a rights-based approach to environment and development.
- Reform property rights to secure gender-equitable rights of access and use of common property resources, forests and water.
- Protect the knowledge and rights of farmers and pastoralists to save seed and improve crop varieties and livestock breeds, for example banning patents and inappropriate intellectual property right (IPR) legislation.
- Re-introduce protective safeguards for domestic economies to guarantee stable prices that cover the cost of production, including quotas and other controls against imports of food and fibre that can be produced locally.
- Implement policies that guarantee fair prices to producers and consumers, as safety nets for the poor.
- Re-direct both hidden and direct subsidies towards supporting smaller-scale producers and food workers to encourage the shift towards diverse, ecological, equitable and more localised food systems.
- Increase funding for, and re-orientate, public sector R&D and agricultural/food-sciences extension towards participatory approaches and democratic control over the setting of upstream strategic priorities, the validation of technologies and the spread of innovations.
- Broaden citizen and non-specialist involvement in framing policies, setting research agendas and validating knowledge, as part of a process to democratise science, technology and policy making for food, farming, environment and development.

Enabling global multilateralism and international policies

- Re-orient the end goals of trade rules and aid, so that they contribute to the building of local economies and local control, rather than international competitiveness.
- Manage supply to ensure that public support does not lead to over-production and dumping that lowers prices below the cost of production—harming farmers in North and South.
- Set up international commodity agreements to regulate the total output to world markets.
- Create regional common agricultural markets that include countries with similar levels of agricultural productivity. For example: North Africa and the Middle East, West Africa, Central Africa, South Asia and Eastern Europe.
- Protect these regional common markets from the dumping of cheap food and fibre. Use quotas and tariffs to guarantee fair and stable prices to marginalised small-scale producers, food processors and small food enterprises. Prices should allow small-scale producers, artisans and food workers to earn a decent income, invest in and build their livelihood assets.
- Challenge corporate investor rules and transform the current international investment law regime. The expansion of current foreign investment rules should be blocked and arbitration processes should be reformed to ensure transparency and fairness. Alternative rules should also be constructed and implemented, focusing on the responsibilities of international investors to ensure sustainable development and enhance environmental, labour and human rights protection.
- Create mechanisms to ensure that the real costs of environmental damage, unsustainable production methods and long-distance trade are included in the cost of food and fibre.



- Ensure clear and accurate labelling of food and feedstuffs, with binding legislation for all companies to ensure transparency, accountability and respect for human rights, public health and environmental standards.
- Restrict the concentration and market power of major agri-food corporations through new international treaties, competition laws and adoption of more flexible process and product standards.
- Develop international collaboration for more effective antitrust law enforcement and measures to reduce market concentration in different parts of the global food system (concerning seeds, pesticides, food processing and retailing, for example).
- Co-operate to ensure that corporations and their directors are held legally responsible for breaches in environmental and social laws, and in international agreements.
- Co-operate on a global level to tax speculative international financial flows (USD 1,600 thousand million/day), and redirect funds to build local livelihood assets, meet human needs and regenerate local ecologies.

It is acknowledged that policies for food sovereignty cannot be specified in detail for all people and places. They have to take into account local history and culture as well as the unique social and ecological contexts in which food systems are embedded. In this context, democratic participation and citizen empowerment are seen as crucial for the process of policy making (who makes policy and how it is made) and the implementation of policies. As Patel puts it, the food sovereignty movement argues *“for a mass re-politicization of food politics, through a call for people to figure out for themselves what they want the right to food to mean in their communities, bearing in mind the community’s needs, climate, geography, food preferences, social mix and history...”* (Patel, 2007)."



Regenerative paths

Towards a responsible world

This chapter builds on Weber (2009, 2010)

Today's financial, fuel and food crises are the expression of a profound ecological crisis. The degradation of the natural capital increases the gross national product of nations and antipollution activities increase it even more. In this context, it would be economically irrational to have positive behaviours towards ecosystems. Nature conservation can only be a philanthropic behaviour left to NGOs and do-good organisations.

In the emerging UNEP Green New Deal, reconstruction is to be achieved on the basis of a green growth centred on increased energy efficiency and reduced consumption. This central idea would be complemented by financial regulations and development aid based on climate adaptation and support to renewable energies. Limited attention is given to account for ecosystems and renewable living resources.

The UNEP Global New Deal is based on the same approach but extends to the whole of the biosphere with major investments in energy and green buildings. Industrialised countries are advised to spend 1 percent of their national product on decarbonisation of the economy and developing countries are advised to use 1 percent of their national product to poverty reduction. The G20 is considered the decision-making international body which should: -decarbonise the economy through the creation of a world market on emission rights, -introduce ecosystems service payments for the poorest, -guaranty free trade with no perverse subsidies.

Tim Jackson in his report "Prosperity without growth" proposes to explore a "steady-state" (prosperity without growth), increasing capabilities and public goods, abandoning the unlimited growth hypothesis. But the idea of prosperity without growth seems difficult to accept in the short term in the present ideological context.

The challenge is how to re-launch an economy on an ecologically sound basis. Is it conceivable for wealth to stem from the maintenance or improvement of ecosystems, knowing that today it is their degradation which creates the wealth of nations?

In the present system, the destruction of natural capital creates wealth. In the proposed new system, the destruction of nature becomes extremely costly and, instead, maintaining or increasing the natural potential becomes very profitable.

The Millennium Ecosystem Assessment proposed to shift the regulatory framework by moving the fiscal pressure from human and infrastructure capital towards natural capital and nature consumption in order to provide incentives to maintain and improve ecosystem services. Shifting regulatory frameworks can be done with two types of regulatory instruments: (i) taxes which can be redistributed and (ii) the establishment of markets of rights. For such a framework to be meaningful, it needs to be accepted globally which would imply the merging of international organisations. Different options are presented in Weber's article to base an economy on the maintenance and improvement of renewable resources and ecosystem services.

Examples include the idea for farmers to have rights on certain volumes of irrigation water which they can buy and sell to each other which would be an incentive to change irrigation systems and save water. The same system could be applied to the use of chemical fertilisers and pesticides and to soils. After decades of agronomical practices that have made the soil sterile followed by the addition of chemical fertilisers, a soil biomass indicator could be established, and a tax, based on this indicator, would favour those who improve soil biomass fertility.

Such a shift in the world regulatory framework with taxes and rights regulated by an international organisation would have a significant impact on the future of poorer countries, insuring a financing



system that would no longer be based on paternalistic international aid. These new regulations, based on ecosystem services, would finance the maintenance of the availability of those services, in particular the biological diversity and the carbon sequestration.

A world which is not viable cannot be sustainable. The vast majority of global conflicts start with issues such as access to and use of natural resources. Climate change will make things worse, creating waves of migrations, indicating it is becoming urgent to invest in countries which will most need it. We might as well do it now to support the maintenance or increase of the natural potential. The fragilisation of the world economy may be the opportunity to confront scarcity in order to avoid it in the future. This may be the time to reframe the world economy and national economies alike, and to redefine the international organisations that can better serve these economies. It would also be the opportunity to invent redistributive mechanisms favouring countries which consume less, thereby putting an end to the international development aid as it is designed today, based on arbitrary charity and fluctuating good will, replacing it by mechanisms based on rigor and justice.

Accounting for nature, accounting for people

Some practical examples of the attempts and techniques used by public and private entities in different parts of the world to account for sustainability, wealth and the use of nature are provided. Going through the literature shows that, while great progress to account for the environmental dimension has been achieved, in particular by the European Union which develops sophisticated approaches to encourage more environmental-friendly practices, the social part is much more difficult to grasp. Who can measure intangible facts such as the pleasure of belonging to a community, the sense of security of knowing that food is produced within borders, the pleasure of buying from a local market rather than from a community or the taste of foods produced locally. Yet, after all, is there really a need to measure it? On which terms? Can we move away from the economical value and find another form of recognition, in order to revalue those aspects of life and agriculture that by today's measurements, fail to give a good reflection of what wealth they actually offer – not economical wealth but rather the depth of their roots, the vibrancy of their communities, the dynamism of their agricultures, the beauty of their landscape, their healthy surroundings including air, water and soils, and the diversity of their diets, customs and beliefs.

In the 1990s, it was found necessary to move away from the narrowly defined gross national product towards something that would better reflect the human dimension of nations, what Amartya Sen defined as advancing the richness of human life, rather than the richness of the economy. UNDP filled this gap by developing the Human Development Index (described below). Today again, we witness a vacuum, the need to find a tool or mechanism which would help us better reflect the wealth or potential wealth of territories, including nature and societies and their intricate fabric; the need for a futurability index or, in other words, the potential for a long term future.

The Beyond GDP initiative is a testimony of this need. The summer of 2009 saw the long-awaited release of the Stiglitz Report, commissioned by French President Nicolas Sarkozy. Produced by a team that included several Nobel Prize-winning economists, the report proposed new national indicators of progress, and includes the “ecological footprint”. The Stiglitz report is not an isolated phenomenon, but one of many signs of a broader turning of the tide. In 2009, Ecuador adopted the footprint, and became the first country to set a formal footprint target.

About Beyond GDP

The Stiglitz Report or “Report by the Commission on the Measurement of Economic Performance and Social Progress” published in 2009 states the following:

“Economic indicators such as GDP were never designed to be comprehensive measures of well-being. Complementary indicators are needed that are as clear and appealing as GDP but more inclusive of other dimensions of progress – in particular environmental and social aspects. We need adequate indicators to address global challenges such as climate change, poverty, resource depletion and health.”



In November 2007, the European Commission, European Parliament, Club of Rome, OECD and WWF hosted the high-level conference “Beyond GDP” with the objectives of clarifying which indices are most appropriate to measure progress, and how these can best be integrated into the decision-making process and taken up by public debate. The conference brought together over 650 policy makers, experts and civil society representatives to address these critical issues. Preceding the main conference, an expert workshop was held, wherein leading practitioners discussed the development and application of indicators of progress, true wealth, and well-being.

On 20 August 2009, the European Commission released its Communication “GDP and beyond: Measuring progress in a changing world”. The Communication—a direct outcome of the Beyond GDP conference—outlines an EU roadmap with actions to improve our indicators of progress in ways that meet citizens’ concerns and make the most of new technical and political developments.” (Stiglitz report 2009)

The report of the Commission may have significant impact on the way our societies look at themselves, and therefore on the way in which policies are designed, implemented and assessed, as what we measure shapes what we collectively strive to pursue. It will be crucial that agriculture be given its due place in this important endeavour, and that the contributions of small-scale producers to the well-being of societies be truly recognised and rewarded. New indexes, specific to agriculture will be needed.

The human development concept: enlarging people’s choices and enhancing human capabilities and freedom

In the 1990s, UNDP launched the human development approach. Mahbub ul Haq, the Founder of the Human Development Report, explained that the goal of development was to “enlarge people’s choices. In his words, “The basic purpose of development is to enlarge people’s choices. In principle, these choices can be infinite and can change over time. People often value achievements that do not show up at all, or not immediately, in income or growth figures: greater access to knowledge, better nutrition and health services, more secure livelihoods, security against crime and physical violence, satisfying leisure hours, political and cultural freedoms and sense of participation in community activities. The objective of development is to create an enabling environment for people to enjoy long, healthy and creative lives.” (in *Origins of the Human Development Approach*²⁵)

Human development is a development paradigm that is about much more than the rise or fall of national incomes. It is about creating an environment in which people can develop their full potential and lead productive, creative lives in accord with their needs and interests. People are the real wealth of nations. Development is thus about expanding the choices people have to lead lives that they value. In other words, it is about much more than economic growth, which is only a means – although a very important one – of enlarging people’s choices.

Fundamental to enlarging these choices is building human capabilities – the range of things that people can do or be in life. The most basic capabilities for human development are to lead long and healthy lives, to be knowledgeable, to have access to the resources needed for a decent standard of living and to be able to participate in the life of the community. Without these, many choices are simply not available, and many opportunities in life remain inaccessible.

This way of looking at development, often forgotten in the immediate concern with accumulating commodities and financial wealth, is not new. Philosophers, economists and political leaders have long emphasized human wellbeing as the purpose – the end – of development. As Aristotle said in ancient Greece, “Wealth is evidently not the good we are seeking, for it is merely useful for the sake of something else.”

In seeking Aristotle’s “something else”, human development shares a common vision with human rights. The goal is human freedom. And in pursuing capabilities and realizing rights, this freedom is vital. People must be free to exercise their choices and to participate in decision making that affects their lives. Human

25 <http://hdr.undp.org/en/humandev/origins/>



development and human rights are mutually reinforcing, helping to secure the wellbeing and dignity of all people, building self-respect and the respect of others.

Amartya Sen's vision of the basic development idea is embedded in the concept of human development: "advancing the richness of human life, rather than the richness of the economy in which human beings live, which is only a part of it." (in *Origins of the Human Development Approach*)

The Human Development approach arose in part as a result of growing criticism of the leading development approach of the 1980s, which presumed a close link between national economic growth and the expansion of individual human choices. Many, such as Dr. Mahbub ul Haq who spearheaded the UNDP human development approach, came to recognize the need for an alternative development model due to many factors, including:

- growing evidence that did not support the then prevailing belief in the "trickle down" power of market forces to spread economic benefits and end poverty;
- the human costs of Structural Adjustment Programmes became more apparent;
- social ills (crime, weakening of social fabric, HIV/AIDS, pollution, etc.) were still spreading even in cases of strong and consistent economic growth;
- a wave of democratisation in the early 1990's raised hopes for people-centred models.

Many of its key principles, however, can be found in the writings of scholars and philosophers from past eras and across many societies.

Desmond Tutu tells us that "Human development and human rights are enshrined in today's world. But they have not yet become the core values of our reality. The stability and success of any country will not be secure until we are able to spread the benefits in a more equitable manner. The obscene wealth of the few cannot be at the expense of the hungry and the destitute." (in *Origins of the Human Development Approach*).

The Human Development Report (HDR) was first launched in 1990 with the single goal of putting people back at the centre of the development process, in terms of economic debate, policy and advocacy. The goal was both massive and simple, with far-ranging implications – going beyond income to assess the level of people's long-term well-being. Bringing about development of the people, by the people, and for the people, and emphasizing that the goals of development are choices and freedoms.



II. LIVESTOCK

Marta G. Rivera Ferre

Introduction

Worldwide, livestock production is an activity that allows people to eat meat, milk or eggs. Additionally, livestock has traditionally provided of leather for shoes or clothes, of energy in the form of work to plough the soil or simply to transport people long distances. In many regions, livestock is an essential component of the livelihood of the community and is also a necessary complement of the agricultural activity: animals eat plants in rangelands that cannot otherwise be consumed or cultivated and produce organic fertilizer in the form of manure. They also are a key component in maintaining natural landscapes in many areas. Human being, livestock and agriculture in a perfect balance with nature, a system in which each component obtains a benefit. The complexity and variety is enormous: thousands of domestic species adapted to many different geoclimatic contexts. This is how the system has worked for centuries. However, during the last century, the system was broken, agriculture and livestock split and transformed into an industrial activity in a global economy of scale. As a result, agriculture to feed the animals are produced far from where animals are, and the nutrients they produce in the form of nitrogen or phosphorus become a pollutant, whilst agricultural systems suffer from nutrients deficit supplied with inorganic fertilizers, which in turn, are also important contaminants and produce CO₂ emissions. It is estimated that the total amounts of nutrients in livestock excreta are as large as or larger than the total contained in all chemical fertilizers used annually (Menzi et al., 2009). Furthermore, since 1945, approximately 17% of vegetated land has been lost to agricultural production due to human-induced soil degradation, often from poor fertilizer and water management, soil erosion and shortened fallow periods (Tillman et al., 2002). The livestock sector is the most important global land user (Steinfeld et al., 2010). Currently land required for livestock production is 70% of all agricultural land (Asner et al., 2004) and about 30% of land globally. Competition for land, water and fossil fuels, along with climate change, will be the key driving forces shaping future livestock forces (Steinfeld et al., 2010)

Adding to that is the fact that lifestyle and dietary habits have changed with urbanization, forced by changes in the economic structure in which industrial production (including industrial agriculture) is dominated by capital-intensive processes (Popkins, 1999). Among these changes, it is highly relevant the increase in the consumption of animal products in developing countries, mostly meat, a trend that has been called the “livestock revolution”. There is not a consensus of whether the highest consumption of meat is a demand-driven (Delgado, 1999) or a supply-driven (Rivera-Ferre, 2009) phenomenon leaded by the lower prices of industrial agricultural products and driven by global and national policies. In any case, the result is that the demand for meat is rapidly increasing worldwide, posing a serious threat to the environment, including increasing emissions of green-house gases (GHG), and public health. It must also be highlighted that demand will also rise as a result of increasing population. This new demand is presently being fulfilled through vertical, intensive, industrialised production systems, particularly of pig and poultry meat. We have then entered in an absurd wheel that we need to rethink and change in order to get the balance livestock-agriculture-human being back again and reduce the impact of livestock production to the environment while fulfilling people's nutritional needs.

How much is produced of meat and how it is produced

From 1970 to now, worldwide meat production has suffered an annual growth of 2.8% with poultry and pig production growing at a double level than ruminants. Steinfeld (2003) emphasizes that, in the last few years, there has been a change in livestock production practices from a local multi-purpose activity into a market-oriented and increasingly integrated process (vertical integration) with more large-scale, industrial production located close to urban centres (geographical concentration), a decreasing importance of ruminants relative to monogastric livestock species, and a substantial rise in the use of cereal-based feed (Naylor et al., 2005). Large food retailers have also had a major role in this



transformation (Steinfeld et al., 2006b). Virtually, all of the growth in livestock production is occurring in industrial systems (Naylor et al., 2005). Intensive landless systems produce about 72% of the world's poultry meat and 55% of the pork (Steinfeld et al. 2010). About half of this originates from developing countries (Steinfeld et al., 2006a). In that manner, industrial livestock production, which was almost non-existent 40 years ago, grew at twice the annual rate of the more traditional, mixed farming systems (4.3% against 2.2%), and at more than six times the annual growth rate of production based on grazing (0.7%) (FAO, 1996). In terms of trade, global trade of meat in relation to production range between 11% for pig meat and 14.6% for bovine meat (Steinfeld et al., 2010). Thus, most meat is traded to supply domestic markets. This is not the case of feedcrops, which are cultivated in only a few countries mostly for exports (eg. soybean).

The current global average meat consumption is 100 g per person per day (36.5 kg/year), with about a ten-fold variation between high-consuming and low-consuming populations (McMichael, 2007). On average, industrialised countries consume 224 g/d (81.8 kg/year; 124 kg in USA) while developing countries consume 47 g/d (17.5 kg/year; 11 kg in Africa). It is estimated that between 1997/1999 and 2030, meat consumption in developing countries will increase to 37 kg per person (Steinfeld, 2004) and that global production and consumption of meat will rise from 233 million tonnes in 2000 to 300 million tonnes in 2020 (Speedy, 2003). If the world's population today were to eat a Western diet of roughly 80 kg meat per capita per year, the global agricultural land required for production would be about 2.5 billion hectares—two-thirds more than is presently used (Smil, 2002). It is important to remark that these projections of increasing consumption are valid only under the current policies framework. For that reason, most reports focus on fulfilling the projected meat demand, looking for alternatives that reduce the environmental and societal impact of livestock systems, under the current development framework. They do not question the fact that is the development paradigm which causes most of the problems, and thus, policies should be targeted towards changing the development paradigm in the livestock systems. Changes in the policies aiming at introduce structural changes in the livestock food system would result in different projections for meat consumption.

Implications of increasing meat consumption in the planet and in human health

Livestock production has severe consequences for the environment. Globally, livestock accounts for about 8% of human water use, mostly for the irrigation of feedcrops (Steinfeld et al., 2006b) and 10% of total water flows (Steinfeld et al., 2010). It is estimated that 1 kg of edible beef requires 12000l of water in grazing systems up to 53200 l in intensive systems (Steinfeld et al., 2010). The livestock sector can harm water quality through the release of nitrogen, phosphorus and other nutrients, pathogens and other substances into waterways and groundwater, mainly from manure in intensive livestock systems (FAO, 2009c). Poor manure management often contributes to GHG emissions, pollution and eutrophication of surface waters, groundwater and coastal marine ecosystems and to the accumulation of heavy metals in soils. This can harm human health, favour loss of biodiversity, and contribute to climate change, soil and water acidification and degradation of ecosystems (FAO, 2009c). Livestock production accounts for 70% of agricultural land and 30% of land globally (Steinfeld et al., 2006b), 26% of the world land is used for grazing and 33% of the agricultural land for feedcrop production. Additionally, intensive livestock production has indirect environmental impact through the promotion of intensive agriculture (see the agricultural part of the report) for feed production. 48% of the fertilizer shipped is used for grow animal feed (Steinfeld et al., 2010). Regarding its contribution to climate change, animal production (mainly cattle and pig) is the largest emitter of CH₄ from enteric fermentation and manure lagoons. In fact, much of the estimated 35% of global GHG emissions deriving from agriculture and land use comes from livestock. Livestock production—including deforestation for grazing land and soy-feed production, soil carbon loss in grazing lands, the energy used in growing feed-grains and in processing and transporting grains and meat, nitrous oxide releases from the use of nitrogenous fertilisers, and gases from animal manure (especially CH₄) and enteric fermentation—accounts for about 18% of global GHG emissions



measured in CO₂ equivalents (Steinfeld et al., 2006b), consisting in 9% of anthropogenic CO₂ emissions, plus 35–40% of CH₄ emissions and 65% of N₂O. Some authors suggest that this value is underestimated and that the real value is of 51% of total GHG emissions (Goodland and Anhang, 2009). For more information on the environmental impact of livestock production we recommend the lecture of Steinfeld et al. (2006b).

Yet, impact on environment varies depending on the production systems and the species grown (Table 1). Intensive farming systems, also called high-input farming systems, have the highest environmental impact (and energy use). They compete directly with human being for food while traditional farming systems normally depend on waste-products or lands that could hardly be used for other purposes. Regarding species, it is accepted that poultry has the lowest environmental impact, while cattle production has the higher. The latest FAO State of World Agriculture Report (FAO 2009i), centred on livestock, qualitatively shows that in placing together these two factors (production systems and species), monogastric (pig and poultry) traditional production is, in general, the less pollutant system, while monogastric industrial systems are the most pollutants. In terms of GHG emissions, again monogastric traditional systems have the lowest emissions levels, while intensive ruminant production has the highest (FAO, 2009c; p.62).

The increasing consumption of meat has also consequences for human health. On the one hand, it is positive because in many parts of the world there is a deficiency of minerals (such as iron) and micronutrients that can be partially solved with the consumption of meat (FAO, 2009c). On the other hand, the excessive consumption of livestock products is associated with increased risk of obesity, heart disease, cancer and other non-communicable diseases (WHO/FAO, 2003, Steinfeld et al., 2010). Furthermore, the concentration of intensive animal production enterprises with a lot of animals concentrated in close proximity to human population centres poses increasing risks for human health arising from livestock diseases. Studies show that there can be a dual benefit for the environment and health from a 'contraction and convergence' model of meat consumption, where developing countries are able to increase meat consumption while industrialised countries reduce consumption. If we rise levels of meat at health recommendations – between 70 and 90g per capita per day we could save up to 2700 Mha of pasture and 100Mha of crop land and have significant impacts on reducing climate emissions (McMichael et al., 2007; Stehfest et al. 2009).

Thus, the argument that all meat consumption is bad is too simplistic and we must avoid making generalised statements about the links between livestock, consumption of meat, greenhouse gas emissions, climate change, food safety or poverty. The context, functions of livestock and trade-offs of animal husbandry are very different all over the world. Strengthening and/or developing ecological, cultural and socially-sound livestock systems is possible, but it starts with understanding the different functions of livestock in rural livelihoods (Maarse, 2009). There is a substantial variation in the production efficiency and environmental impact of the major classes of meat consumed by people as well as a big difference of meat consumption among different countries. According to Maarse (2009) the vast majority of emissions come from wealthy countries practicing factory farming. All of Africa's ruminants combined, for example, account for only 3% of the global methane emissions from livestock. Furthermore, a substantial proportion of animals are grass-fed. Pasturing frequently uses land that would otherwise be unproductive and much of the grassland that is used to feed these animals could not be converted to arable land or could only be converted with major adverse environmental outcomes (Godfray et al., 2010). Arguments to show that not all livestock production is negative to the environment are given below.

Another argument that should be considered in the discussion of livestock and climate change is the false dichotomy of mitigation and adaptation strategies. A recent review of opportunities and challenges for mitigation in the agricultural sector noted the synergy among mitigation in agriculture, adaptation, sustainable development, food security, poverty alleviation and energy security, and stressed the need to address the interlinked issues of mitigation and adaptation simultaneously (UNFCCC, 2009). Mitigation and adaptation strategies are complementary, and both mitigation strategies can facilitate adaptation strategies and the other way around, as it is the case of pastoralist systems or carbon sequestration.



Table 1. Comparison of the impact of grazing and intensive (confined/industrialized) grain-fed livestock systems on water use, grain requirement, and methane production. Source: Godfray et al. (2010)

Water	Measure of water use	Grazing	Intensive
		Liters day ⁻¹ per animal at 15°C	
Cattle	Drinking water: all	22	103
	Service water: beef	5	11
	Service water: dairy	5	22
Pigs (lactating adult)	Drinking water	17	17
	Service water	25	125
Sheep (lactating adult)	Drinking water	9	9
	Service water	5	5
Chicken (broiler and layer)	Drinking water	1.3–1.8	1.3–1.8
	Service water	0.09–0.15	0.09–0.15
Feed required to produce 1 kg of meat		kg of cereal per animal	
Cattle		–	8
Pigs		–	4
Chicken (broiler)		–	1
Methane emissions from cattle		kg of CH ₄ per animal year ⁻¹	
Cattle: dairy (U.S., Europe)		–	117–128
Cattle: beef, dairy (U.S., Europe)		53–60	–
Cattle: dairy (Africa, India)		–	45–58
Cattle: grazing (Africa, India)		27–31	–

Note: The table does not include other impacts of differing livestock management systems such as (i) nutrient run-off and pollution to surface and groundwater, (ii) protozoan and bacterial contamination of water and food, (iii) antibiotic residues in water and food, (iv) heavy metal from feed in soils and water, (v) odour nuisance from wastes, (vi) inputs used for feed production and lost to the environment, (vii) livestock-related land-use change

Cooling the planet and feeding the world through livestock production

Since the FAO Livestock's Long Shadow Report in 2006, there has been an important increase in research regarding the importance of livestock for food security, the growth suffered by the sector and the impact on climate change. Researchers worldwide investigate the role of livestock in climate change and study alternatives for mitigation and adaptation. But most of the proposals are based on new technologies to reduce emissions, using top-down approaches. Most reports defend intensification as the most efficient way to reduce the GHG emissions from livestock while providing food worldwide (Steinfeld et al. 2010). However, these solutions are the result of a compartmentalised and market-focused approaches that do not look at the whole picture of livestock (direct and services provided to human being and ecosystems not measured in economic returns) and do not contextualise for all different situations and livelihoods related to livestock²⁶. They all give for granted the fact that the livestock sector has to increase, and to

²⁶ It is remarkable how the report from Steinfeld et al. (2010) have a wide and complete section of the state of the art on livestock systems, with some interesting and innovative proposals, including structural changes, rights-based development or empowerment of farmers (e.g. Ch 8, Ch 13, Ch15). However, in the responses section, these proposals are vaguely or simply not considered. Outdated and conservative, market-based solutions (more intensification, increasing productivity, top-down technological solutions or free trade) aiming at adapting to the situation generated by policies are proposed instead. Also, despite some chapters call for holistic approaches, the responses are again compartmentalised.



provide safe, cheap and plentiful meat for a growing demand. Yet, some authors (Rivera-Ferre, 2009) defend that the increasing demand is supply-driven, and thus, the trend can be reverted, being the most efficient way to reduce environmental damage of livestock. Furthermore, the increase in demand for meat and dairy also has an impact on discussions on food security and the need for agricultural intensification in crops in general. While the need to double food production by 2050 is defended by policy makers, yet the majority of this increase in crop production is to feed industrial livestock not humans, which in turn, is not a real need²⁷.

A first step to understand and promote a shift towards sustainable livestock production aiming at reducing impacts on climate change as well as reducing hunger might be through structural changes adopting a rights-based approach to agriculture and climate policies (Constantins, 2009) centred on the food sovereignty paradigm. In this sense, the shift from market-based policies to food sovereignty policies focused would open a wide range of possibilities and perspectives (figure 1). For example, most of the solutions given to address climate change or food security issues through agriculture and livestock are market-based. However, approximately 80% of the value of livestock in low-input developing-country systems can be attributed to non-market roles, while only 20% is attributable to direct production outputs (FAO, 2007e). By contrast, over 90% of the value of livestock in high-input industrialized-country production systems is attributable to the latter. Thus, rather than focusing policies on how to increase productivity, policy-makers should consider the opinion of those who produce the food to address their real needs.

A right-based approach with a food sovereignty focus should lead us to prioritize the fulfilment of the right to food, the right of peasants to produce food or the right to a preserved healthy environment over the costs and benefits on a given system. Adding to that, it should be clarified that economic return and productivity of production systems are relative to what is measured and how. For instance, pastoral systems are found to be more productive per unit area due to the ability of pastoralists to move their herds opportunistically and take advantage of seasonally available pastures (Sandford, 1983) and to be more economically feasible than either sedentary or ranching systems (Niamir-Fuller, 1999). In fact, pastoralism does not represent its true value (Nassef et al., 2009). Omissions are related to the value of the informal economy and the subsistence function of pastoralism, and the value of maintaining the health of ecosystems and other land uses. However, if only the net amount of meat per animal were to be measured, ranching systems would be more productive. This is the case of dairy farming, where a recent report from FAO (2010e) suggest less emissions from intensive farms measured in kg of fat or protein (with an error of 26%). Yet, if figures were given in energy use or land use, numbers could probably give a different picture. One more example of non-coincident numbers is the study of Subak (1999) for beef production. She compares GHG emissions between standard US feedlot and African pasture systems. According to her, African pasture system produces more CH₄ than the feedlot system due to the much longer life of the animals, but when incorporating indirect greenhouse gas production from fossil fuels used in production the feedlot produces nearly twice the greenhouse gases at 14.8 kg CO₂ equivalent per kg of beef, compared to 8.1 kg CO₂. For that reason, the focus of policies is important, and we find relatively useless to discuss numbers that show only a partial picture of reality, and suggest to discuss the whole picture, not only the farm or the animal, but the food system. Furthermore, important discussions are still running about how to measure the non-measurable (eg. biodiversity loss). Perhaps, with a food sovereignty focus, this debate would just seem useless, given the fact that the objectives of the policies are dealing with life and equity in the earth, an objective that is more important than any market decision. In any case, it is important to highlight here one contradiction that market-based approaches do normally face: on the one hand, market-based solutions aim at finding the best cost-benefit alternative considering livestock production as an industrial activity, on the other hand, the solutions proposed, based on expensive technologies, are normally more expensive (both in research expenditure and final cost of implementation) than solutions based on traditional farming systems. The latter, however, are more politically challenging.

27 See <http://www.soilassociationscotland.org/News/NewsItem/tabid/91/smId/463/ArticleID/360/reftab/311/Default.aspx>



To achieve the goal of cooling the planet through livestock farming, as in other sectors, the first option must be to find a balance in the consumption/production ratio among regions in the world. As some authors have suggested (McMichael et al., 2007; Rivera-Ferre, 2009) meat consumption should decrease in industrialized countries and increase in developing countries. Since available technologies for reduction of emissions from livestock production, applied universally at realistic costs, would reduce non-carbon dioxide emissions by less than 20% (McMichael et al., 2007), this would be one of the more efficient ways to reduce GHG emissions in the short and medium-term. Achieving this goal would require, for example, removing state subsidies for animal feed (corn, soy) and intensive production which, at the same time, would redirect grain stocks to local diets, as well as to put into practice the “polluters pays” laws, which should charge all polluting ways of food production. As FAO (2009c) suggests, agricultural and trade policies can influence dietary choices by making certain products more or less readily available and affordable. McMichael et al. (2007) propose a global target of meat consumption of 90g/day, which would allow to improve human health both in industrialised and developing countries, as well as to reduce emissions from livestock production. Once the balance would have been achieved, the challenge is to produce meat (and other livestock products) through environmentally and socially-friendly production systems.

There is increasing recognition that small-scale farmers and agroecological production methods need to play a central role in solving the global hunger and environmental crises. The IAASTD (2009) pointed to the relevance of indigenous and traditional knowledge in building a climate-friendly agriculture system. The UN Environmental Programme (UNEP) and the UN Conference on Trade and Development (UNCTAD) point to the failure of the technological progress of the past half century in reducing hunger. A number of UN agencies (UNEP, FAO, UNCTAD), have emphasize the potential of sustainable farming to meet the growth in food demand. Last year, the 17th session of the UN Commission on Sustainable Development (New York, 4-15 May 2009), adopted a Declaration recognizing that ‘*sustainable agricultural practices as well as sustainable forest management can contribute to meeting climate change concerns*’. The UN Special Rapporteur on the Right to Food, has stressed that: “*The UN now recognizes that it has been a mistake to exclusively support large agricultural enterprises. The Green Revolution model has produced more food and more hunger at the same time. Alternatives are silenced, not taken serious or widely underestimated. In reality, agro-ecological farming is extremely productive per hectare. It is necessary to re-invest in smallholder agriculture.*”²⁸ Furthermore, the development of more sustainable farming approaches is also directly linked to the right to food through the strong link between the state of the environment and food production.

Sustainable meat production should then focus not only in the production of meat, but also in the provision of other benefits to human being and nature. It should transform negative impacts of meat production (contribution to climate change, environmental pollution, loss of biodiversity, smallholder expulsion from farming or damage to human health) into beneficial trends (net sequestration of carbon, increasing biodiversity, maintenance of livelihoods and improving global health). The challenge is how to achieve these goals. The answer might be in the promotion of traditional farming systems and support of small livestock farmers. For instance, pastoral livestock production makes extensive use of ecosystem and eliminates most of the problems associated to confinement production. Ruminant production also takes advantage of their high-efficiency to convert low-quality forage into high-protein human foods. When appropriated managed, grassland-ruminant ecosystems are an efficient, sustainable method of producing high-quality protein with minimal environmental impacts (Tilman, 2002). Most farmers in developing countries practice either mixed-crop and livestock farming or pastoral production on rangelands. These smallholders and herders leave insignificant environmental footprints in terms of inputs (Sere, 2009). But these changes would require political commitments to reduce demand for cheap meat and dairy in line with both health and environmental recommendations.

28 Olivier de Schutter, the UN Rapporteur on the Right to Food. 2009. In a debate on The Future of Agriculture and our Food (Rode Hoed, Amsterdam, 10 November 2009).



Cooling the planet and feeding the people: The theory

In general, several arguments support the cooling capacity of sustainable, traditional and small scale livestock farming systems and their contribution to the function of feeding world population:

- conversion of low-quality food into high-protein food.
- use of land areas (drylands, mountains) that could hardly be used for other purposes.
- capacity to storage CO₂ through soil conservation in grassland, drylands and rangelands.
- Longer productive-life of animals reduces emissions/animal in dairy and egg production, as well as in cattle meat coming from dairy farming.

Improved grazing and grassland management are considered valuable strategies for restoring soil and increasing land resilience while building the carbon pool. Soils represent the earth's largest carbon sink that can be controlled and improved – more even than forests. Soil carbon sequestration is the mechanism that holds the greatest technical mitigation potential within the agricultural sector. The NGO GRAIN found that policies oriented towards agriculture in the hands of small farmers and focused on restoring soil fertility could, over the next 50 years, capture about 450 billion tonnes of CO₂, which is more than two-thirds of the current excess in the atmosphere (GRAIN, 2009). Grassland management is the second most important agricultural technology available for climate change mitigation (FAO, 2009g). Livestock products are the main outputs of grazing lands. Thus, through better livestock management, grasslands and drylands, that occupy a vast extension of worldwide land, have a strong potential capacity to sequester and store carbon in soils.

Grasslands cover approximately 26% of the emerged land surface and 70% its agricultural lands (FAO, 2005; WRI, 2000). Drylands occupy 41% of the land area where more than 2 billion people live (FAO, 2004a; UNEP, 2006). Grasslands are ecosystems where the dominant vegetation component is comprised of herbaceous species, with less than 10% tree cover (Jones and Donnelly 2004). They are estimated to store up to 30% of the world's soil carbon in addition to the amount of above-ground carbon stored in trees, bushes, shrubs and grasses (White et al., 2000; Grace et al., 2006). For that reason, conversion of rangelands to cropland is a major cause of emissions, resulting in 95% loss of above-ground carbon and up to 60% loss of below-ground (Reid et al., 2009). Grasslands have a higher storage capacity in soils than in vegetation, increasing its sink's capacity. Also, grasslands are home to a great diversity of domestic plants and livestock, they are the origin of at least 30% of the world's cultivated plants. In grasslands, livestock grazing can contribute to maintaining healthy vegetation, which captures carbon, reduces erosion, maintains soils and facilitates water holding capacity. Yet, it is important to differentiate among different types of grasslands. Some are intensively managed, requiring high levels of pesticides and thus, reducing their potentiality to reduce carbon. Others have been artificially created through deforestation. The conversion of forest to grazing land is an important cause of emissions. An important driving force of this conversion has been the growth of soybean production destined to intensive livestock systems which in turns, has also forced the need for new grasslands for extensive livestock. Soybean, produced to feed intensive animal systems, generates a vicious triangle created by intensive livestock production: the tropical deforestation syndrome (for cropland cultivation but also for the subsequent reduction of pastures and thus, the need of more pastures for grazing animals), intensive agricultural practices for cultivation of soy and intensive livestock practices. All of them have a high contribution to environmental unsustainability and GHG emissions²⁹.

Up to 71% of the world's grasslands were reported to be degraded to some extent in 1991 (Dregne et al., 1991). Degradation of grassland and dryland soils means that they are far from saturated (in carbon) and thus potentially have a significant capacity to store more carbon (Farage et al., 2003). Estimates of carbon

²⁹ GM soy varieties using herbicides sprayings and no tilling farming practices have made land available for agriculture (for industrial crops used as animal feed) that was formerly only of use for livestock grazing, and that this has been one of the main factors in the intensification of livestock production.



storage for each dryland region indicate that 36% of total carbon storage worldwide is in the drylands, and 59% of the total carbon stock held in Africa is in the drylands (Campbell et al., 2008; UNEP, 2008). In view of the vast extent of grasslands and rangelands and the degraded nature of large areas of these systems, the potential to sequester carbon through improved management is significant. The potential of carbon sequestration through desertification control and restoration has been estimated at 12–18 billion tonnes of carbon over a 50-year period (Lal, 2004). Lal (2004) estimates that the potential of soil carbon sequestration to offset emissions is 5 to 15% of global emissions. With proper management, pastoralists, ranchers and farmers could achieve a 1–2% increase in soil-carbon levels on existing agricultural, grazing and desert lands over the next two decades. According to GRAIN (2009), a 1–2% of organic matter in the top 30 cm increase could take 30% of the current excess CO₂ in the atmosphere.

Some improved livestock management practices can include rotational grazing, that can sequester more carbon if heavier grazing intensities in short periods are practiced (favouring immobilization in roots rather than in above-ground plants), as well as reduce CH₄ emissions (FAO, 2009g) and N₂O (Hopkins and del Prado, 2007). Thus, one of the most effective strategies for sequestering carbon is fostering deep-rooted plant species on land used for agriculture, through rotations that include grass fallow or grass leys, and integrating fodder crops, cover crops or perennial species into the cropping systems. Furthermore, the IPCC (2007) has reported that pasture quality improvement can be important in reducing methane, because this results in improved animal productivity and reduces the proportion of energy lost as CH₄. The technical mitigation potential of grazing systems' carbon sequestration is considered significantly higher than methane emissions resulting from enteric fermentation or manure management (FAO, 2009g). They also support sustainable pastoral and agropastoral livelihoods for millions of people.

In addition to their mitigation potential, grasslands (including agroforestry) play a significant role in human and environmental health and, if not adequately addressed, will have potentially dramatic consequences for food security, environmental degradation and livelihoods (FAO, 2009c).

Cooling the planet and feeding the people: The practice

The livelihoods of millions of small-scale families in marginal areas depend on livestock through the use of traditional farming systems. These systems are considered essential in the mitigation strategies of climate change through the mechanisms previously explained. Traditional farming systems include grazing systems, pastoralism/agro-pastoralism systems, mixed farming systems, agroforestry systems that include several livestock species and backyard production, mostly of pig and poultry. Their contribution to meat consumption is very important worldwide. If meat consumption is balanced worldwide, these systems could satisfy the demand through local markets (FOE, 2009).

Extensive grazing systems

Extensive grazing systems cover most of the dry areas of the world that are marginal for crop production. Such areas tend to be sparsely populated and include, for example, the dry tropics and continental climates of southern Africa, central, eastern and western Asia, Australia and western North America (FAO, 2009c). These systems are characterized by ruminants (e.g. cattle, sheep, goats and camels) grazing mainly grasses and other herbaceous plants, often on communal or open-access areas. The main products of these systems include about 7% of global beef production and about 12% of sheep and goat meat production (FAO, 2009c).

Pastoralism, the raising of livestock in extensive grazing systems using mobility as a management tool, is an adaptation to marginal environments that are characterised by climatic uncertainty and low and variable biomass (WISP, 2007). It is considered the most economically, culturally and socially appropriate strategy for maintaining the well-being of communities in dryland landscapes, because it is the only one that can simultaneously provide secure livelihoods, conserve ecosystem services, promote wildlife conservation and honour cultural values and traditions (FAO, 2009g). Increasingly, it is recognised that mobile livestock production is vital for dryland ecosystem health, and many rangelands are grazing



dependent (WSP, 2007). In sub-Saharan Africa, 40% of the land area is dedicated to pastoralism (IRIN, 2007). The land management strategies traditionally employed by mobile pastoralists have been recognised as one of the most effective means of restoring ecosystem health and reversing degradation in drylands, and are being implemented as a rehabilitation strategy for degraded land (Nassef et al., 2009).

Healthy grasslands, livestock and associated livelihoods constitute a win-win option for addressing climate change in fragile dryland areas where pastoralism remains the most rational strategy for maintaining the wellbeing of communities (FAO, 2009c). A recent report from FAO (2009c) reviews the role of pastoralism in climate change. For instance, African livestock systems can be carbon-negative. According to Mario Herrera and Shirley Tarawali from ILRI, a typical 250 kilogram African cow produces approximately 800 kilogram CO₂ equivalents per year, whilst carbon sequestration rates (the amount of carbon taken up in the soil) can be about 1400 kilograms of carbon per hectare per year under modest stocking rates, making a positive balance. Also, soil organic carbon in savanna-like ecosystems can be substantially greater than that of the original grassland (Steinfeld et al., 2010).

Furthermore, pastoralist livestock breeds retain many genetic traits, such as fertility, vitality, and resistance to diseases and drought that no longer exist in animals kept in industrial systems. These traits are likely to be of increasing value in the face of climate change.

Intensive grazing systems

They are systems where different livestock species are produced through a relatively intensive management of grasslands. They are found in temperate zones where high-quality grassland and fodder production can support larger numbers of animals. These areas include parts of Europe, North America, South America, parts of Oceania and some parts of the humid tropics. These systems are characterized by cattle and are based mostly on individual landownership. They contribute about 17% of global beef and veal supply, and 17% of the sheep and goat meat supply (FAO, 2009c). As in the case of pastoral systems, intensive grass-fed meat production can contribute to cooling the planet through improved management practices of grassland, resulting in better productivity of animals, less CH₄ emissions and carbon sequestration. However, it is important to consider their social implications. Land ownership in these systems is a critical issue in the promotion of fairer systems. In some places, big extensive cattle ranchers own several thousand hectares. This is not compatible with a food-sovereignty focused approach, since it promotes inequality within the food system. In that case, the production system is an important target to cool the planet, but agrarian reform must be another key issue to promote justice within the system.

Mix-farming systems

In mixed farming systems, cropping and livestock rearing are linked activities. Mixed farming systems are defined as those systems in which more than 10% of the dry matter fed to animals comes from crop by-products or stubble or where more than 10% of the total value of production comes from non-livestock farming activities (FAO, 2009c). Mixed systems produce close to 50% of the world's cereals and most of the staples consumed by poor people. *Rainfed mixed farming systems* are found in temperate regions of Europe and the Americas and subhumid regions of tropical Africa and Latin America. They are characterized by individual ownership, often with more than one species of livestock and produce about 48% of global beef (FAO, 2009c) and 33% of mutton (Steinfeld et al., 2010). *Irrigated mixed farming systems* prevail in East and South Asia, mostly in areas with high population density. They provide about 30% of the world's pork and mutton and 20% of its beef (FAO, 2009c). On the global scale, mix-farming systems accounts for 90% of milk and 70% of ruminant meat output, 43% of pork and 25% of poultry meat (Steinfeld et al., 2010). Within the developing countries, they contribute to 45 and 39% of pig and poultry meat and eggs³⁰.

There is a close connection between mixed-farming systems and small-sized family farms in developing countries. In turn, 84% of agricultural populations in these countries are in mixed systems. Small family farms contribute significantly not only to total output but also to overall employment in rural areas.

³⁰ They do not say whether these numbers include or not backyard production systems.



Additionally, small crop-livestock producers are also linked to informal and internal markets in which the supply chains generate more employment per unit of output (Steinfeld et al. 2010). These systems face also many constraints in compare with intensive systems.

Agroforestry systems: Agroforestry is a form of agriculture which deliberately integrates trees and crops and/or livestock in farming systems. Examples of animals in agroforestry systems include chickens in garden systems, orchards and forest; ducks in aquatic environments, such as rice paddies; geese to control grasses in orchards and livestock in forest (silvopasture).

Backyard Pig and Poultry production: As previously stated, traditional pig and poultry productions are the less environmentally damage production systems in terms of GHG emissions. They are also the ones mostly practised by women in developing countries. In backyard systems, they are fed on household waste and agro-industrial by-products, turn biomass that would otherwise go to waste into high-value animal protein. Pigs and poultry also require less feed per unit of output than ruminants. As such, they demand less land for feed production, not compromising food security, and help to recycle the nutrients within the family unit. More than 90% of rural families in most developing countries keep one or more poultry species (i.e. chickens, ducks, guinea fowls, geese, pigeons, etc.), and all ethnic groups tend to be involved in family poultry production. This system is appropriate for supplying the fast-growing human population with high-quality protein, while providing additional income to the generally resource-poor small farmers, especially women (Guèye, 2005). Regarding pigs, it is estimated that pigs in mixed systems account for about 35% of global production (including silvopasture). Since pig and poultry intensive production systems have suffered a strong impulse in developing countries in the last decade, being the ones that have made possible the so-called “livestock revolution”, they compete with more traditional farming systems which in turn, are less pollutant. Special policies are required in order to promote family farming of pig and poultry, including better access to local markets avoiding the dumping that nowadays these systems suffer from vertical, integrated intensive farming systems.

Erroneously, the change from extensive grazing systems towards intensive farming systems are presented as a development pathway driven by factors such as land availability, fossil fuel prices, consumer preferences, technology or food safety and quality. Presented like this, it can be perceived as if external factors determine this pathway or as if this change was a natural development process. In fact, policies oriented towards an outdated and invalid development paradigm are the main reason for this change, since they favour intensive systems rather than traditional ones. In this sense, proposals for more intensification and market-based livestock farming aiming at fulfilling the increasing supply-driven consumption of meat (Steinfeld et al., 2010) and do not question the role of policies are, simply, wrong.

The first, short-term steps to promote traditional systems would be a change of policies that presently favour intensive farming systems. Some of these strategies would include strategies such as “polluter pays and provider gets” principles, internalization of environmental costs, or to avoid concentration and bringing livestock density into balance with the absorptive capacity of the surrounding land (Steinfeld et al., 2010). But more structural changes are required if we bear in mind that sustainable livestock farming systems have to develop their strategies in a policy context that poses several constraints for their development. Such constraints need to be addressed at the global level and include:

- (i) privatization of land, which makes difficult the access to land for grazing, including land grabbing for alternative industrial land-uses or intensive cropping (e.g., soybean in Brazil or conversion of pastures into cropland). To overcome this particular constraint, food sovereignty oriented agrarian reforms are required in most countries;
- (ii) food safety legislation developed for industrial agriculture that can not be and should not need to be implemented in small farms. In this case, specific policies that differentiate small-holders food production from industrial food production in terms of food safety requirements are needed;
- (iii) modernisation policies that refuse traditional farming, or aim at sedentarise pastoralist and modernise their livelihood system, ignoring the vital need for mobility and resource access;



- (iv) agriculture and trade policy that provides direct and indirect subsidies for intensive systems and prejudices against traditional systems;
- (v) excessive control of livestock by corporations that aim at uniform inputs and products and create a cheap meat culture.

Cooling the planet through livestock while feeding the world has to consider these constraints which, in the end, help to conform a global picture of small-scale family farming.

Conclusions

Food security, poverty, the loss of global biodiversity and climate change are closely linked. Policymakers must address all fronts simultaneously. In the case of livestock, differentiated policies should be provided that support rather than neglect the diverse small livestock enterprises that make food production possible throughout the developing world. Contrary to what some suggest (FAO, 2009c; Steinfeld et al., 2010), the best way to address food security and climate change in the livestock sector is through decreasing the global livestock numbers worldwide that are raised in intensive factory farms, while increasing the number of farmers that rely on more sustainable farming systems, which at the same time, are more labour-intensive.

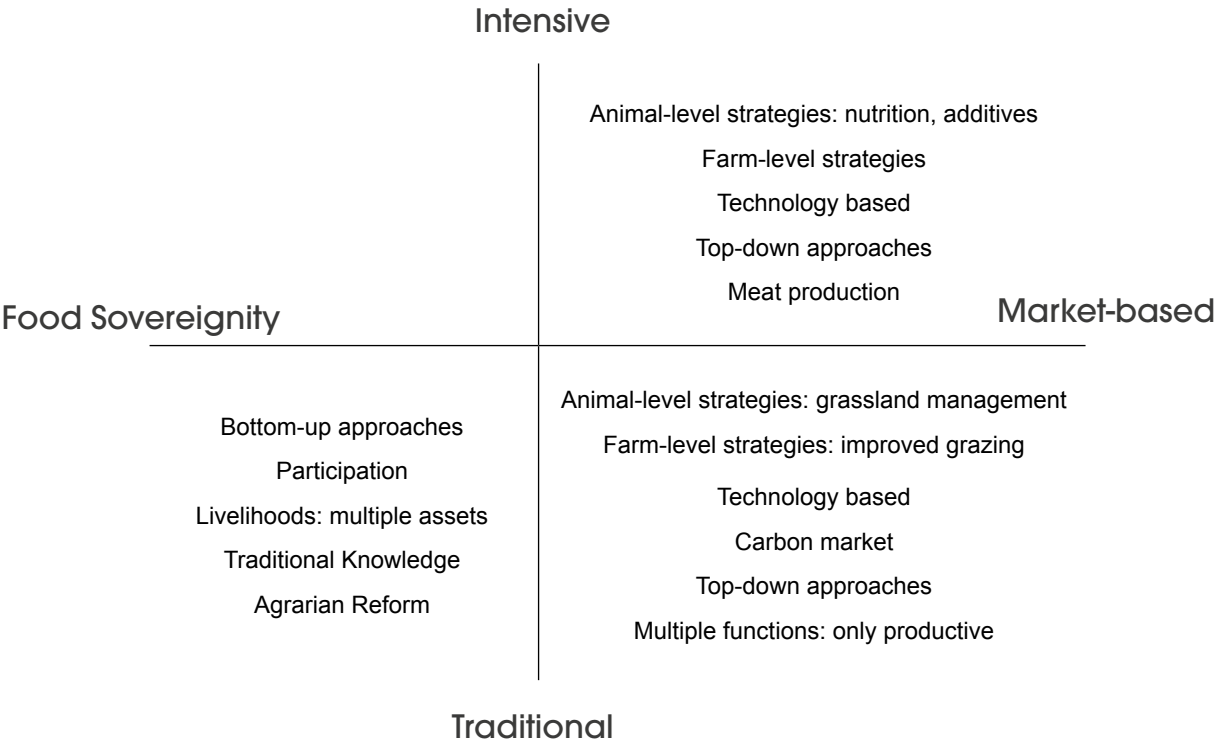
Both intensive and traditional farming systems, as well as market-based and food sovereignty approaches propose different alternatives to reduce emissions and feed the planet. The main differences among them are the scale and origin of the proposals (Fig. 1). In the first case (intensive, market-based approaches), most of the solutions are top-down, technological strategies at the farm-level, even at the animal-level, through improvement in nutritional strategies, breeding of animals or genetic improvement of crops. It is important though to remark that in this case the solutions are targeting problems that were mostly created by the intensive systems themselves (including the increasing level of meat consumption) and sociological aspects are not considered. In the second case (traditional farming systems, food-sovereignty), there are different scales, both at the farm level (improved grassland management) but also at the global level, and bottom-up approaches and traditional knowledge are essential for their success, thus people are an important asset. In this case, proposals aim at solving a problem created by others (just a few) but suffered by everyone. It is important to highlight that traditional livestock farming also play a key role in ensuring other benefits of livestock farming systems such as livelihoods and maintaining biodiversity. In this case, the scale of the production systems is also relevant, since there exist market-based, export-oriented traditional systems that do not have a role in promoting equity in society and thus, can not be considered as an alternative for food sovereignty.

Traditional farming systems then have the potential to cool the planet at the same time that feeding the world population. However, this requires political changes that eliminate the global constraints that nowadays are threatening these systems, such as access to land (both at the individual and community level). It will also be necessary to enhance the participation of farmers in the decision-making processes. Democratic decision-making around food and climate policies is a fundamental precondition to achieving sustainable solutions (Constantins, 2009). It is also time to start a new era in formal research where traditional knowledge should be as important as formal knowledge and farmers can contribute to the process of research and decision-making together with researchers and policy-makers.

In summary, it is suggested that changes can be managerial, technical and structural. Steinfeld et al. (2010) suggest that order, in our opinion, changes should be first structural, directed towards decreasing the number of animals raised in intensive livestock systems and support agrarian reforms and food sovereignty proposals, and later, managerial and technical, to improve the livestock practices of indigenous, peasant and small holder farmers and pastoralists.



Figure 1. Examples of solutions proposed to mitigate GHG emissions from livestock based on production systems (intensive vs. traditional) and the focus of the policies (market-based vs. food sovereignty).



III. FISHERIES

Feeding the world, cooling the planet, preserving the environment:

The role of small-scale and artisanal fisheries

K.G. Kumar

Introduction

Human beings, probably for as long as they have existed, have relied on fishing and fisheries-related activities not only to supply them with food – especially in the form of affordable and accessible protein, particularly for the poor in developing parts of the world -- but also as a source of employment, income and other social and economic benefits that sustain livelihoods and cultures.

As a source of food, fish is one of the most versatile commodities that can be utilized in myriad ways and product forms. It is generally distributed as either live, fresh, chilled, frozen, heat-treated, fermented, dried, smoked, salted, pickled, boiled, fried, freeze-dried, minced, powdered or canned, or as a combination of two or more of these, forms. Little wonder then that fish has continued to occupy pride of place at tables around the world.

For long it was imagined that the bounty of the sea would be inexhaustible and that living aquatic resources, being inherently renewable, would be almost infinite. With increasing scientific knowledge and the (often dire) experience of fisheries growth and development in various parts of the world, it became apparent that the oceans' riches were, in fact, not limitless but were subject to overexploitation through modern advanced fishing and processing technologies, which led to increased fishing effort and intensity, growing international demand for fish and fishery products, and State-led promotion of fisheries as a critical, market-driven, dynamically developing sector of the food industry. The collapse of certain fisheries – like the Atlantic cod fishery in New England and eastern Canada (Kurlansky 1997; 2008) – and, with it, the disappearance of a way of life drove home the point that fisheries resources are not an unlimited gift of nature but ought to be subject to responsible management.

With that realization came moves by States and governments to examine fisheries management afresh by incorporating conservation and environmental, as well as social and economic, considerations into resource management. In 1982 with the adoption of the United Nations Convention on the Law of the Sea (UNCLOS), a new framework for the better management of marine resources was made available. Coastal States could use this new legal regime of the oceans to wrest rights and responsibilities for the management and use of fishery resources within the areas of their national jurisdiction, which embrace almost 90 per cent of the world's marine fisheries.

Also aiding the process was the concurrent widespread adoption of exclusive economic zones (EEZs -- zones under national jurisdiction [up to 200-nautical miles wide] declared in line with the provisions of UNCLOS, within which the coastal State has the right to explore and exploit, and the responsibility to conserve and manage, the living and non-living resources therein.)

Recent times have witnessed threats to the long-term sustainability of the world's fisheries and their contribution to global food supply. These have manifested as signs of overexploitation of important fish stocks in different parts of the world, including through illegal, unreported and unregulated (IUU) fishing, changes to ecosystems, significant economic losses, and international conflicts on management of fish resources and global trade in fish.

Global status of fisheries today

According to the Food and Agriculture Organization of the United Nations (FAO), capture fisheries and aquaculture supplied the world with about 110 million tonnes of food fish in 2006, accounting for a per



capita supply of 16.7 kg (live weight equivalent), which is among the highest on record for the period 2002–2006, for which fairly reliable data is available (FAO 2009g).

Global capture fisheries production in 2006 was about 92 million tonnes, with an estimated first-sale value of US\$91.2 billion, comprising about 82 million tonnes from marine waters and a record 10 million tonnes from inland waters. China, Peru and the United States of America remained the top producing countries.

China is the world's largest producer, with reported fisheries production of 51.5 million tonnes in 2006 (17.1 and 34.4 million tonnes from capture fisheries and aquaculture, respectively). Asia's share of total catches exceeded 52 per cent of the global capture fisheries production in 2006, the largest share so far recorded. Among the top ten producers are six Asian countries (China, Indonesia, Japan, India, Thailand and the Philippines), while four other Asian countries (Myanmar, Viet Nam, the Republic of Korea and Bangladesh) occupied positions 12–15 (FAO 2009g).

Aquaculture is today the fastest-growing animal food-producing sector and outpaces population growth, with per capita supply from aquaculture increasing from 0.7 kg in 1970 to 7.8 kg in 2006, an average annual growth rate of 6.9 per cent. Aquaculture is set to overtake capture fisheries as a source of food fish. The Asia–Pacific region dominates world aquaculture, accounting for 89 per cent of production in terms of quantity and 77 per cent in terms of value. This dominance is mainly due to China's enormous production, which accounts for 67 per cent of global production in terms of quantity and 49 per cent of global value.

The per capita consumption of fish in the world has been steadily rising, from an average of 9.9 kg in the 1960s, 11.5 kg in the 1970s, 12.5 kg in the 1980s and 14.4 kg in the 1990s, to reach 16.4 kg in

2005. This growth has been fuelled by changing consumer tastes (linked to, for example, the health benefits associated with the Omega-3 fatty acids in fish, and the growing preference for moderately priced white-meat fillets), and advances in technology, packaging, logistics and transport.

Fish as food and nutrition

Fish is a valuable and highly nutritious supplement for a diversified and balanced diet. Not only does it supply high-value protein, but it is also an important source of a wide range of essential micronutrients, minerals and fatty acids. On average, fish provides about 20–30 kilocalories per person per day.

For many communities, especially in the developing world, fish is part of the daily diet and is often the only affordable source of animal protein. Fish is also customarily preferred because it has long been part of local and traditional recipes.

Overall, fish provides more than 2.9 billion people with at least 15 per cent of their average per capita animal protein intake. The share of fish proteins in total world animal protein supplies grew from 14.9 per cent in 1992 to a peak of 16.0 per cent in 1996, declining to about 15.3 per cent in 2005 (FAO 2009a).

According to FAO, despite the relatively low fish consumption by weight in low-income food-deficit countries (LIFDCs) of 13.8 kg per capita in 2005, the contribution of fish to total animal protein intake was significant – at 18.5 per cent. This level could actually be higher since official statistics do not factor in the under-recorded contribution of small-scale and subsistence fisheries.

It is estimated that fish contributes to at least 50 per cent of total animal protein intake in some small island developing States, as well as in Bangladesh, Cambodia, Equatorial Guinea, French Guiana, the Gambia, Ghana, Indonesia and Sierra Leone (FAO 2009a).

In 2006, more than 110 million tonnes (77 per cent) of world fish production was used for direct human consumption. Almost all of the remaining 33 million tonnes (around one-quarter of world fish production) was destined for non-food products, in particular the manufacture of fishmeal and

fish oil. The remainder, mainly consisting of low-value fish, is largely utilized as direct feed in aquaculture and livestock.



Fisheries and livelihoods

Fisheries and aquaculture, directly or indirectly, play an essential role in the livelihoods of millions of people around the world. In 2006, an estimated 43.5 million people were directly engaged, part-time or full-time, in primary production of fish either in capture from the wild or in aquaculture, and a further 4 million people were engaged on an occasional basis (2.5 million of these in India). In the last three decades, employment in the primary fisheries and aquaculture sector has grown faster than the world's population and employment in traditional agriculture.

Eighty-six per cent of fishers and fish farmers worldwide live in Asia, with China having the greatest numbers (8.1 million fishers and 4.5 million fish farmers). In 2006, the other countries with a significant number of fishers and fish farmers were India, Indonesia, the Philippines and Viet Nam. Most fishers and fish farmers are small-scale, artisanal fishers, operating on coastal and inland fishery resources (FAO 2009a).

In 2006, the estimated number of fish farmers was nearly 9 million people, with 94 per cent operating in Asia. For each person employed in the primary sector, it has been estimated that there could be four employed in the secondary sector (including fish processing, marketing and service industries), indicating employment of about 170 million in the whole industry. Taking account of dependants, about 520 million people -- or nearly 8 per cent of the world population -- rely on the fisheries sector for their livelihood.

The number of people employed in fisheries and aquaculture has been growing steadily in most low-income and middle-income countries, but employment in the sector has fallen or remained stationary in most industrialized economies.

Fishing fleets

In 2006 an estimated 2.1 million fishing vessels powered by engines were in operation, of which almost 70 per cent were concentrated in Asia. Of the remaining vessels, most were accounted for by Africa, followed by Europe, the Near East, Latin America and the Caribbean. Almost 90 per cent of motorized fishing vessels in the world are less than 12 metres long, and they dominate in countries in Africa, Asia and the Near East. The fishing fleets in the Pacific region, Oceania, Europe and North America tend to consist of vessels that, on average, are slightly larger. Industrialized fleets comprise vessels of more than 100 gross tonnage (GT), roughly more than 24 metres long. There is a higher proportion of vessels over 100 GT in the Europe, North America and Latin America and Caribbean regions than in the Africa and Asia regions.

State of global marine fishery resources

An overall review by FAO of the state of marine fishery resources confirms that the proportions of overexploited, depleted and recovering stocks have remained relatively stable in the last 10–15 years, after the noticeable increasing trends observed in the 1970s and 1980s with the expansion of fishing effort (FAO 2009a). In 2007, about 28 per cent of stocks were either overexploited (19 per cent), depleted (8 per cent) or recovering from depletion (1 per cent) and thus yielding less than their maximum potential owing to excess fishing pressure. A further 52 per cent of stocks were fully exploited and, therefore, producing catches that were at or close to their maximum sustainable limits, with no room for further expansion. Only about 20 per cent of stocks were moderately exploited or underexploited with perhaps a possibility of producing more.

Most of the stocks of the top ten species, which together account for about 30 per cent of world marine capture fisheries production in terms of quantity, are fully exploited or overexploited. The areas showing the highest proportions of fully-exploited stocks are the Northeast Atlantic, the Western Indian Ocean and the Northwest Pacific. Overall, 80 per cent of the world fish stocks for which assessment information is available are reported as fully exploited or overexploited and, thus, requiring effective and precautionary



management. According to FAO, the maximum wild capture fisheries potential from the world's oceans has probably been reached, and a more closely controlled approach to fisheries management is required, particularly for some highly migratory, straddling and other fishery resources that are exploited solely or partially in the high seas.

The United Nations General Assembly Resolution 62/177 in 2007 deplored the fact that fish stocks in many parts of the world are overfished or subject to sparsely regulated fishing effort.

In a widely reported, though controversial, study a 14-member team led by Boris Worm of the Department of Biology, Dalhousie University, Halifax, NS, Canada, predicted that if present trends continue most fish stocks would collapse by the middle of the century. The team found that in 1950, only six commercial seafood species worldwide had collapsed. By 2003, more than 2,200 species -- 29 per cent of all commercially fished species on the planet -- had collapsed. Based on that rate of decline, the study then projected that most world fisheries could collapse by 2048 (Worm 2006).

More recently, Worm has shown greater optimism. He quotes examples of successful rebuilding of depleted fish stocks in Latin America, particularly in Chile and Mexico, where open-access fisheries for valuable invertebrates were transformed by the establishment of spatial management units that gave exclusive access to local fishing organizations. *"It appears that a combination of traditional approaches (catch quotas, community management), coupled with strategically placed fishing closures, more selective fishing gear, ocean zoning, and economic incentives holds much promise for restoring marine fisheries and ecosystems,"* he concludes (Worm 2009).

Inland capture fisheries production

Catches from inland waters, almost two-thirds of which were taken in Asia in 2006, have shown a slowly but steadily increasing trend since 1950, partly due to stock enhancement practices and possibly also due to improved reporting.

China and other developing countries together now account for 95 per cent of global inland capture production. In several developing countries, inland fisheries constitute a primary source of animal proteins, and a significant addition to the main diet in many others. In many parts of the developing world, small indigenous freshwater fish species (SIFFS) play a crucial role in poverty alleviation, food security and conservation of biodiversity (ICSF 2010a). On the other hand, in most industrialized countries, the number of recreational fishers now greatly exceeds that of professional ones, as inland water harvests have been significantly reduced.

Aquaculture

According to Ichiro Nomura, Assistant Director-General, FAO Fisheries and Aquaculture Department, *"A milestone may be near. After growing steadily, particularly in the last four decades, aquaculture is for the first time set to contribute half of the fish consumed by the human population worldwide. This reflects not only the vitality of the aquaculture sector but also global economic growth and continuing developments in fish processing and trade"* (FAO 2009a).

The contribution of aquaculture to global supplies of fish, crustaceans, molluscs and other aquatic animals has continued to grow, increasing from 3.9 per cent of total production by weight in 1970 to 36.0 percent in 2006. In the same period, production from aquaculture easily outpaced population growth, with per capita supply from aquaculture increasing from 0.7 kg in 1970 to 7.8 kg in 2006, an average annual growth rate of 7.0 per cent. Aquaculture accounted for 47 per cent of the world's fish food supply in 2006. In China, 90 per cent of fish food production comes from aquaculture. Aquaculture production in the rest of the world accounts for 24 per cent of food fish supply.

World aquaculture has grown dramatically in the last 50 years. From a production of less than 1 million tonnes in the early 1950s, production in 2006 was reported to have risen to 51.7 million tonnes, with a value of US\$78.8 billion. This means that aquaculture continues to grow more rapidly than other animal



food-producing sectors, with per capita supply from aquaculture increasing from 0.7 kg in 1970 to 7.8 kg in 2006, an average annual growth rate of nearly 7 per cent (FAO 2009).

The Asia-Pacific region accounts for 89 per cent of world aquaculture production in terms of quantity and 77 per cent in terms of value. This dominance is mainly due to China's enormous production, which accounts for 67 per cent of global production in terms of quantity and 49 per cent of global value. China produces 77 per cent of all carps and 82 per cent of the global supply of oysters. The Asia-Pacific region accounts for 98 per cent of carp, 95 per cent of oyster production, and 88 per cent of shrimps and prawns. Norway and Chile are the world's two leading producers of cultured salmons, accounting for 33 and 31 per cent, respectively, of world production.

Recently, a Norwegian scientist at the head of the new Centre of Excellence for Capture-based Aquaculture in Tromsø trumpeted the capture-based approach as the "future of fishing". Senior Scientist Kjell Midling of research group Nofima, who set up the centre at the behest of the Norwegian Ministry of Fisheries and Coastal Affairs, was quoted in fishnewseu.com: *"If you catch 100 tonnes of wild cod in April, capture-based aquaculture enables you to sell 200 tonnes in December. This is the fishing method of the future."*³¹

China could soon take over from Japan and become Norway's largest market for the export of salmon to Asia. In 2009 only, the export of salmon to China increased by nearly 60 per cent. Norway is now selling 23,000 tonnes of salmon to China annually, and last year the export was worth NOK 800 million (approx. US\$130 mn). The main reason for the increase is the rising prosperity among the Chinese, and consumer preference for healthy food.

Nonetheless, the aquaculture industry around the world has been beset with problems of effluent and wastewater discharges, leading to environmental degradation of land, outbreak of fish disease in shrimp farms, erosion of fish genetic diversity, and lack of uniform standards and certification procedures. Many private initiatives have been launched to develop and test specific organic aquaculture standards and accreditation bodies. These standards often vary significantly from place to place, certifier to certifier, and species to species

The trend towards the patenting of fish genetic resources, and even the patenting of new breeds of fish, is accelerating as the aquaculture industry applies biotechnology shortcuts—including hybridization, sex manipulation, polyploidy and genetic engineering—which are more amenable to patenting than selective breeding (Prat 2002).

The threats that genetically modified organisms (GMOs) pose to the environment and human health have also fuelled public perception that aquaculture harms the environment. FAO and its partners have drafted guidelines for aquaculture certification. These guidelines cover animal health and welfare, food safety and quality, environmental integrity and social responsibility associated with aquaculture. They provide guidance on the development, organization and implementation of credible aquaculture certification schemes. The aims are: (i) to reassure producers, buyers, consumers and civil society regarding the quality and safety of aquaculture products; and (ii) to provide a further tool to support responsible and sustainable aquaculture (FAO 2009a).

Fisheries management

Evidently, there is a great need for efficient and practicable fisheries management policies that will help arrest – and possibly reverse – the declining trends in fisheries resources. But poor countries, especially those that lack financial and administrative capacities, face daunting challenges in making improvements in resource management. A key fisheries management issue is the lack of progress

with the reduction of fishing capacity and related harmful subsidies. The 2007 session of the FAO Committee on Fisheries (COFI) referred to the lack of progress in this area and the need to match

31 <http://www.fishnewseu.com/latest-news/world/3302-scientist-hails-capture-based-aquaculture-as-the-fishing-method-of-the-future.html>



fishing capacity with sustainable harvesting levels. The relationship between excess capacity and illegal, unregulated and unreported (IUU) fishing has also been highlighted in several international forums.

Code of Conduct for Responsible Fisheries

In March 1991 the 19th Session of the FAO Committee on Fisheries (COFI) recommended new approaches to fisheries management that would embrace conservation and environmental, as well as social and economic, considerations. FAO was asked to develop the concept of responsible fisheries and elaborate a Code of Conduct to foster its application.

The International Conference on Responsible Fishing, held in Cancún, Mexico, in May 1992, endorsed the Declaration of Cancún which was then brought to the attention of the UNCED Rio Summit in June 1992, which supported the preparation of a Code of Conduct for Responsible Fisheries.

The Code was adopted at the 28th Session of the FAO Conference on 31 October 1995. The Code is voluntary. However, certain parts of it are based on relevant rules of international law, as reflected in the 1982 UNCLOS (FAO 1995).

The precautionary approach

Principle 15 of the Rio Declaration of the UN Conference on Environment and Development (Rio de Janeiro, 1992) states that *“In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation.”*

The precautionary approach involves a set of agreed cost-effective measures and actions, including future courses of action, which ensures prudent foresight, reduces or avoids risk to the resource, the environment, and the people, to the extent possible, taking explicitly into account existing uncertainties and the potential consequences of being wrong.

By stressing prudent foresight the precautionary approach considers the needs of future generations and seeks to avoid changes that are not potentially reversible. It also tries to identify beforehand undesirable outcomes and measures that will avoid them or correct them promptly.

In fisheries, the precautionary approach takes into account the fact that changes in fisheries systems are only slowly reversible, difficult to control, not well understood, and subject to change in the environment and human values.

Precautionary management involves explicit consideration of undesirable and potentially unacceptable outcomes and provides contingency and other plans to avoid or mitigate such outcomes. Undesirable or unacceptable outcomes include overexploitation of resources, overdevelopment of harvesting capacity, loss of biodiversity, major physical disturbances of sensitive biotopes, or social or economic dislocations (FAO 1996a).

To ensure broad acceptance, precautionary management seeks active consultation with the fishing industry, conservation groups, and other interested parties at all stages of planning. It also seeks to establish legal or social management frameworks for all fisheries.

The ecosystem approach to fisheries

The ecosystem approach to fisheries (EAF) has been defined thus: *“...an ecosystem approach to fisheries strives to balance diverse societal objectives, by taking account of the knowledge and uncertainties of biotic, abiotic and human components of ecosystems and their interactions, and applying an integrated approach to fisheries within ecologically meaningful boundaries”* (FAO 2003).

Ecosystem models represent a wider range of technological and ecological processes that affect the species in the ecosystem (including multispecies and whole ecosystem models). EAF recognizes the



limitations of a single-species approach to fisheries management, and factors in other relevant variables and processes (which can include biological, ecological, social and economic factors).

In considering multiple users of the ecosystem, EAF addresses a wider range of objectives, frequently ignored in the past, to select optimal fisheries management measures and strategies. It also attempts to reconcile and resolve conflicts between different stakeholder groups so that the overall societal goals are achieved.

FAO reports limited progress in the implementation of measures to mainstream the precautionary and ecosystem approaches to fisheries, eliminate bycatch and discards, regulate bottom-trawl fisheries, manage shark fisheries, and deal with IUU fishing in a comprehensive manner. A sharp focus on capacity building for fisheries management is a priority both for developing and developed countries.

Small-scale and artisanal fisheries

“Small-scale”, “subsistence”, “traditional”, “artisanal”, “inshore”, “peasant” -- these are some of the terms that have been used to define the small-scale fishery sector. As FAO notes, defining small-scale and artisanal fisheries is a challenge as the terms have been used for decades by various interests to represent different points of view and socioeconomic dimensions in different national contexts.

Attempting to combine all the characteristic dimensions of these fisheries, FAO defines artisanal fisheries as “traditional fisheries involving fishing households (as opposed to commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption. In practice, definition varies between countries, e.g. from gleaning or a one-man canoe in poor developing countries, to more than 20-m. trawlers, seiners, or long-liners in developed ones. Artisanal fisheries can be subsistence or commercial fisheries, providing for local consumption or export. They are sometimes referred to as small-scale fisheries” (FAO 2010b).

Small-scale fisheries are characterized by certain common attributes (Kurien 1996):

- 1) use of small craft and simple, relatively inexpensive gear
- 2) skill-intensive fishing operations
- 3) traditional knowledge and skills of the aquatic milieu and fishery resources
- 4) predominance of share-workers or owner-operators of fishing units
- 5) decentralized and scattered settlement pattern, with high population density
- 6) largely open-access fishing regimes, with certain notional customary rights claims
- 7) linkages to local hinterland market networks
- 8) financial dependence on middlemen
- 9) relative social and economic backwardness, with low employment mobility

Small-scale fishers often employ dynamic livelihood strategies that rely on the largest possible range of approaches and available assets, thus reducing risks created by natural or market vagaries. One proven fisheries livelihood strategy is harvesting various fisheries resources with different gears, depending on the season. Another is to engage in fisheries during the “peak abundance” main season and then switch to another productive activity the rest of the year, such as transplanting rice, raising pigs or repairing farm tools for the village. Such multiple livelihood sources help reduce the catastrophic effects fisheries management measures can have where a fishery must be closed or reduced due to the state of resources (FAO 2010b).

Advantages of small-scale/artisanal fisheries

Small-scale fisheries offer certain advantages in several contexts around the world (FAO 2010b):

Lower running costs and fuel consumption since fishing vessels and techniques are less mechanized and passive gear like handlines, longlines, gillnets and fish traps are used extensively.



Lower ecological impact due to the prevalence of passive fishing gear.

Higher employment opportunities since the sector is more labour-intensive and offers opportunities in not just catching but processing and trade of fish and fishery products as well.

Higher versatility since small craft with shallow draft can better access more restricted waters and small ports and landing sites.

Lower construction costs for relatively lightly (and inexpensively) built boats that do not go far offshore.

Less expensive technology arising from low-cost equipment and cheap labour.

Daniel Pauly, Director of the University of British Columbia Fisheries Centre and Project Leader of The Sea Around Us, offers the following simple, but striking, summary of the benefits of small-scale fisheries:

Policymakers continue to grant industrial fishers a competitive edge, despite conservation biologists pointing out the vastly greater ecological impacts of large-scale industrial fisheries compared with small-scale, artisanal ones. This is due to a widely held perception that they catch the vast majority of the world's fish. Recently, though, more-thorough estimates of annual global catch proved that assumption wrong: it turns out that small-scale fisheries actually land as much as their industrial counterparts, at least as far as fish destined for human consumption are concerned (Pauly 2006).³²

The limitations of large-scale industrial fisheries have long been recognized. Economist Jean-Philippe Platteau wrote in 1989: "The ultra-modern fishing sector, which uses highly capital-intensive harvesting and processing technologies, tends to form an autonomous, self-contained entity with practically no links with small-scale fishing communities. In many developing countries this sector is controlled, to a large extent, by foreign capital, by public national capital or by a combination of both under the form of joint ventures. The considerable capital costs, as well as the high risks, associated with such fishing enterprises (think, for example, of the long-range purse seiners used to catch tuna off the coast of West Africa, or to catch pelagic species destined for fish reduction into meal in Asian and Latin American waters) do not make them an attractive business proposition for local private capital or for inexperienced local entrepreneurs" (Platteau 1989).

"There is actually ample evidence to show that the small-scale fishing sector is capable of important adaptations and transformations which help sustain its economic viability. Small-scale fishermen in many countries have been quick to adopt technological innovations (outboard motors, changes in the shape of craft, the introduction of new nets, etc.) whenever they seemed appropriate to them. Actually, these small-scale improved technologies often seem to be more economically profitable and ecologically sound than industrial techniques when these are in direct competition with each other for catching given species of fish in inshore areas" (Platteau 1989).

To a large extent, the problems that have beset the fisheries of the South can be traced to misguided and damaging development projects from the North, according to renowned fishery economist and development adviser, the late Francis Christy Jr. *"This was due to two deficiencies in development aid: (a) an almost total lack of understanding of the special characteristics of the nature of fisheries and (b) an insensitivity to the organization of the social customs and cultural mores of local fishing communities. The North has subsequently learned something more about the former factor but has responded generally by throwing up its hands and doing nothing, because it has not figured out how to provide the continuity of attention that is necessary. There are also some improvements with regard to the latter factor. In both cases, the North has much to learn from the South if it is to provide useful aid to the South on fisheries"* (quoted in Kurien 2002).

From a resource conservation and fisheries management perspective, mere input-control measures — restrictions on gear, engine, size of the vessel, fishing area, and fishing time (days at sea), elimination of destructive fishing techniques such as bottom-trawling and dynamiting — will not work comprehensively

32 See: <http://www.conservationmagazine.org/2008/07/10-solutions-to-save-the-ocean/>



on their own. These have to be combined with effective monitoring, control and surveillance (MCS) and enforcement measures. Simultaneously, coastal fishers should be provided with viable redeployment and alternative employment schemes.

Traditional ecological knowledge systems and customary rights

With the growing global concern about declining fishery resources, and recognition of the need to manage fisheries resources, current emphasis is shifting to a “rights-based approaches to fisheries management”, advocating the introduction of some form of rights to resources for individuals or groups. However, the focus so far has been largely restricted to fisheries in temperate ecosystems and may not suit the techno-ecological or socioeconomic attributes of small-scale fisheries in developing countries, where multi-gear, multi-species fisheries predominate.

Fisheries scientists are now offering a menu of property-rights regimes, such as individual transferable quotas (ITQs) and territorial use rights in fisheries (TURFs). However, these solutions fail to consider traditional ecological knowledge systems (TEKS), also referred to as traditional knowledge (TK), indigenous knowledge (IK), traditional environmental knowledge (TEK) and local knowledge. They refer to the long-standing traditions and practices of certain regional, indigenous, or local communities. Traditional knowledge, which is the summation of wisdom, knowledge, and teachings orally passed on for generations from person to person, can take the form of stories, legends, folklore, rituals, songs, and even laws. They often contribute to the collective cultural ethos of a community.

Communities may have developed new systems for management through trial and error; systems which they have maintained through their traditions (Christy 2009).

TEKS are (i) systemic, meaning that any part of the ecosystem is known as it relates to the whole; (ii) local, meaning that they take as a reference the world the cultures inhabit; and (iii) indissoluble from the culture as a whole, meaning that they cannot be understood on their own.

Today's coastal marine biodiversity is largely a result of coastal indigenous peoples and local communities' TEKS. These also encompass the use of marine biodiversity for many needs other than food, including medicinal use. Such uses, though, remain largely unpublicized and poorly understood (Prat 2002).

Conventional management tools used for industrial fisheries are generally unenforceable in small-scale fisheries when implemented in a top-down manner. More successful forms of governance have involved local communities in a co-management arrangement with government or nongovernmental organizations (Worm 2009). An example is the rebuilding of depleted fish stocks on Kenyan coral reefs. A network of closed areas and the exclusion of highly unselective beach seines were implemented in co-operation with local communities and led to a recovery of the biomass and size of available fish. This translated into steep increases in fishers' incomes, particularly in regions that had both closed areas and gear restrictions in place.

“It appears that a combination of traditional approaches (catch quotas, community management), coupled with strategically placed fishing closures, more selective fishing gear, ocean zoning, and economic incentives holds much promise for restoring marine fisheries and ecosystems” (Worm 2009).

Christy points to traditional systems of community control of resources that provide an important lesson for management. *“They indicate that, where satisfactory exclusive use-rights are in place, the community will often work out effective use-patterns and behaviour. However, these traditional systems are fragile (particularly where they are not supported by government) and tend to break down under pressures of various kinds. These pressures include: intrusion of large-scale operations into inshore waters; depletion of stocks; entry into communities of displaced land-labour; population growth within communities; shift from subsistence to market-economies; and environmental degradation” (Christy 2000).*

Though Christy believes that the ITQ system will work for large-scale fisheries in developed countries by reducing the onus and cost of governmental involvement, there are situations where government-



imposed ITQs cannot be used. *“Small-scale fisheries in many developing countries are marked by a multiplicity of gear, craft, species and landing areas. In these situations the only apparent solution is to devolve management authority and let communities or groups of fishermen assume the responsibility. Such community-based TURFs would permit fishermen to adopt those measures most suitable for their particular situation and reduce the conflict and waste that is prevalent at present”* (Christy 2000).

As participants at the Siem Reap workshop on “Asserting Rights, Defining Responsibilities: Perspectives from Small-scale Fishing Communities on Coastal and Fisheries Management in Asia” asserted, the transfer of the sea from a common-pool resource into private ownership will be seen by the region’s small-scale fishers and fishing communities as a violation of their rights (ICSF 2007).

Guaranteeing preferential access to small-scale and artisanal fisheries within a precautionary-approach framework can also contribute to vital equity considerations in many Asian fisheries, especially to provide the needs of coastal fishing communities.

Women in fisheries

Women play an important role both as workers in the fisheries sector and in ensuring household food security. Millions of women around the world, especially in developing countries, work in the fisheries sector, providing labour before, during and after the harvest stage, in both artisanal and commercial fisheries. They usually work in making and mending nets, baskets and pots, and baiting hooks. Though rarely engaged in commercial offshore and deep-sea fishing, some women fish from small boats and canoes in coastal or inland waters – harvesting bivalves, molluscs and pearls, collecting seaweed and setting nets or traps (FAO 2009h).

Women also play an important role in aquaculture, where they attend to fish ponds, feed and harvest fish, and collect prawn larvae and fish fingerlings. However, their most important role in both artisanal and industrial fisheries is at the processing and marketing stages. Nonetheless, much of this work remains invisible in available statistics, and goes unrecognized and unacknowledged. As a result, women fail to get due recognition in public or official efforts to develop the fisheries sector, and they women have been excluded from planning “mainstream” fisheries activities.

Many women activists and fishworker organizations are now focusing on gender in fisheries – on the roles and relationships between women and men that are determined by social, political and economic contexts, which determine power relations between men and women in fishing communities. There have been several organizational initiatives of women themselves. Around the world, they have organized, as part of co-operatives, self-help groups, etc., to defend their economic interests. Women have also organized politically as part of unions and community-based organizations to raise issues such as the need for transport, market facilities, access to fish, and social security. They have raised their voices as members of fishing communities, responsible for the wellbeing of the community—on issues related to health, sanitation, education, displacement, pollution and climate change, among others. In many parts of the world, women have also been active as part of community-based organizations in protecting and managing natural resources (ICSF 2010b).

Ecosystem-based adaptation and climate change

In view of the dangers of natural hazards like the 2004 Indian Ocean tsunami which devastated coastal communities around the Indian Ocean region, and the potential threats from climate change and global warming to the livelihoods, food security and health of the poor, especially in coastal areas, ecosystem-based adaptation (EBA) is an approach that is now being promoted. EBA works with nature to help vulnerable communities build resilience of their ecosystems and livelihoods being threatened by climate change impacts (UNEP 2010).

Climate change solutions should aim to avoid damaging biodiversity and ecosystem services, increasing inequity and exacerbating poverty, especially since people living in poor countries are disproportionately



vulnerable to the loss of biodiversity and reduced ecosystem services. The current emphasis on resource consumption as the primary driver of economic growth has only increased environmental degradation, biodiversity loss and unsustainable economies. There is now need to *“develop economic models that reverse the market failures of the existing models by fully valuing the environment. They must be able to balance the capacity of the worlds’ ecosystems to provide essential services with the basic needs of all sections of human society in an equitable way”* (UNEP 2010).

Small-scale fishing communities have a special concern on this score since although they are responsible for emitting the lowest levels of greenhouse gases, they will suffer the most from the impacts of climate change and rising sea levels.

Conclusions

The sustainable development of the world’s fishery resources revolves around the twin goals of equity and effective fisheries management. Feasible and long-lasting solutions to conservation and management must be: (i) socially acceptable and just; (ii) effective from both biodiversity and livelihood perspectives; and (iii) based on strengthened institutions at local and international levels (FAO 2009h).

From that point of view, a shift from industrial fisheries to sustainable small-scale fisheries may well be one way out of the conundrum of stock depletion, habitat degradation and reduced incomes. Around the world, small-scale and artisanal fisheries have, by and large, displayed a responsible, selective and labour-intensive nature. The essential characteristics of the small-scale sector — being relatively environmentally benign through the operations of a multitude of fishers working inshore, using mainly small craft and passive gear and thereby consuming relatively little fuel per unit of catch landed – augur well for effective conservation and management. These features ought to be sustained and nurtured within a framework that incorporates the precautionary approach, the ecosystem approach to fisheries, and a rights-based approach that reiterates the rights of traditional and community-based organizations to conserve and co-manage coastal and inland fishery resources, and to benefit from them.

In the words of Daniel Pauly: *“In the long term—possibly as little as two or three decades—fisheries and fishing-based cultures will not survive if we do not manage to put small-scale fisheries and resources first. However, for these fishers to assume a more dominant role and to possibly contribute toward sustainability, they will have to be given exclusive access to coastal resources. That means not only reining in competition from industrial fishing operations but also protecting fishing rights from the massive throngs of unemployed farmers and other rural residents who are moving to the coasts and taking up fishing as an occupation of last resort—a central cause of coastal overfishing in many developing countries. Many examples of small-scale fisheries that work exist throughout the world, and their broad-scale emulation would go a long way toward overcoming the global crisis of fisheries”* (Pauly 2006).



IV. CONCLUSIONS

Angela Hilmi and Aksel Nærstad

In this Part II of *A Viable Food Future*, we have reviewed where the foods we consume daily come from and how humans have coevolved with nature, developing sophisticated resilient systems of knowledge and adaptation which may very well provide us with the keys to face the challenges ahead. Rather than waiting for hypothetical solutions still to be invented, this report argues that the solutions are within our hands. More resilient and sustainable models of food production exist. They have evolved and adapted for millennia in traditional forms of agriculture and are more relevant than ever as viable tools in alleviating hunger and unemployment worldwide. They can be combined with latest science and technology on sustainable forms of production. But this requires a shift, a shift in thinking, in priorities and in approaches, a shift that puts the human, *humane* dimension at the centre, and the small-scale food producers at the heart of decisions with new diverse and multi-scale sustainable forms of food production still to be invented and developed. This report is about this shift towards greater democracy and participation to creatively cope with the challenges ahead. This is what the Food sovereignty movement does by putting those who produce, distribute and consume local foods at the heart of food systems, rather than the demands of markets and corporations. The food sovereignty framework recognizes and values the contributions, knowledge and skills of women and men, peasants and other small-scale family producers, pastoralists, small-scale fishers, forest dwellers, indigenous peoples, agricultural and fisheries workers, and other small-scale food providers who cultivate, grow, harvest and process food.

In this report, reference is made to the latest literature and proof of concept available today on some crucial issues of special relevance to understand the wider context to which our foods belong to. Part II also shows that we cannot think our foods and our future without thinking of the nature and the ecology they are embedded in. Our planet has finite natural resources, and unless we move towards maintaining and enhancing these resources upon which not only humans, but all living organisms of the Earth depend, we will face irreversible damage. This report presents some additional insights on the vast array of viable practices which we know for certain are highly successful and which give us the direction for the gradual changes required to help us move away from unsustainable practices of the past. It demonstrates that a transition is needed, that supports sustainable and resilient models of production.

These are exemplified by small and medium-scale farmer-centered gender-fair ecological agricultures that promotes social equity, economic justice and political empowerment. These models of agriculture play a crucial role in mitigating climate change and in conserving the environment while enriching local cultures. They represent the majority of the world's agriculture and are based on locally-available resources. They build on past and present knowledge systems and practices, and respect the fragile interaction of humans with the different elements of nature and the Earth. They provide nutritious and affordable food sources for local communities, promote sustainable livelihoods and industries and build resilience to the adverse impacts of climate change.

In order to promote and unlock the potentials of small and medium-scale ecological agriculture there is a need to rethink and change policies, institutions, enclosures (monopoly control, land grabs, intellectual property rights, etc.), technologies (external input-dependency, GMOs, hybrids) and markets which are today centred on industrial and monoculture agricultural production.

Supporting small-scale food producers will mean ensuring direct participation of communities and the producers' own organisations in decision-making at all levels, and ensuring access to productive resources (land, water, seeds, knowledge systems etc.). It implies the recognition and respect of the rights of communities to productive resources and their capacities as generators of knowledge. It allows to reinvent a viable food future for humanity and at the same time, to counter the unacceptable increasing waves of poverty spreading across the continents of the Earth.



V. RECOMMENDATIONS

The recommendations below are an extended version of the recommendations in Part I of this report. They are written by the editor, based on discussions in the advisory group and the document *Policies and actions to eradicate hunger and malnutrition* which present comprehensive policies and actions to eradicate hunger and malnutrition. The recommendations below deal only with policies and actions directly linked to the production and harvesting of food.

Nothing is more important than to end hunger and severe poverty, stop climate change and stop the destruction of the natural resources that are so critical for the future of humanity. Drastic changes of policies and actions in many areas are needed, but long journeys always start with small steps. There are many actions that can be taken immediately to move in the direction of a viable food future.

The report and the recommendations are based on the human right to adequate food which imposes a number of clear obligations on States (De Schutter, 2009).

Start moving towards small-scale ecological food production

A shift in focus and policies of governments and international institutions is needed. Even if the importance of small-scale ecological food production is underlined in every Food Summit declaration, every report and every white paper, the reality is still that industrial agriculture is promoted and supported, and small-scale ecological food production is not.

Governments, institutions and organisations should decide to support, promote and fight for small scale ecological food production, harvesting and gathering, including pastoralism, artisanal fisheries, urban and peri-urban agriculture. They should also clearly state that industrial agriculture and fisheries are not sustainable and cause huge health problems and environmental damage, including climate change, and therefore need to be transformed. All governments and international institutions dealing with agriculture should approve and decide to implement the findings of the *International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD)*.

The first priority in food production and consumption policies at all levels should be to support and protect food production for local markets and consumption in the communities themselves. Smallholder and peasant-based ecological farming, pastoralism and small-scale fisheries are the foundation of sustainable food production and provision. These diverse production systems, with many different crops and products and types of livestock produced within a single area and a variety of aquatic species harvested sustainably, ensure dietary diversity. Such production systems also empower women's capacities for food provision and social reproduction.

Peasant-based production, pastoralism and small-scale fisheries are the world's largest economic sectors in terms of the numbers of people engaged, and, with appropriate policy and government support, can sustain food supplies and be key pillars of robust domestic economies. Sustainable food provision requires localised, ecological, diverse, and low external input methods of production, harvesting, fishing, pastoralism, processing and distribution. These maximise the contribution of ecosystems and improve the resilience and adaptation of production and harvesting systems, especially in the face of climate change. Accordingly, research, development and production systems should build upon the skills and local knowledge of food providers and their organisations that conserve, develop and manage localised food production and harvesting systems, and reject technologies that undermine, threaten or contaminate these, such as genetically-modified crops, aquatic organisms and animals.

It also requires that local small-scale food providers have secure access to and control over land, fishing grounds, water, seed varieties, aquatic species and livestock breeds with full respect by states and societal actors for their use, access, governance and right to benefits. For generations, small-scale fishing and farming, pastoral and indigenous communities have shared and protected the, land, water and natural



wealth upon which life depends, in socially, environmentally and economically sustainable ways, sustaining diversity, building traditional knowledge and respecting collective rights.

Production methods that harm beneficial ecosystem functions, that depend on energy intensive monocultures and livestock factories, that use destructive fishing practices and other industrialised production methods, that damage the environment and contribute to global warming, should be transformed to minimise greenhouse gas emissions and other environmental damage.

Support and strengthen the organisations of small scale food producers

Strong social movements are vital for making the changes needed in policies and practices which are needed, as well as for democratic and sustainable development of societies. It is therefore of utmost importance to support and help strengthening the organisations of small scale food producers and food providers, and especially to strengthen the participation and role of women. It is also important to pay special attention to and support active participation of youth in these organisations.

The organisations of small scale food producers and providers must be consulted on all relevant issues and given a leading role in defining policies and actions for food and agriculture.

Development assistance should support local communities, community-based organisations and social organizations, especially organizations for small scale food producers, in building political empowerment, the capacity of people to articulate their views, implementation of their own development models and meaningful participation in development processes.

Reorient incentives to small scale farmers and regulation for agribusiness

Governments and international institutions should support and promote small-scale, diversified and ecological food production. The first priority at all levels should be to support and protect food production for local markets and consumption in the communities themselves. Incentives in food production and provision must be redirected from supporting industrial agriculture and agribusiness to support ecological food production and small scale farmers.

Ecological production sustains agricultural biodiversity, is resilient to climate change and other shocks, regenerates and locks carbon in the soil, improves water quality, and restores natural and managed habitats. The transition to a viable food future will require a shift towards low carbon ecological practices for cropping, nomadic pastoralism that conserves and uses rangelands sustainably by keeping carbon in the soil, and small-scale fisheries that promote sustainable use of fisheries resources. These production systems are supported by appropriate technologies, including small-scale mechanisation, that encourage innovation and reduce drudgery, and result in good quality food products without negatively affecting the environment.

Regulation and transformation of unsustainable large-scale industrialised agriculture, livestock raising and fisheries towards smaller-scale ecological production systems is also urgently required if hunger is to be eradicated, an equitable food system established and the environment restored.

Sanitary regulations must respect and support small-scale, diversified, culturally appropriate and ecological food production and processing. Sanitary and phytosanitary regulations should not block or reduce the possibilities for preserving and continuing to practice local food cultures, and traditional methods of food production, processing, and products.

Changes in the Codex Alimentarius are also needed. Today it promotes and supports industrialised and standardised food production, destroying small-scale, traditional and diversified food production under the guise of “safe food” and consumer protection. This has reduced the nutritional quality, diversity and taste of foods, and contributed to increased obesity and other forms of malnutrition. Sanitary and phytosanitary regulations should be based on and support the real and diverse needs of local food production and processing, whilst regulating large scale, damaging and polluting industrial food production.



Reorient research and breeding agenda

Agricultural knowledge, science and technology (AKST) must be redirected and strengthened to support agroecological and other forms of ecological food production and based on the needs of the small-scale food producers. Such reorientation must be clearly translated in the research and breeding agenda of national agricultural research systems (NARS), regional research networks and the international agricultural research centers (IARCs) being recommitted towards fulfilling their mandates to promote agricultural development in developing countries and support poor farmers that comprise the bulk of the rural population. Research programs must be geared towards low-external inputs sustainable agriculture, diversified and integrated farming systems, and other production systems that build on local and traditional knowledge systems and sustainably harness locally available resources. Lessons and experiences in participatory plant breeding, ecological pest management, farmer-to-farmer knowledge exchange, and models of formal-informal knowledge system integration should inspire policy makers to adopt and integrate such models in their agricultural development program, taking into account the specific needs and realities of farming communities.

Agricultural research must be democratized through the active participation of farming communities in all stages of the research process, from shaping the research agenda and identifying research priorities, to conducting research and development efforts, and formulating appropriate agricultural programs resulting from participatory researches. Governments must commit to institute mechanisms to ensure that the priorities, programs and outputs of participatory research processes are adopted and implemented.

Agricultural research must be guided by farming systems approach covering all aspects of farming from production to processing and marketing, from breeding to post-harvest, with farmers as active participants and researchers at local level. Mechanisms must be instituted to ensure accountability of researchers and research institutions to farming communities. To ensure that research and breeding programs are more responsive to the realities of small-scale farmers and the challenges of climate change, in-situ and on-farm conservation must be adopted as the primary strategy, with ex-situ conservation as a complementary approach. Breeding agenda that has the needs of small-scale food producers at the center must be complemented by incentives for the use and adoption of local and traditional varieties.

Stop landgrabbing

The selling, renting and leasing out of land to multinational companies and foreign governments for agricultural production must be stopped immediately. The fast land grabbing now going on in developing countries is pushing people off land they use for their survival, undermines the local and national food security and promotes unsustainable production models and practices. Most of the land which is now leased out or sold is used by pastoralists, gatherers and small scale farmers or set aside for the next generations. Governments and policy makers must immediately stop the expropriation of lands, natural wealth and territories from local communities through land grabs, economic concessions, plantations, industrial agriculture, aquaculture and all other means.

Available land should rather be subject of agrarian reforms which could give land to rural landless people and small scale farmers than be given away to multinational companies. Gender equity must be at the heart of genuine agrarian reforms. Reforms should guarantee women full equality of opportunities and rights to land and natural wealth, and redress historical and ongoing discrimination. Governments, policy makers and society must recognise and respond to the rights and particular needs of female food producers.

All human rights must be respected when leasing and renting out of land for large scale farming is considered. There must be full transparency and disclosure in foreign direct investments in land so the local population and other civil society actors are given the possibility to influence the process.

Re-direct funding for climate change to support small scale farmer solutions

Farmers and pastoralists are directly and hard hit now by climate change and their situation will be dramatically worse with further climate change. Climate change is threatening future global and local food security.



The highly unequal relationship that is magnified in the context of climate change has brought to the fore the call for the repayment of the climate debts owed by industrialised countries to developing nations. Climate debt is based on the reality that industrialised countries have long used up their fair share in the world's available carbon space and have already usurped the carbon space that developing and least developed countries are entitled to. Repayment of climate debts should come in the form of allocating a significant proportion (at least 1%) of the annual GDP of industrialised countries to pay for the costs of adaptation in countries in the South.

Small scale farmers and local communities are developing coping strategies and farming systems to cope with and adapt to changing conditions. Ecological farming represent also one of the most efficient and best possibilities for carbon capturing and storage. It can play a major role in stopping climate change. A funding window must be established under the UNFCCC to support small-scale food production and provision as a means to reduce greenhouse gas emissions. The food and agriculture sectors should be excluded from carbon offsetting schemes, flexibility mechanisms and the carbon market. Putting the world's food supplies at risk in such highly speculative and unreliable schemes is unacceptable.

Stop the extinction of fish stocks

Over exploitation of fish stocks and extinction of species threaten future food provision for a growing population, and must be stopped. Industrial fishing must be regulated more strongly and governments should prioritize artisanal fisheries.

It must be ensured that foreign fleets and large-scale fishing boats do not have access to fishing grounds upon which small-scale local fisheries depend, whether through fisheries agreements or through private licensing, and that the fishing vessels are prohibited from using non-selective and otherwise destructive fishing gear.

Stop gambling with the future

Humankind cannot allow some governments, scientists or companies to gamble with the very existence of life on earth.

Genetically modified plants and animals in agriculture and livestock production and genetically modified and exotic species in aquaculture should be rejected. Research and funding for genetically modified plants, trees, fish and animals in agriculture, livestock, fisheries and aquaculture must be redirected. Gene modified seeds that include technologies that prevent germination – terminator technology –; Genetic Use Restriction Technologies (GURTS) might create tremendous and irreversible environmental problems. The de facto moratorium, agreed by the Parties to the Convention on Biological Diversity, on the release and commercial sale of Genetic Use Restriction Technologies (GURTS), known as “terminator seeds”, must be upheld.

Geoengineering: Real-world experiments and deployment of geo-engineering, such as ocean fertilization, restructuring of clouds and blocking of solar rays through stratospheric barriers must be stopped and forbidden.

Nanotechnology can bring benefits for societies, but can also be used to create extreme control over societies and power by very few, and to make tremendous and irreversible damage on human beings and nature. Governments and international institutions must therefore immediately put in place regulatory bodies and control mechanisms for nanotechnologies.

Synthetic biology: Scientists are now able to create totally new life forms. The first-ever synthetic, self-reproducing microorganism – “Synthia” – has now been created. The worst science fiction scenarios might look like nice fairytales if such technologies are not regulated and controlled by democratic multilateral institutions. No products of synthetic biology should be released into the environment. Governments and multilateral institutions must immediately put in place regulatory bodies and control mechanisms to govern experiments on synthetic biology.



Support and implement food sovereignty

Food sovereignty has been developed and being promoted by the social movements, especially small scale food producers and -providers. It puts those who produce, distribute and need wholesome, local food at the heart of food, agricultural livestock and fisheries systems and policies, rather than the demands of markets and corporations that reduce food to international tradeable commodities and components. Food sovereignty prioritises local and national economies and markets and empowers peasant and family farmer-driven agriculture, artisanal - fishing, pastoralist-led grazing, and food production, distribution and consumption based on environmental, social and economic sustainability. It offers a strategy for viable livelihoods and sustainable food systems and to resist and dismantle the current corporate trade and food regime. Food sovereignty promotes transparent trade that guarantees just incomes to all peoples as well as the rights of consumers to control their food and nutrition. It ensures that the rights to use and manage lands, territories, waters, seeds, livestock and biodiversity are in the hands of those of us who produce food.

Governments, institutions and organisations should build their food and agricultural policies on food sovereignty and implement it.

Longer term actions

Develop strategies and plans for solving the most important and pressing problems for humanity and the environment

Based on their political support for small scale diversified and ecological food production and for food sovereignty, governments, institutions and organisations should develop strategies and concrete plans for how they are going to put this (including the points below) into practice. Such strategies and plans must be worked out in close collaboration with the small-scale food producers and be based on their needs. The knowledge of women, their crucial role in food production and their special needs must be recognized. Policies and programs must be designed to meet the needs of women and to support their role in decision-making bodies and processes.

The youth represent the future, but most rural youth do not see their future in agriculture and other kind of food provision. It is therefore of great importance that governments creates conditions which make youth wanting to be working as farmers, fisherfolks, pastoralists and other kind of food producers. Institutions and organisations should also pay special attention to the needs of youth.

There should be full transparency in the policy- and planning processes, and open also for other actors to come with their inputs and viewpoints. Governments and institutions should regularly present progress-reports of the implementation and plans for how they will follow up so they can be held accountable by parliaments, civil society and others.

Preserve and increase agricultural biodiversity, restore soil fertility, retain the water and protect ecosystem health

All healthy food and agricultural systems are dependent upon the protection of the natural world, with all its biodiversity intact. This protection must be a priority for all governments and communities and all rules should be aligned with this purpose. Governments, institutions and organisations must support the conservation of endangered genetic diversity, primarily *in situ* but also *ex situ*, with the permission and guidance of peasants. There is a need to for a global effort to improve and restore soil fertility. Healthy soil, rich in organic matter, can retain huge amount of water, which will be needed to create resilience in farming systems, to deal with climate and water crisis. Increased organic matter in soils will also help to capture substantial amounts of the current excess CO₂ in the atmosphere.

Support should be given to diversified and resilient agricultural systems provide critical ecosystem services (water supply and regulation, habitat for wild plants and animals, genetic diversity, pollination, pest control, climate regulation) as well as adequate food to meet local consumer need. This includes managing extreme rainfall and using inter-cropping to minimize dependency on external inputs like artificial fertilizer, pesticides and blue irrigation water.



Natural control of pest weed and diseases must be strengthened through support of restoration of crop diversity and wild crop relatives, field edges, forest and wetland. This should be combined with biological control including establishment and facilitation of natural predator host plants and insects, enzymes, mites or natural pathogens.

A reward system for actions taken by small-scale farmers to ensure preservation of ecosystems must be developed and implemented. To prevent ecosystems destruction, stronger regulation and effective penalty systems must be developed that deal with such crimes where they occur.

Transform industrialised agriculture, livestock production and fisheries

Stricter and better regulation of industrial farming is needed to stop its negative environmental and social impact. Governments should regulate and eliminate the widespread pollution of soils, watercourses and aquatic ecosystems which has a fundamentally negative effect on their productive and regenerative capacities. Governments must enforce sanctions to reduce the negative social and environmental impacts of industrial food production. The social and environmental costs of destructive production systems should be internalised within the price of products. Governments should remove all subsidies that undermine ecological food provision and take active measures to rebuild the capacity of soils and waters to produce healthy food.

Governments should also put in place programmes to guide and support farmers in transforming industrial types of agriculture to ecological production. Small-scale family farming, pastoralism and artisanal fisheries should again become the cornerstone of food production all over the world. In the process of transforming production, small-scale food providers who are caught in the trap of the dominant industrial production system should be supported to minimise external inputs (fertilisers, pesticides, fossil fuels, etc.) and preserve the natural wealth of agricultural and grazing lands, soil, biodiversity, water, aquatic resources, etc. used in production.

Governments should direct any available subsidies or financial incentives for food and agriculture to ecological food production including support during the transformation process and for capacity building and training, especially for women and young people.

Cut the meat economy and change to healthier diet

Perhaps the most profound and destructive transformation that the industrial food system has brought upon us is in the livestock sector. What used to be an integral and sustainable part of rural livelihoods has become a mega-industrial meat factory system spread around the world, but controlled by a few. It has also contributed to create the obesity problem and destroyed – through subsidies and dumping – local meat production in developing countries. This has to stop. Meat production should be an integrated part of a small-scale farming system and based on each country's own natural resources. Consumption patterns, especially in the rich countries, have to change to less meat consumption, and more fruit, vegetables, roots and cereals.

Governments play a key role in such shifts both in the production and the consumption. Tariffs, taxation, subsidies, support programs etc are essential for the shifts needed, but consumer campaigns etc are also be useful tools. Awareness-raising campaigns on healthy food habits, safe foods and key nutritional issues should be promoted at all levels. Governments should ensure full transparency for consumers on the quality and nutritional values of food.

Ensure a decent income for all peasants and farmers

There is a strong need for developing food price mechanisms and support for farmers and other food producers which provide them an assured income, commensurate with a decent livelihood. Such systems must be based on the work and real needs of the food producers living under very different natural conditions and at the same time be simple, transparent and flexible. Guarantees of minimum prices of the produce is one important element, but not sufficient to secure decent income for those who produce under difficult natural conditions. The income of farmers should reflect the amount of work put in, not



size of land or tons of production. Subsidies and other forms of support systems which now mostly benefit corporations and the larger farms must be reformed, and support systems must be developed to reach all small scale food producers.

Small scale farmers produce the most important products for human being – food, and at the same time preserve and develop biodiversity, natural resources, knowledge and culture, but they are not adequately paid for the economic wealth and other values they generate. In the absence of an assured income, commensurating with a decent livelihood, farmers are being forced to abandon agriculture and migrate to the cities looking for menial jobs, often leading to social unrest.

There is an urgent need to derive a system of reward for actions taken by small-scale farmers to ensure preservation of ecosystems and for the utilisation of their services for the benefit of humanity. These services are limited and must be managed for the overall common good, while not denying immediate “owners” the benefits of taking such actions. A reward system should be constructed as not to be a means or outcome of commodifying nature but recognizing the potential costs of restoring exploited and damaged ecosystems.

Establish new international trade rules

Agriculture is multifunctional, dependent on very different natural conditions and is essential for people's survival. Therefore food cannot be treated like nails when it comes to international trade rules.

International trade rules, in the WTO and under bilateral and regional trade agreements, must be changed to support rather than undermine local small-scale ecological food production for local and national markets. International trade rules for food should only deal with produce that crosses borders. Each country must have the right to decide its levels of self sufficiency, and its ways of protecting and supporting sustainable food production for local and national consumption. All direct and indirect subsidies on export production in the industrial countries must be banned.

Multilateral trade agreements must be subservient to the International Bill of Human Rights and associated rights and environment conventions of the United Nations. In case of conflicts between trade agreements and human rights or environment conventions, the latter should prevail.

Local and national markets should be prioritized over international trade. Regulatory incentives should be used by governments to protect and enhance local production, local markets and consumption. Before allowing entry of global retail food giants the social and economic impacts of oligopolistic retail food markets should be examined, including potential impacts on peasants food production (both rural and urban), the survival of small business in the formal and informal sector, and the nutrition and diets of consumers, especially the poorest.

Develop an index for well-being and sustainability

Governments, international institutions and civil society organisations should work together to develop new indexes which reflect the development of wellbeing for people, societies and nature. Setting the UNDP Human Development Index was a big step forward from only measuring progress and setbacks for societies in economic terms such as gross national income and gross national product. However, new indexes are needed to reflect the holistic situation for people, societies and nature. Some attempts for this are encouraging and interesting, like the *gross national happiness (GNH)* in Bhutan, the work in Bolivia around the *Mother Earth* concept and the discussions linked to the Millennium Ecosystem Assessment and the Green Economy Initiative.

Explore new innovative possibilities for supporting ecological food production

Principles, vision and mission of small-scale agriculture-peasant/family farmers, fisher- folk, and indigenous peoples' movements have been clearly defined and stated in recent international fora³³. New networks, organisations and initiatives are constantly being developed, and new technologies used for

33 One of the most important is Declaration of Nyéléni 2007- Forum for Food Sovereignty. www.neleni.org



sharing information and knowledge. But still there is need for more, new and innovative networks and methods to support and promote ecological food production. How can better links and cooperation be built between small scale farmers and scientists? How can business people contribute? How can modern information and communication technology be used to share experiences and information among small scale farmers? Is it possible and would it be useful to build a broad and strong alliance for ecological food which could counter the multinational companies, alliances and other interests promoting industrialised agriculture? We encourage all who reads this to brainstorm and put up ideas for discussion on new and innovative possibilities for supporting ecological food production.



VI. ANNEXES

ANNEX 1: Projections, visions and initiatives

Angela Hilmi

Models and figures

FAO Expert Meeting: How to feed the world in 2050, June 2009

Global projections were presented at the “Expert Meeting on How to Feed the World in 2050” organised by FAO in June 2009 based on key documents on world food and agriculture to 2030/50 including:

1. *How do climate change and bioenergy alter the long-term outlook for food, agriculture and resource availability?* by Günter Fishcher;
2. *Highlights and views from mid-2009*, by Nikos Alexandratos;
3. *The resource outlook to 2050: By how much do land, water and crop yields need to increase by 2050?*, by Jelle Bruinsma.

Fishcher presented an integrated agro-ecological and socio-economic spatial global assessment of the interlinkages of emerging biofuels developments, food security, and climate change. Its purpose is to quantify the extent to which climate change and expansion of biofuel production may alter the long-term outlook for food, agriculture and resource availability developed by FAO in its “Agriculture Toward 2030/50” assessment. The International Institute for Applied Systems Analysis’ (IIASA’s) modelling framework and models have been developed to analyze spatially the world food and agriculture system and evaluate the impacts and implications of agricultural policies. The modeling framework has recently been extended and adapted to explicitly incorporate the issues of biofuel development. The analysis is based on a state-of-the-art ecological-economic modelling approach. The scenario-based quantified findings of the study rely on a modelling framework which includes as components, the FAO/IIASA agro-ecological zone model (AEZ) and the IIASA world food system model (WFS). The conclusion on the risk of hunger are presented in below.

“Estimates of the number of people at risk of hunger vary greatly according to socioeconomic development trajectories, in particular assumed income levels and income distribution, and population numbers. ... According to this reference projection, the estimated number of undernourished would slowly decrease between 2010 to 2020 (to about 900 million), would fall to 760 million by 2030, to 530 million by 2050, and to some 150 million by 2080.... It is worth noting that in these simulations the recorded climate change impacts on undernourishment are relatively small; in the early periods due to relatively small global yield impacts and small resulting price effects, in the long-term, when yield impacts become substantial, due to the improved socio-economic conditions and small absolute number of undernourished” (Fishcher, 2009).

Alexandratos provided a reality check which revisits current estimates. He tested OECD/FAO projections against (a) actual outcomes, as far as data permitted, in the first eight years of the projection period (to 2008), and (b) against the just completed 10-year projections 2009-2018 of OECD/FAO, both with and without the quantities used as biofuels feedstocks. The conclusion is that on both counts and disregarding biofuels, the study’s projections are still broadly valid at the level of the aggregates considered.

“The advent of biofuels requires a fresh look at the long-term picture. The existing medium-term biofuel production projections and, in some cases, also of the corresponding crop quantities to be used as feedstocks, indicate that further growth is in prospect, though not at the very high rates of the last few years. The quantities of cereals by which, in these projections, world aggregate consumption would be higher because of biofuels would be still relatively modest (7 percent of world consumption in 2018, up from the current 4.8 percent),



much of which will likely come from increased production over and above what it would be without biofuels. However, the potential exists for biofuels to be a major disruptive force conditioning agricultural futures because of the growing integration of the energy and agriculture markets. This is a theme which, together with the possible impact of climate change, must inform all future attempts to speculate about long-term futures of world food and agriculture” (Alexandratos 2009).

Bruinsma provided an indication of the additional demands on natural resources derived from the crop production levels in 2030 and 2050 as foreseen in the FAO 2006 projections. The summary and conclusions consider that agricultural production would need to increase by 70 percent by 2050.

“Growth in agricultural production will continue to slow down as a consequence of the slowdown in population growth and of the fact that an ever increasing share of world population is reaching medium to high levels of food consumption. Nevertheless, agricultural production would still need to increase by 70 percent (nearly 100 percent in developing countries) by 2050 to cope with a 40 percent increase in world population and to raise average food consumption to 3130 kcal per person per day by 2050. This translates into an additional billion tonnes of cereals and 200 million tonnes of meat to be produced annually by 2050 (as compared with production in 2005/07).

Ninety percent (80 percent in developing countries) of the growth in crop production would be a result of higher yields and increased cropping intensity, with the remainder coming from land expansion. Arable land would expand by some 70 million ha (or less than 5 percent), the expansion of land in developing countries by about 120 million ha (or 12 percent) being offset by a decline of some 50 million ha (or 8 percent) in the developed countries. Almost all of the land expansion in developing countries would take place in sub-Saharan Africa and Latin America.

Land equipped for irrigation would expand by some 32 million ha (11 percent) while the harvested irrigated land would expand by 17 percent. All of this increase would be in the developing countries. Mainly (but not only) due to slowly improving water use efficiency, water withdrawals for irrigation would grow at a slower pace but still increase by almost 11 percent (or some 286 cubic km) by 2050.

Crop yields would continue to grow but at a slower rate than in the past. This process of decelerating growth has already been underway for some time. On average, annual growth over the projection period would be about half (0.8 percent) of its historical growth rate (1.7 percent; 0.9 and 2.1 percent for the developing countries). Cereal yield growth would slowdown to 0.7 percent per annum (0.8 percent in developing countries), and average cereal yield would by 2050 reach some 4.3 tonne/ha, up from 3.2 tonne/ha at present. ...

Does this mean that all is well? Certainly not. The conclusion that the world as a whole produces or could produce enough food for all is small consolation to the persons and countries (or regions within countries) that continue to suffer from undernourishment. The projected increases in yields, land and irrigation expansion will not entirely come about spontaneously (i.e. driven by market forces) but require huge public interventions and investments, particularly in agricultural research and in preventing and mitigating environmental damage. In the problem countries, public intervention will continue to be required on the one hand to develop agriculture and to adapt agriculture to local circumstances and on the other hand to establish social safety nets” (Bruinsma, 2009).

Livestock in a changing landscape

“Livestock in a Changing Landscape” is an inter-institutional collaboration between the Food and Agriculture Organization of the United Nations (FAO); International Livestock Research Institute (ILRI); FAO’s Livestock, Environment and Development Initiative (LEAD); the Scientific Committee on Problems of the Environment (SCOPE); the Swiss College of Agriculture (SHL) of the Bern University of Applied Sciences, Switzerland; the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD); and the Woods Institute for the Environment at Stanford University. The goal of this effort has been to achieve an integrated view of the global livestock sector, its drivers, consequences



and responses to issues of concerns, alongside with current practices and possible future scenarios. In order to achieve this overview, many academic, technical, and socioeconomic experts have engaged to consider the multiple dimensions of the livestock industry.

This joint inter-institutional collaboration has culminated in two publications: a technical and scientific volume *Livestock in a Changing Landscape, Volume 1: Drivers, Consequences and Responses* and a case study volume *Livestock in a Changing Landscape, Volume 2: Experiences and Regional Perspectives*.

The following summarises some findings of the report:

The growing worldwide demand for meat is likely to have a significant impact on human health, the environment and the global economy in the next 50 years.

Global meat production has tripled in the past three decades and could double its present level by 2050. The livestock industry is massive and growing.

Among the key findings are:

- More than 1.7 billion animals are used in livestock production worldwide and occupy more than one-fourth of the Earth's land.
- Production of animal feed consumes about one-third of total arable land.
- Livestock production accounts for approximately 40% of the global agricultural gross domestic product.
- The livestock sector, including feed production and transport, is responsible for about 18% of all greenhouse gas emissions worldwide.

Impacts on humanity: although about 1 billion poor people worldwide derive at least some part of their livelihood from domesticated animals, the rapid growth of commercialized industrial livestock has reduced employment opportunities for many. In developing countries, such as India and China, large-scale industrial production has displaced many small, rural producers, who are under additional pressure from health authorities to meet the food safety standards that a globalised marketplace requires.

Beef, poultry, pork and other meat products provide one-third of humanity's protein intake, but the impact on nutrition across the globe is highly variable. Too much animal-based protein is not good for human diets, while too little is a problem for those on a protein-starved diet, as happens in many developing countries. Human health also is affected by pathogens and harmful substances transmitted by livestock.

Environmental impacts: the livestock sector is a major environmental polluter. Much of the world's pastureland has been degraded by grazing or feed production, and many forests have been clear-cut to make way for additional farmland. Feed production also requires intensive use of water, fertilizer, pesticides and fossil fuels. Animal waste is another serious concern. Because only a third of the nutrients fed to animals are absorbed, animal waste is a leading factor in the pollution of land and water resources, as observed in case studies in China, India, the United States and Denmark. Total phosphorous excretions are estimated to be seven to nine times greater than that of humans, with detrimental effects on the environment.

Greenhouse gasses: the beef, pork and poultry industries also emit large amounts of carbon dioxide, methane and other greenhouse gases. Climate-change issues related to livestock remain largely unaddressed. Without a change in current practices, the intensive increases in projected livestock production systems will double the current environmental burden and will contribute to large-scale ecosystem degradation unless appropriate measures are taken.

Solutions: the report concludes with a review of various options for introducing more environmentally and socially sustainable practices to animal production systems.

One solution is for countries to adopt policies that provide incentives for better management practices that focus on land conservation and more efficient water and fertilizer use.



Royal Society – Reaping the Benefits

“Science and the sustainable intensification of global agriculture” – October 2009

In the foreword, Lord Rees of Ludlow OM, President of the Royal Society states that: “... projections for the coming decades are deeply disquieting. We are already unduly dependent on farming techniques that have harmful environmental impacts. To meet the needs of a growing population with changing consumption patterns, productivity must be enhanced, but it must be done so sustainably.

This report describes how the prudent application of recent and prospective biological advances can contribute to the ‘sustainable intensification’ of agriculture. It argues that a multi-pronged approach is needed. Improvements in farming practices and crop management are essential, but modern genetics must be utilised too.

There is a big gap between sophisticated UK laboratories and the reality of subsistence farming in Africa: to eliminate malnourishment requires an adequate economic and political infrastructure as well. But the message of this report is that scientific advances are necessary, even if they are not sufficient, if global food supplies are to be ensured.

Since the first ‘green revolution’ 50 years ago, international research institutes have made hugely valuable contributions to human welfare. UK laboratories have been at the forefront of these efforts. Their mission has never been as important as today, nor has biological knowledge ever offered such great potential. The challenge of learning how to feed the world cannot be left to the private sector: governmental support—increasingly (and gratifyingly) augmented by major charities—is crucial. This authoritative and balanced report offers enlightening reading for all policy makers; its well judged recommendations should be heeded.”

The introduction states: “Food security is one of this century’s key global challenges. By 2050 the world will require increased crop production in order to feed its predicted 9 billion people. This must be done in the face of changing consumption patterns, the impacts of climate change and the growing scarcity of water and land. Production methods will also have to sustain the environment, preserve natural resources and support livelihoods of farmers and rural populations around the world. There is a pressing need for the ‘sustainable intensification’ of global agriculture in which yields are increased without adverse environmental impact and without the cultivation of more land.

Addressing the need to secure a food supply for the whole world requires an urgent international effort with a clear sense of long-term challenges and possibilities. Biological science, especially publicly funded science, must play a vital role in the sustainable intensification of food crop production. ...

Current approaches to maximising production within agricultural systems are unsustainable; new methodologies that utilise all elements of the agricultural system are needed, including better soil management and enhancement and exploitation of populations of beneficial soil microbes. Agronomy, soil science and agroecology—the relevant sciences—have been neglected in recent years.

Past debates about the use of new technologies for agriculture have tended to adopt an either/or approach, emphasising the merits of particular agricultural systems or technological approaches and the downsides of others. This has been seen most obviously with respect to genetically modified (GM) crops, the use of pesticides and the arguments for and against organic modes of production. These debates have failed to acknowledge that there is no technological panacea for the global challenge of sustainable and secure global food production. There will always be trade-offs and local complexities. This report considers both new crop varieties and appropriate agroecological crop and soil management practices and adopts an inclusive approach. No techniques or technologies should be ruled out. Global agriculture demands a diversity of approaches, specific to crops, localities, cultures and other circumstances. Such diversity demands that the breadth of relevant scientific enquiry is equally diverse, and that science needs to be combined with social, economic and political perspectives.”



The 12 recommendations of the report place a strong emphasis on research from groups such as UK research councils, such as the Biotechnology and Biological Sciences Research Council (BBSRC), universities, DFID, and the Consultative Group on International Agricultural Research (CGIAR). This included new mechanisms for international research collaborations with emerging scientific bases such as in China, Brazil, India and South Africa and proposals to strengthen advisory functions on food security (UK Department for Environment, Food and Rural Affairs [DEFRA])), regulation systems for new agricultural processes (UK government with EU partner countries), reviews of patenting that works against poverty alleviation (UK department for Business, Innovation and Skills), joint initiatives between the public sector and industry, linking UK science with developing countries (farmers and extension services), support to long-term, high-risk approaches to high-return targets in genetic improvement of crops, support public sector crop breeding and genomics programmes to understand, preserve and enhance the germplasm of priority crops and train the next generation of plant breeders and support for ecosystem-based approaches.

On-going initiatives

AGRA

Alliance for a Green Revolution in Africa (AGRA) is one of the most important and controversial on-going large-scale programmes in agriculture. The initiative for a new green revolution in Africa came from the Rockefeller Foundation which had played an important role in the first green revolution in Asia in the 1960s and 1970s. In 2006, AGRA was formed through an alliance between the Rockefeller Foundation and the Bill & Melinda Gates Foundation. Since then, AGRA has established partnerships with many UN institutions, research and financial institutions, governments and other organisations.

According to AGRA's webpage (available at www.agra-alliance.org):

"AGRA works to achieve a food secure and prosperous Africa through the promotion of rapid, sustainable agricultural growth based on smallholder farmers. Smallholders--the majority women--produce most of Africa's food, and do so with minimal resources and little government support. AGRA aims to ensure that smallholders have what they need to succeed: good seeds and healthy soils; access to markets, information, financing, storage and transport; and policies that provide them with comprehensive support. Through developing Africa's high-potential breadbasket areas, while also boosting farm productivity across more challenging environments, AGRA works to transform smallholder agriculture into a highly productive, efficient, sustainable and competitive system, and do so while protecting the environment."

Many civil society organisations are strongly opposed to AGRA. Mariam Mayet, Director of African Centre for Biosafety (ACB)³⁴ raised serious concerns about AGRA in an article in Cape Times in 2009:

"A tendency of the Green Revolution is to myopically view food shortages as a shortcoming of food supply rather than a more complex phenomenon requiring a holistic understanding of why people go hungry. ...

The philanthropic money pouring into Africa is used to lay the groundwork for the industrialisation of African agriculture and creation of markets for agribusiness. In turn, this is paving the way for the emergence of a new rural private sector, agro-processors and exporters who contract small farmers to produce crops for them. ...

The imposition of a technology and technological quick-fix solutions to what are inherently social, political, historical and economic crises within African agriculture will drastically transform African rural economies, social relationships, agrarian policies and, generally, the rural development trajectory in Africa. Agricultural production in Africa will increasingly be dominated by transnational seed, GM, agro-chemical and agribusiness. This will accelerate the destruction of traditional agricultural systems and facilitate the shift towards an externally oriented, input-based agricultural system."

³⁴ www.biosafetyafrica.net



The Green New Deal – UN Environmental Programme

The emerging Green New Deal is based on green growth centred on increased energy efficiency and reduced consumption. The core idea is complemented by financial regulations and development aid based on climate adaptation and support to renewable energies. Limited attention is given to account for renewable natural resources.

The Global New Deal is based on the same approach but extends to the whole of the biosphere with major investments in energy and green buildings. Developed countries are advised to spend 1 percent of their gross national product on decarbonisation of the economy, and developing countries are advised to use 1 percent of their gross national product for poverty reduction. The G20 is considered the decision-making international body which should: decarbonise the economy through the creation of a world market on emission rights, introduce ecosystems service payments for the poorest, and guarantee free trade with no perverse subsidies.

A “Global Green New Deal” (GGND) report was produced to encourage governments to make the most of the opportunity provided by the crisis to focus their fiscal stimulus for recovery on policies that create green jobs, reduce carbon dependency and improve the management and sustainable use of ecosystem resources.

.....
“The energy and climate crisis continues to advance. Our demand on the planet’s natural capital has doubled over the last 40 years and today global greenhouse emissions at 42 GtCO₂ (gigatonnes of carbon dioxide equivalent) per annum are five times greater than the Earth can absorb. If current patterns of energy consumption remain unchanged, the International Energy Agency has estimated that by 2030 global energy demand and GHG emissions will increase by 45 percent.

While many factors have contributed to this set of challenges, a common denominator is identifiable: patterns of investment that have failed to deliver on objectives of viable development while adding to human and ecological risks. Unsound financial investments lie at the root of the financial and economic crisis from which some, but not all, countries have emerged. Unsound investments in how we meet our growing population’s need for energy are the core of the climate crisis.

As governments around the world devise policy responses, there are fundamental lessons to be learned about our investment strategy of the past. Falling world trade, rising prices, massive losses of jobs, ecosystem degradation and collapse, widespread concern over delivering action on climate change, and public resentment of the excesses of “casino capitalism” have sent a wake up call that it is time for a fresh way of thinking.

UNEP launched the Green Economy Initiative (GEI) in October 2008 to put forward strong and convincing evidence that would support a global plan for a transition to a green economy- one that is dominated by investment in and consumption of environmentally enhancing goods and services. GEI will consider the economic returns, income generation, job creation, and poverty reduction that can be achieved by investing in a new generation of assets including clean and efficient technology, renewable energy, ecosystems and biodiversity-based product and services, chemicals and waste management, and the construction or retrofitting of “green cities” with ecologically-friendly buildings.”

The Green Economy Initiative- UNEP.
.....



The High-Level Task Force

The Comprehensive Framework for Action (CFA)³⁵ developed by the High-Level Task Force on the Global Food Security Crisis (HLTF)³⁶ in 2008, is the new base for both immediate actions and long term policies and actions. All UN institutions and the Task Force's other members (see the list in next paragraph). Also many other institutions and governments use the CFA as a guiding document for their policies and actions.

4. "The dramatic rise of global food prices and the crisis it triggered led the United Nations (UN) Chief Executives Board in April 2008 to establish a High-Level Task Force (HLTF) on the Global Food Security Crisis. Under the leadership of the UN Secretary-General, the Task Force brings together the Heads of the UN specialized agencies, funds and programmes, as well as relevant parts of the UN Secretariat, the World Bank, the International Monetary Fund, the Organization for Economic Cooperation and Development and the World Trade Organization. The primary aim of the Task Force is to promote a comprehensive and unified response to the challenge of achieving global food security, including by facilitating the creation of a prioritized plan of action and coordinating its implementation. ...
5. *In July 2008, the Task Force responded to the request for a plan of action and produced the Comprehensive Framework for Action (CFA). The CFA is a framework that sets out the joint position of HLTF members, and aims to be a catalyst for action by providing governments, international and regional organisations, and civil society groups with a menu of policies and actions from which to draw appropriate responses...*³⁷
6. The general response to the Comprehensive Framework for Action (CFA) from social movements and other civil society organisations (CSOs) was that the document promoted a mix of contradictory policies and actions. The CSO document *Policies and actions to eradicate hunger and malnutrition*³⁸ states the following about the CFA:
7. *"The Comprehensive Framework for Action (CFA) developed by the UN High-Level Task Force on the Global Food Security Crisis promotes some positive policies such as giving increased importance and support to smallholder agriculture and sustainable food production systems, and to a paradigm shift in urban planning. However, at the same time the CFA also promotes policies and actions that will increase hunger, malnutrition and poverty, exacerbate climate change, and undermine biodiversity and soil fertility. These include further trade liberalisation, unsustainable, chemical-intensive agriculture and increased power to corporations and the World Bank. The CFA thus cannot be the foundational document for policies and actions to ensure adequate food for all."*³⁹
8. In May 2010, the HLTF in cooperation with Irish Aid and Concern worldwide organized a consultation with CSOs, governments and institutions to provide inputs to the revision of the CFA.⁴⁰ Based on the inputs and internal discussions, the HLTF will publish a revised version of the CFA (in preparation).

35 [www.un.org/issues/food/taskforce/Documentation/CFA Web.pdf](http://www.un.org/issues/food/taskforce/Documentation/CFA%20Web.pdf)

36 www.un.org/issues/food/taskforce/background.shtml

37 www.un.org/issues/food/taskforce/background.shtml

38 In 2009 many social movements, NGO's and individuals from all over the world developed a working document called Policies and actions to eradicate hunger and malnutrition (www.eradicatehunger.org) with policy recommendations on a wide range of areas. About 250 organisations have signed on to the main conclusions of the document.

39 Policies and actions to eradicate hunger and malnutrition (www.eradicatehunger.org), page 11

40 Documents and information available at <http://un-foodsecurity.org/node/510> and www.concern.net/update/cfa



ANNEX 2: The Rights of Mother Earth

The Rights of Mother Earth, a concept developed by the government and civil society organisations in Bolivia, has been promoted especially in the negotiations and discussions linked to climate change. In April 2010, tens of thousands of people from all over the world gathered in Bolivia for the World Peoples Conference on Climate Change and Rights of Mother Earth. Seventeen working groups worked on different issues and came up with their proposals and recommendations. One of them found that the United Nations should adopt a universal declaration of Mother Earth, and the working group proposed a text for the declaration. The preamble outlines the direction:

“We, the peoples and nations of Earth:

- considering that we are all part of Mother Earth, an indivisible, living community of interrelated and interdependent beings with a common destiny;
- gratefully acknowledging that Mother Earth is the source of life, nourishment and learning and provides everything we need to live well;
- recognizing that the capitalist system and all forms of depredation, exploitation, abuse and contamination have caused great destruction, degradation and disruption of Mother Earth, putting life as we know it today at risk through phenomena such as climate change;
- convinced that in an interdependent living community it is not possible to recognize the rights of only human beings without causing an imbalance within Mother Earth;
- affirming that to guarantee human rights it is necessary to recognize and defend the rights of Mother Earth and all beings in her and that there are existing cultures, practices and laws that do so;
- conscious of the urgency of taking decisive, collective action to transform structures and systems that cause climate change and other threats to Mother Earth;
- proclaim this Universal Declaration of the Rights of Mother Earth, and call on the General Assembly of the United Nation to adopt it, as a common standard of achievement for all peoples and all nations of the world, and to the end that every individual and institution takes responsibility for promoting through teaching, education, and consciousness raising, respect for the rights recognized in this Declaration and ensure through prompt and progressive measures and mechanisms, national and international, their universal and effective recognition and observance among all peoples and States in the world.” (Mother Earth, 2010).



ANNEX 3: Answering the five questions

Angela Hilmi

This report tries to give answers to the following questions

What kind of food production can

- drastically reduce poverty,
- reduce climate change and cool the planet,
- restore biodiversity, soil fertility and water resources,
- improve livelihoods and provide employment for billions of peoples,
- produce enough, good and nutritious food for 9 billion people or more?

Drastically reduce poverty

The main drivers of the agrarian crisis which have plunged millions of farmers into poverty can be summarised as follows: the industrial revolution which gave birth to industrial agriculture (based on mechanisation, high yield plants and animals, synthetic fertilizers, concentrated feed for livestock, chemical inputs) highly subsidized and supported by governments, increased exponentially the global volumes of crops/animal products available and resulted in a dramatic fall in prices.⁴¹

Farmers who were no longer able to invest saw their income collapse and had to abandon farming as a remunerative activity. The same happened with small farmers around the world. With the dumping of cheap food in local markets, they could no longer sell their own produce and get the indispensable cash to renew basic implements and to cover basic household needs. They were forced to sell ever more of their harvest, for an ever decreasing price with the direct consequence of no longer being able to keep enough food to feed their own families. The abysmal gap in labour productivity which created surpluses of cereals worldwide (dumped through different means in developing countries), blocked any possibility for small farmers to get a decent income as a fruit of their labour.

Public policies did not consider the need to support small farming as the key to healthy and diverse foods, employment, and the source of landscapes and vivid economies in rural communities. Small and medium farmers were not supported in their development, and found themselves in an impasse. The way out is for public policies to rebuild the safety nets of fixed minimum prices for basic crops in order to counterbalance the volatility of global prices, and, the most innovative and modern breakthrough any government could propose, to provide a fixed income for farmers, in addition to appropriate welfare measures (included in the recommendations of this report).

If nothing is done, it is no mystery that increasing waves of millions of small farmers will migrate to urban areas with serious consequences for the world future's peace and stability. In India alone, the number of people estimated to migrate from rural to urban India by the year 2015 will be equal to twice the combined population of UK, France and Germany. These 400 million displaced will constitute the new class of migrants - agricultural refugees⁴².

Accepting and leaving "business as usual" is the best way to create poverty, big poverty. Today, the Multidimensional Poverty Index, or MPI, the new measure of poverty which supplants the Human Poverty Index in the annual Human Development Reports of UNDP since 1997, tells us that in the

41 The gap in labour productivity, or to simplify, the difference between small and large farmer, which was from 1 to 10 during the interwar period, increased to 1 to 2000 at the end of the XXth century: one farmer could produce 10 tonnes of cereals per ha on a 200 ha surface in one year, which is 2000 times more than what a farmer with manual tools can produce (with manual tools, one farmer can produce one tonne of cereal on one hectare in one year). Thus the difference between least equipped and most equipped farmer was multiplied by 2000 instead of by 10 a few decades earlier.

42 Stated by Ismail Serageldin, former vice-president of the World Bank and former chairman of the Consultative Group on International Agricultural Research (CGIAR).



104 countries covered⁴³ (78 per cent of the world total), about 1.7 billion people – a third of their entire population - live in multidimensional poverty, according to the MPI. This exceeds the 1.3 billion people, in those same countries, estimated to live on USD 1.25 a day or less, the more commonly accepted measure of ‘extreme’ poverty. Half of the world’s poor as measured by the MPI live in South Asia⁴⁴ and one quarter in Africa⁴⁵. There are more MPI poor people in eight Indian states alone than in the 26 poorest African countries combined.

A closer look at the five linked components of poverty recognized by The Millennium Ecosystem Assessment (MA)⁴⁶ provides some of the answers as to the role of small-scale farming on the reduction of poverty. These five components are the following: the necessary material for a good life, health, good social relations, security, and freedom and choice.

Sustainable small and medium-scale food production influences these five components positively when practiced in a conducive environment. Small-scale food production is hard work, knowledge-rich, and the most labour intensive sector of the economy, able to provide labour to millions of people while at the same time fulfilling their basic food and shelter needs. When given access to the basic means of production (land, through common or private property, basic implements, seeds etc.), small farmers transform free energy (sun, rainwater) into food and develop vivid local economies while maintaining and nurturing a diversity of local cultures. The use of non-renewable resources, such as fuel, is limited or nil, and food can be produced without external chemical inputs, as agroecology and thousands of years of traditional agriculture have demonstrated. The food is consumed locally, the seeds and other foods are bought or exchanged in local neighbouring markets, which means that there is no, or limited, fossil fuel spent in machinery or transport of goods.

In contrast, the high fossil fuel energy model in which industrial agriculture is grounded, depletes finite, non-renewable natural resources, drastically reduces labour and creates vast lands of polluted monocultures, also called “dead zones”, based on hired imported labour, with no space for rural communities, as ownership is normally distant, the concept of family farm becomes irrelevant, and the incomes from labour are spent in distant cities and countries.

Still, where small and medium scale food production takes place, there is a patchwork of landscapes and rural life. The places where small-scale producers have lived for generations are filled with history, culture, beliefs, cosmovisions, traditions, diverse foods and recipes originating from parents and grandparents and transformed over time, base of diverse and healthy diets, and of knowledge on local plants and medicines. This also reduces poverty because it brings a sense of belonging, of connection to a place, a landscape, a line of ancestors, a connection to the Earth. It gives the possibility to plan for a future. It gives a range of choices to draw from. It also allows for generations to work together, to transfer knowledge, and for the youth to take over.

Poverty has also been defined as the impossibility to look ahead, to plan for a future. Small-scale farming is embedded in a wider dimension of time. This is why also small peasants and indigenous peoples are the best custodians of natural resources. Because of this projection in time, where natural resources and ecosystems being the condition for life, the Earth is respected and nurtured; knowledge is transferred through generations, communities are permanently innovating and creating new forms of adapting and using resources in a viable form, with a very long projection in the future.

These are some of the reasons why despite being ignored, marginalised, undervalued and encumbered, even hijacked or enslaved, small-farmers have resisted for millennia and still exist today when in pure economical logic they should have disappeared since long. Small-scale food production is a buffer

43 with a combined population of 5.2 billion.

44 51 per cent or 844 million people

45 28 per cent or 458 million

46 The MA has involved the work of more than 1,360 experts worldwide. In March 30, 2005 it released the results of its first four-year study of the use and depredation of a variety of the planet’s natural resources.



against risk and adversity, it is a way to survive and provide for livelihoods which is energy-cheap and beneficial for societies and which allows, when basic access to resources and to decision-making is given, to produce food and landscapes in a healthy environment not only for rural communities but for urban ones as well.

Reduce climate change and cool the planet

The challenge of addressing climate change has given rise to many alternative strategies that are often presented as - or assumed to be - equivalent. However, there are clear and important differences between fossil fuel emission reductions, carbon sequestration, and avoided biotic emissions (reductions in forest clearance, for example, – where biotic carbon, as opposed to fossil carbon, remains undisturbed). And this means that the different models of food production have a very different impact on green house gas (GHG) emissions and a very different ability and flexibility to be able to contribute to cooling the planet.

Biotic carbon emissions occur in addition to fossil fuel emissions, further aggravating the challenge of reversing climate change. Land-use change stimulated by the expansion of industrial agriculture is the most significant source, contributing more than 15 percent of global greenhouse gas emissions. Biotic emissions differ from fossil fuel emissions, as they can open up equivalent opportunities for sequestration in the future (for example, as soils degrade they emit greenhouse gases, but as they are rebuilt they draw in carbon in from the atmosphere; similarly, replanting cleared forests rapidly takes up carbon from the atmosphere). No such option exists for fossil fuel emissions.

Industrial agriculture consumes large amounts of fossil fuel, with a direct greenhouse effect, mainly because of mechanisation and massive use of inputs, in particular fertilizers (the production of synthetic nitrogen is a high consumer of fossil energy). To this we need to add the large amounts of fossil fuel used in the corporate chain of which industrial agriculture is a part. This includes transport of goods to the farms (seeds, chemical inputs, implements), and then from the farm to distant markets (grain transported for further processing for animal food, for biofuel or for human food, and transport of processed goods to wholesale distribution channels. On average the food we have in our plate has travelled 6,400 km. In the case of sustainable small-scale production, there is practically no use of fossil fuel when the food is processed and consumed locally. On the other hand, small farms have a great potential for carbon sequestration.

There are three different contributions agriculture can make:

- There are reductions in fossil fuel usage that can be made (for example, in transport and fertilizer production).
- There is also significant potential to slow the release of biotic carbon and address methane emission from livestock and rice cultivation.
- There is also vast sequestration potential, in particular in soils.

But the latter two approaches will only buy time to achieve rapid and drastic reductions in fossil fuel use throughout the global economy.

In these three categories, GRAIN (2009) has calculated that:

- by distributing food mainly through local markets instead of transnational food chains, total GHG emissions can be reduced by 10-12 percent;
- by decentralising livestock farming and integrating it with crop production, total GHG emissions can be reduced by 5-9 percent;
- by stopping land clearing and deforestation for plantations, total GHG emissions can be reduced by 15-18 percent;
- by using agroecological practices to rebuild the organic matter in soils lost from industrial agriculture, sequestration equivalent to 20-35 percent of current GHG emissions can be achieved.



Clearly, there is significant potential for agriculture to reduce fossil carbon emissions, and to undertake sequestration of atmospheric carbon. GRAIN notes that the expansion of the industrial food system is the leading cause of climate change. Through its reliance on fossil fuels, massive exports, market concentration, erosion of soils and expansion of plantations, it generates 44-57 percent of the total global GHG emissions. The most devastating consequence of this industrial food system is that it is destroying other food systems that can turn climate change around and provide for the world's food needs.

Climate change adaptation

The compartmentalisation of institutions and disciplines disguises the fact that measures to reduce emissions, capture carbon and support adaptation to climate change can be combined. But the reality is that some agricultural systems - too often the unknown, unnoticed and marginalised systems - do exactly this. Concrete examples can be seen in traditional forms of agriculture and in the infinitely diverse sustainable forms of production. These systems are being developed around the globe, focussing on cultural practices that have the potential to reduce emissions and increase carbon capture by soil and vegetation, while at the same time adapting to transformations of the climate.

Building soil quality is a prime example of the inter-linkages between adaptation and mitigation in agriculture. Long term scientific studies have established the importance of soil quality to resilience, demonstrating that higher levels of soil organic matter - the non-living decomposed and partially decomposed plant and animal tissues that are found in soils - conserve the soil itself and, critically, water resources within the soil. However, soil composition is not static. Soil organic matter and the biodiversity of organisms within the soil in agro-ecosystems vary, meaning that the approach to agriculture is critical in maintaining or diminishing the productivity and resilience of the agroecosystem.

A side by side comparison of organic and industrialized farms that has run continuously since 1948 demonstrates the impact of farming practice. It found that organic methods, in which crop rotations, manuring, organic fertilizers and biological pest controls are employed in place of chemical inputs, reduce soil erosion and maintain productivity over the long term. The study found that the organically farmed soils had 'significantly higher levels of organic carbon' concluding that organic farmers 'can, and generally do, achieve higher organic matter levels in their soils than do industrialized farmers'. A similar study, based on a 22 year continuous field scale trial, found that 'high levels of soil organic matter helped conserve soil and water resources and proved beneficial during drought years with significantly higher yields resulting from organically farmed soils during the most severe drought.

Sustainable forms of agriculture encourage and require farmers, fishers and herders to be responsive to their environment, engendering flexibility and experimentation in breeding and management practices. It is this ability to experiment and innovate in order to maximise the productive capacity of the available resources that underpins the adaptive capacity of farmers. Methods for coping with harsh environments exist within different communities, and tend to be 'knowledge-intensive rather than input-intensive', creatively applying agroecological principles to a particular context.

Clearly, the combination of creativity, innovation and experimentation inherent in small-scale sustainable agroecological methods as employed by farmers, fishers and herders worldwide is a precondition to adaptation to changing conditions. In the case of industrial agriculture, the innovative and creative process has been taken away from farmers by large corporations, transforming farming into a repetitive and boring endeavour. It is only in small and medium-scale sustainable farming that it is possible to reduce the emission of GHG by reducing or eliminating the use of fossil fuel, to increase the sequestration of GHG in particular by soils, and also to adapt to future climate variabilities through constant innovation, experimentation- in short through coevolution- at farmers field level. Large industrial farms do not have this capacity because their existence depends on the heavy use of fossil fuel, and they totally lack the capacity to adapt and innovate.



Restore biodiversity, soil fertility and water resources

Biodiversity

Regarding agricultural biodiversity, industrial agriculture has, over the years, been substituting traditional crop varieties by high yield commercial uniform varieties thus losing diversity and thereby losing options to cope and adapt to changing environments. The State of the World on Plant Genetic Resources for Food and Agriculture (FAO 1997) gives examples of the loss of diversity which occurred in a few decades: out of the 7,098 apple varieties that were documented in the US at the beginning of 20th century, 96 percent have been lost. Similarly 95 percent of the cabbage; 91 percent of the field maize; 94 percent of the pea and 81 percent of the tomato cannot be found anymore. In Mexico, only 20 percent of the maize varieties reported in 1930 are now known. In the Republic of Korea, only 26 percent of landraces of 14 crops cultivated in home gardens in 1985 were still present in 1993. In China, in 1949, nearly 10,000 wheat varieties were used in production, by the 70s only about 1,000 remain in use.

How does this come about? Out of 30,000 species of edible plants, small farmers have cultivated about 7,000, but it is often stated however that only 30 crops feed the world. These are the crops providing 95 percent of dietary energy (calories) or protein. Half is provided by wheat rice and maize, and then the rest comes essentially from sorghum, millet, potatoes, sweet potatoes, soybean and sugar (cane/beet). Yet many other species that are important to large numbers of people tend to be neglected. Small farmers cultivate and harvest minor crops and underutilized species such as yam, proso millet, fonio ("hungry rice"), bambara, groundnut, oca, taro/cocoyam, canihua, breadfruit, Amaranthus, quinoa, acanyt and buckwheat, as well as vegetables, fruits and other species, including wild plants and "weeds" gathered for food which contribute to nutrition and dietary diversification and trees managed in agroforestry systems.

Wild species are also important, both nutritionally and culturally, to many people. The variation within farmers' varieties, or landraces, is very high. For example, the Arguarana Jivaro community in the Peruvian Amazon grows 61 distinct cultivars of cassava, while some small communities in the Andes grow as many as 178 locally named potato varieties.

The complex use of diversity in farming systems is further illustrated by bean production in Malawi by small-scale farmers, who typically grow a large number of varieties (an average of 12 seed types), some in pure stands, some in mixtures and some interplanted with local or hybrid maize. Each is valued for different reasons. Small farmers attach high importance not only to yield, but also to various other attributes including taste, cooking ability, marketability, early maturity, ability to utilize residual soil moisture, and storability.

Farming systems based on diversity also provide a range of products with multiple uses, including varied food and other products, fuel, medicines, construction material, etc. The use of a wide diversity of crops and crop varieties can also be very important from a nutritional perspective. Traditional vegetables, often grown in gardens, provide valuable minerals, vitamins and amino acids, making a substantial contribution to household food security. The contribution of such plants to alleviating micronutrient deficiencies is greatly underappreciated. In addition, complex farming systems based on diversity tend to support a wider range of animal and fish life which also make a valuable contribution to local diets.

Women farmers are particularly aware of the usefulness of plant genetic diversity as in many parts of the world they are the ones with primary responsibility for the production of subsistence crops that are essential to household food security. Women are often a reservoir of traditional knowledge of cultivation, maintenance and use of traditional varieties.

While improved varieties will usually have a higher potential yield than traditional varieties, such yield potential often cannot be achieved in resource poor environments and may involve risks to people's livelihoods. By using locally adapted farmers' varieties, or mixtures of varieties, farmers are able to spread the risk of crop failure resulting from pest and disease epidemics or adverse environmental effects such as drought. Often, farmers' varieties are well adapted to poor conditions.



The improvements in agricultural production brought about through the use of modern varieties have been possible because of the rich and varied genetic diversity in farmers' landraces, together with material from wild and weedy species. The initial stages of breeding for most crops have been based on locally adapted landraces. Landraces have provided many individual traits which have been introduced into existing improved breeding lines. It should be noted that some genes which once appeared to be of no particular value have since proved crucial in developing new varieties and conferring various resistances.

The main cause of genetic erosion in crops is the replacement of local varieties by improved or exotic varieties and species. The dangers of planting large areas to a genetically uniform crop variety are well known, as these varieties could suddenly become uniformly susceptible to new pathogen races and be wiped out. The most famous example of this is the potato famine of 1845-1848, when a pandemic of late blight (*Phytophthora infestans*) wiped out the potato crop in Europe and North America. In Ireland alone this led to the deaths of 1.5 million people who were wholly dependent on potatoes for their staple diet and did not have the economic or political means to avert catastrophe. Some further examples of vulnerability are outlined as follows:

The genetic uniformity of resistance genes in modern wheat varieties in India was responsible for many severe epidemics of Shoot fly (*Atherigona* spp.) and Karnal bunt (*Tilletia indica*) in the 1970s. In 1972, the winter wheat cultivar "Bezostaya" was grown over 15 million hectares in the Soviet Union. It had been moved beyond its original area of cultivation far into the Ukraine during a succession of mild winters. However it was wiped out in 1972 by a severe winter. In Cuba, during 1979/80, a rust attack on the variety of sugar cane which covered 40 percent of the country resulted in the loss of more than 1 million tonnes of sugar, worth about USD 500 million. Bananas are another example of the costs of genetic uniformity. All five major varieties used for commercial production derive from one original banana variety (Cavendish). All these varieties are highly susceptible to the fungal disease black Sigatoka.

Soil fertility

Soils are home to over one fourth of all living species on earth, and one teaspoon of garden soil may contain thousands of species, millions of individuals, and a hundred metres of fungal networks. Bacterial biomass is particularly impressive and can amount to 1-2 t/ha – which is roughly equivalent to the weight of one or two cows – in a temperate grassland soil.

Most of the species in soil are microorganisms, such as bacteria, fungi and protozoans, which are the chemical engineers of the soil, responsible for the decomposition of plant organic matter into nutrients readily available for plants, animals and humans. Soils also comprise a large variety of small invertebrates, such as nematodes, pot worms, springtails, and mites, which act as predators of plants, other invertebrates or microorganisms, by regulating their dynamics in space and time. Most of these so-called biological regulators are relatively unknown to a wider audience. Earthworms, ants, termites and some small mammals are ecosystem engineers, since they modify or create habitats for smaller soil organisms by building resistant soil aggregates and pores.

The decomposition of soil organic matter by soil organisms releases nutrients in forms usable by plants and other organisms. The residual soil organic matter forms humus, which serves as the main driver of soil quality and fertility. As a result, soil organisms indirectly support the quality and abundance of plant primary production. It should be underlined that soil organic matter as humus can only be produced by the diversity of life that exists in soils – it cannot be man-made. When the soil organic matter recycling and fertility service is impaired, all life on earth is threatened.

Soil biodiversity promotes pest control, either by acting directly on belowground pests, or by acting indirectly on aboveground pests. The majority of human activities result in soil degradation, which impacts the services provided by soil biodiversity. Soil organic matter depletion and soil erosion are influenced by inappropriate agricultural practices, over-grazing, vegetation clearing and forest fires. Inappropriate soil irrigation practices may also lead to soil salinisation. Soil compaction impairs the



engineering action of soil ecosystem engineers, resulting in further compaction. This has dramatic effects on soil organisms, by reducing the habitats available for them, as well as their access to water and oxygen.

The pollution of European soils is mostly a result of industrial activities and of the use of fertilisers and pesticides⁴⁷. Toxic pollutants can destabilise the population dynamics of soil organisms, by affecting their reproduction, growth and survival, especially when they are bio-accumulated. In particular, accumulation of stressing factors is devastating for the stability of soil ecosystem services. Pollutants may also indirectly affect soil services, by contaminating the belowground food supply and modifying the availability of soil organic matter.

Holistic approaches, that investigate the impacts of chemical pollutants on soil ecosystem functioning as a whole are still lacking and only recently started to be covered in ecological risk assessments. However, significant impacts can be expected on nutrient cycling, fertility, water regulation and pest control services. Genetically modified crops may also be considered as a growing source of pollution for soil organisms. Most effects of GMOs are observed by altering the structure of bacterial communities, bacterial genetic transfer, and the efficiency of microbial-mediated processes. GMOs have also been shown to have effects on earthworm physiology.

- One hectare of soil contains the equivalent in weight of one cow of bacteria, two sheep of protozoa, and four rabbits of soil fauna.
- There are typically one billion bacterial cells and about 10,000 different bacterial genomes in one gram of soil.
- Every year, soil organisms process an amount of organic matter equivalent in weight to 25 cars on a surface area as big as a soccer field.
- Only 1 percent of soil microorganism species are known.
- Fungal diversity has been conservatively estimated at 1.5 million species.
- Several soil organisms can help plants to fight against aboveground pests and herbivores.
- The elimination of earthworm populations can reduce the water infiltration rate in soil by up to 93 percent.
- The improper management of soil biodiversity worldwide has been estimated to cause a loss of 1 trillion dollars per year.
- The use of pesticides causes a loss of more than 8 billion dollars per year.
- Soils can help fight climate change.

Water

With respect to water, the following figures give an idea of the importance of management of water resources, closely tied up with a good local governance of resources and the limitation of waste.

- Globally, rainfed agriculture is practised on 80 percent of cultivated land and supplies more than 60 percent of the world's food.
- Agriculture is far the biggest user of water, using almost 70 percent of all withdrawals, and up to 95 percent in developing countries.
- The use of water, primarily in industrial agriculture, exceeds supply rates in many cases and is therefore unsustainable. 15-35 percent of irrigation withdrawals exceed supply rate.
- There is serious concern about the groundwater level in many countries. For example the groundwater level in the North China plain where more than half of China's wheat and one third of the country's maize are produced, is rapidly sinking. Due to over consumption the level of the groundwater basin is forcing well-diggers to go deeper to search for water which is not renewable.

⁴⁷ Chemical fertilizer pollution is the primary cause of 400 coastal "dead zones" that now cover an area of 245,000 km² (the size of UK or Ghana). Oxygen-depleted marine waters have increased by one-third since 1995.



Improve livelihoods and provide employment for billions of peoples

The health implications of industrial agriculture have been widely documented. It is now known that the chemicals commonly used in industrial agriculture (pesticides, insecticides, herbicides, fungicides, and antimicrobials) cause endocrine disruptions and cancer in humans. The excessive use of antibiotics in livestock contributes to resistance among humans. Synthetic growth hormones have also been a major concern for decades as it, in turn, alters normal human hormone levels and functions.

In addition to the chemicals used to grow food, industrial meals have invaded the planet as processing food add months and even years to the shelf life of products, allowing to market globally. Humans have an inherited preference for energy dense food, as natural selection has predisposed us to the taste of sugar and fat. It is the increased energy density of processed foods that is causing Type II diabetes and obesity now affecting 400 million people worldwide and additional 1.6 billion currently overweight. Overall 2.7 million deaths annually are attributable to low fruit and vegetable intake, being the cause of 19 percent of gastrointestinal cancer, 31 percent of ischemic heart disease and 11 percent strokes .

The environmental burdens from industrial agriculture are monoculture production, toxic herbicides, insecticides, and chemical fertilizers which accumulate in the water and pollute water supplies. Massive amounts of faecal waste create toxic chemicals in manure holding pits seeping poisons into the soil and air near water and food sources. This causes streams, rivers, and groundwater to gather pollutants. Foul odours, dust, and small airborne particles are absorbed affecting human health causing asthma and other related diseases.

Another major concern directly attributable to industrial agriculture is the emergence of viral diseases with increasing risks for a devastating pandemic. It is currently estimated that a severe pandemic would cost around 3 trillion USD, apart from health implications and societal disruptions, much worse than a combination of 10 earthquakes, tsunamis, cyclones or the melting of the North Pole taken together.

Shifting towards more sustainable practices in agriculture can help depollute the environment, decontaminate landscapes make them a better place to live with better soil, water and air. The landscapes can thus also become a recreational space for people living in towns. Small and medium size farms that sell their produce in local markets gives the opportunity for people to bridge the gap between consumer and producer and understand better where their foods come from. Locally sold fresh products also are the basis for healthy diets. Green recreational landscapes are also a means to improve the quality of life. Research on Green exercise (Pretty and Barton, 2010), an activity in the presence of nature, has shown that it leads to positive short and long-term health outcomes.

With respect to livelihoods of small-scale food producers in developing countries, their importance in terms of number and role in feeding the majority has been repeatedly highlighted and the sections above have emphasized the ways in which small farming can contribute to livelihoods and health. It is estimated that there are “1.5 billion small-scale producers on 380 million farms; 800 million more growing urban gardens; 410 million gathering the hidden harvest of our forests and savannas; 190 million pastoralists and well over 100 million peasant fishers. At least 370 million of these are also indigenous peoples. Together these peasants make up almost half the world’s peoples and they grow at least 70 percent of the world’s food. Better than anyone else, they feed the hungry. If we are to eat in 2050 we will need all of them and all of their diversity.”

Small producers-based rural economies do also provide the basis for strong national economic development and play a crucial role as stewards of natural resources. The diversity of farming systems allows preserving cultivated and surrounding uncultivated lands, providing important ecosystem services to the larger society.

Provide employment for millions of people

When we add up the number of smallholder farmers, urban gardeners, livestock keepers, nomadic pastoralists, fishers and forest-keepers around the world we reach the astronomic figure of 3 billion



people, half the population of the planet today. Farming and the web of employment it creates in the rural communities and increasingly around urban agriculture, is more extended and complex than we realize.

As often described, and also touched upon in the National Commission on Small Farms in the US, small farms, are immersed in a large web which in turn is a source of employment. They embody diversity, stewardship of natural resources, equitability through empowerment of communities with farmers relying on local business and services for their needs, they are nurturing places for families and children thereby expanding on family networks and institutions including education and health, they open local market possibilities that connect consumers with nature and with the people growing their food and they represent the vitality of local economies. Another dimension not thought of is that they widen our perception of time. Too often short-term objectives aiming at fast-track solutions are making for a badly planned future with increasingly complex and unmanageable risks to cope with. Small farms are a good place to start extending our very idea of a future. Anyone having taken the time to talk to a farmer will have felt this difference in perception, and in the timescale of planning ahead.

Though the benefits of small/medium farms are recognised, the lack of supporting policies for small farms has meant that farm employment has been drastically reduced in all industrialized countries. For example it accounted for only 1.7 percent of the US employment sector in 1993, down from 6.4 percent three decades earlier. The mass exodus of millions of farmers and farm workers into other sectors of the economy already had taken place by the 1970's, even as farm output continued to surge. The same tendency occurred in the last decades in European countries and in countries which adopted mechanised models of production.

But, in developing countries agriculture remains the principal economic sector with farmers often accounting for more than half of the total population. India for example is the eleventh largest economy in the world by nominal GDP and fourth largest by purchasing power parity. Still, agriculture is the predominant occupation, accounting for about 52 percent of employment.

The question is why policies continue to support this seemingly ineluctable trend of decline of the agricultural sector and of the number of small farms, when no other sector of the economy is able to absorb this segment of the population, and when this sector is so acutely needed for conserving and developing the wealth of Nations.

Labour intensity is the very essence of small-scale production. Small-scale producers are highly productive, not in terms of yields of monocultures, but in terms of total output per unit of area as they will make use of every possible niche in their land both horizontal and vertical by mixing very many different layers of crops and alternating crops growing at different levels, including trees, roots and tubers, legumes and pulses, beans, cereals and often integrating cattle, fish, chicken and pigs. Harvests will be scaled in time and will be diverse, providing the possibility of income returns at different times of the year, and a buffer when one crop harvest fails due to climatic or other shortfalls.

Small farms are also more labour intense because they are embedded in the complexity of nature and mimic ecosystems. Rather than blank repetitive chemical spraying (e.g. by plane for example on banana plantations in Cameroon), of massive amounts of insecticides/pesticides to fight pest invasion, agroecological small farms will use integrated pest management practices which imply being able to observe nature and apply the natural predators at the right time. They will also use far more inputs per unit area than large farms, favouring non-purchased inputs such as manure and compost instead of using agrochemicals in the case of large mechanised farms. And in case of irrigated agriculture, sophisticated irrigation systems, often stemming from immemorial times, are used and managed by the communities with long-tested and thought-of rules based on access and use of common property resources.

Unsustainable models of production that increase the dependency of small farmers towards external inputs (synthetic fertilizers, herbicides, pesticides etc.), making them become dependent on increasingly



tight enclosures (specially seeds.) and creating a greater dependence of farmers on external inputs can lead to increased indebtedness and have tragic consequences⁴⁸.

Produce enough, good and nutritious food for 9 billion people or more

“Feeding people” does not refer to the passive action of handing out food. Eradicating hunger is about much more than making sure food is available and accessible to all. Eradicating hunger begins with preserving and creating viable communities where people have control over their own lives and livelihoods. Then it is about producing food – producing enough food and producing the right food.

Half of the more than one billion people suffering from hunger are small-scale farmers and their families. If they could increase their own production to provide enough healthy food for themselves, it would be the most successful reduction of hunger in human history.

Small-scale farmers produce at least 70 percent of the food consumed in the world today and have a huge potential for increasing this production even more. Large-scale studies show potential production increases from 79 to 132 percent, while small-scale studies have shown the potential for fivefold increases in production.

Hans Herren, co-chair of IAASTD, states very clearly there should be no doubt about the capacity for ecological farmers to feed the world:

“The evidence in support of low input, ecological or “conservation” agriculture is undeniable, from the IAASTD, to the Union of Concerned Scientists to a recent UNCTAD report that states “organic agriculture can be more conducive to food security in Africa than most conventional productive systems, and is more likely to be sustainable in the long term.” And evidence that sustainable, ecologically based agriculture can provide the nutrition and income to the billion plus poor and hungry of today, and the 2 billion newcomers by 2050, is now well proven”.

This premise is usually overlooked in discussions on how to end hunger and feed future generations, even though it has been tirelessly repeated by the small-scale farmers themselves, as well as many NGOs and scientists. The fact that increased support to ecological agriculture can substantially increase food production has to be the principal strategy of any move from unsustainable industrial agriculture to a viable, multifaceted small-scale agriculture that can feed future populations.

The following lists some of the results of studies conducted around the world on the impact of introducing ecological farming in smallholder systems:

- Illustrative scientific research conducted in 57 countries found resource-conserving agriculture could increase the average crop yield by 79 percent (Pretty *et al.*, 2006)
- The average crop yield increase were 116 percent increase for all African projects and 128 percent increase for the projects in East Africa (UNEP-UNCTAD, 2008).
- Overall, the world average organic yields are calculated to be 132 percent more than current food production levels (FAO 2007a).
- Maize yields increased maize between 20 and 50 percent in Brazil by using green manure (Greenpeace 2002).
- Farmers in Nepal increased yields 175 percent by using agroecological management practices (Greenpeace 2002).
- In Tigray, Ethiopia, composted plots had yields three to five times higher than those treated only with chemicals (Greenpeace 2002).

⁴⁸ This has been the case in India where some 200,000 farmers have committed suicide since 1997, and another 40 % are trying to quit agriculture if given a choice (information based on government survey). These suicides have been directly attributed to the Green Revolution.



- Farmers throughout the developing world consistently high yield ratios when they incorporated intensive agroecological techniques, such as crop rotation, cover cropping, agroforestry, addition of organic fertilizers or more efficient water management. (Badgley 2007)

Can industrial agriculture also feed us?

Large-scale industrial agriculture produces only around 30 percent of the food consumed globally, while small-scale food producers produce at least 70 percent. Expansion of industrial food production on a scale necessary for meeting the current demand of the majority world's population, not to mention the extra 2.2 billion who will join the ranks by 2050, would cause enormous environmental and social problems.



ANNEX 4: CASE STUDIES

Ecological agriculture: Experiences from Tigray, Ethiopia

The Tigray Region of Ethiopia is highly degraded, which is posing difficult challenges to farmers. Furthermore, the degraded environment contributes to low agricultural production, which in turn exacerbates rural poverty.

The Institute for Sustainable Development (ISD) in Tigray has since 1996 encouraged farmers to move from chemical fertilizers to manure, and the result in terms of crop production has turned out to be very positive. The project is demonstrating that ecological agricultural practices, such as composting, water and soil harvesting and crop diversification to mirror the diversity of soil conditions can bring benefits to poor farmers, particularly to women-headed families, who mostly are the most vulnerable.

The project is led by farmers, and builds on the local technologies and knowledge of the farming communities. As a result, local communities have been empowered and now develop legally recognized bylaws to govern their land and other natural resources management activities. The government of Ethiopia has adopted the approach used by the project as its main strategy for combating land degradation and for eradicating poverty from Ethiopia, and as a result, the project now include more communities in the Tigray region and in the rest of the country.

The main activities of the project are training and follow-up on compost making and use including monitoring impacts on crop yields, to facilitate water and soil conservation, restricting free grazing and instead feeding animals from cut grass and branches of woody plants, making community ponds, small dams and river diversions to catch and hold water for use in the dry season as well as promoting and encouraging innovator farmers in water harvesting, bee keeping and use of biopesticides based on indigenous knowledge. Through supplying seeds of spices and training in raising fruit and forage tree seedlings for sale to their neighbors, the project is helping women-headed and elderly families. The project also focus on experience sharing through cross visits and support the use of new and easily managed technologies such as treadle pumps.

Farmers, development agents, local administrations and ISD staff identified the following positive effects of the Tigray project:

- Crop yields are as good as, and often better than those obtained using chemical fertilizers.
- Agro-biodiversity is maintained and improved. In the area of Ziban San, the farmers used to grow only two different kinds of crops; durum wheat and teff, but after they started to grow mixed crops by adding maize and faba bean, they made a more complex agricultural system, which was more likely to be resilient to climate change. If the yields from one or two crops fail, they can still generate food and income from the other crops.
- Both biomass and biodiversity increase in the areas protected from free grazing, with many plant and animal species that had disappeared from the local ecosystems returned e.g. Aardvark, which digs up damaging termites. In addition, the improved vegetation cover protects the soil from erosion and provides good bee forage, helping the farmers and their ecosystems become more resilient to climate change.
- Weed are reduced in fields where composts has been applied – weed seeds, pathogens and insect pests are killed by the high temperature in the compost pits, while earthworms and other soil organisms establish well. They also found that weeds that do well in poor nutritious soils, such as wild and striga, are much reduced in soil fertilized with compost.
- Increased moisture retention capacity of a soil – if rain stops early, crops grown on soil treated with compost resist wilting for about two weeks longer compared to fields treated with chemical fertilizer. This is crucial during times of drought, which remains a recurring problem in many parts of Ethiopia, especially along the east.



- Plants grown with compost are more resistant to pests and diseases than crops grown with chemical fertilizer.
- Residual effect of compost – the positive effects of compost can remain for up to four years. The farmers have realized that, in contrast to chemical fertilizers, they do not need to apply compost each year as after adequate amounts of compost have been applied in one year, they can obtain good yields from their crops for the next two or three years without applying compost afresh.
- Farmers have been able to get out of debt from buying chemical fertilizers – the economic returns from making and using compost are positive as farmers have been able to stop buying fertilizers, and at the same time they get even higher yields.
- Food made from grain grown in fields fertilized with compost are said to have a better flavor than foods made from crops grown in fields treated with chemical fertilizers.

Furthermore, each project site has its distinctive features and problems, and the outcomes achieved are also distinctive. However, in general for all project sites, the environment has been rehabilitated, food and feed production greatly improved, tree and grass cover as well as biodiversity returned, and soil protected from erosion. By 2008, the Bureau of Agriculture and Rural Development (BoARD) of Tigray, claimed that soil erosion in the region had been reduced by over 60% since the project started in 1996.

Based on Sue Edwards, Sue; Egziabher, Tewolde Berhan Gebre and Araya, Hailu: Successes and Challenges in Ecological Agriculture: Experiences from Tigray, Ethiopia. FAO 2010d
www.fao.org/docrep/012/al134e/al134e11.pdf



Sustainable agriculture in Cheha, Ethiopia

Challenge: Since the devastating 1984 drought, Ethiopia has remained largely reliant on food aid, undermining farmers' ability to develop economically viable agriculture. Livestock farming has been hit badly too: for instance, in the Cheha region in Southwest Ethiopia, where households once commonly held hundreds of livestock, herds have fallen victim to cattle diseases and parasites. Farmers in the Cheha area have thus bound together to develop sustainable practices to enable the region to feed itself.

Response: Working together to escape the food-aid trap, and economically disempowering food-for-work arrangements, thousands of farmers in the Cheha region have transitioned to sustainable — and highly productive — growing practices, emphasizing new vegetable crop varieties, current and forest trees, use of organic manures to build soil fertility, and non-toxic botanicals for pest-control. Farmers in the program have also focused on replicating their efforts by training others, expanding these new practices into more communities.

Results:

- 12,500 farm households have adopted sustainable agriculture on about 5,000 ha.
- Crop yields have increased by 60 percent.
- With increased crop yields and livestock, area nutrition levels have improved by 70 percent. Local food availability has improved, and since 1985 there has not been another large-scale food shortage in the Cheha area, despite ongoing problems in other parts of Ethiopia.
- Some farmers have begun to produce excess crops which they sell in local markets, earning much needed income for their families.
- Using the new farming methods, such as inter-cropping, micro -irrigation and planting of drought resistant crops, participating farmers are better able to cope with drought and other environmental challenges.
- The bio-diversity of the project area has been enhanced by the introduction of different horticultural crop seeds, forest and fruit tree seedlings.
- The portion of land that is inter-cropped has increased significantly, while mono-cropping has been decreased, since the inception of the Cheha Integrated Rural Development Project; much of this is due to the agroforestry project component.
- The increase in livestock numbers has resulted in increased income for farmers and their families, both through the sale of animal products, and through the sale of additional crops produced.
- Farmers are taking the initiative to replicate activities (including farmers outside the project area), where once they had to be encouraged to participate through food-for-work payments.
- The overall health status of project beneficiaries has improved through the life of the Project, due to a focus on health and nutrition education, and to an emphasis on hygiene and sanitation, and the development of potable water sources throughout target communities.

Project Agency (Gov., NGO): Cheha Integrated Rural Development Project

Sources:

UNCTAD, "Organic Food Security in Africa," 2008. SAFE-World Project
(<http://www.essex.ac.uk/ces/research/susag/SAFEAfrica-Projects/ethiopia/ChehaIRPD.pdf>)



Building farmers' organizations in Ghana

Challenge: In Northern Ghana, subsistence farmers struggle to survive, battling fragile soils that are becoming increasingly infertile, in part from intensification of agriculture. In recent years, farmers have reached a crisis level, unable to obtain credit, and finding themselves increasingly dependent on exorbitantly priced agricultural chemicals. Similarly, a blend of high inflation rates and structural adjustment policies that reduced subsidies left even most basic farming tools out of reach for most growers.⁴⁹

Response: With the aim of stabilizing food production and eliminating costly and toxic petrochemicals, farmers worked with indigenous and international NGOs to integrate sustainable farming with local traditions and knowledge. The project has educated farmers about the health hazards of using unregulated pesticides that have proliferated in Ghana despite being banned in Europe. Participatory farmer trainings have emphasized adopting technologies such as composting, the use of manure, and organic pesticides, as well as managing and conserving community resources such as water, and promoting access to resources and equality for women. Farmer Alima Harundi describes, "I used to apply chemical fertilizer DDT to my vegetables which was not easy to afford and was also harmful to my health. Now I use organic manure in my garden, it is less expensive for me and it is not harmful to my life."

Results:

- Communities have developed 24 farmer organizations to share their practices improving pest management, post-harvest storage, soil and water conservation and agroforestry.
- Farmer Field Schools in 8 communities have provided training to over 200 farmers who in turn pass on their skills to 3,200 neighboring farmers.
- 26 communities and farmers' organizations are supported in promoting organic farming and educating people about the financial, environmental and health costs associated with the misuse of agrochemicals.
- 32 people, aided by African Initiatives have trained and educated farmers to participate in democratic processes. This has improved the implementation of water and soil conservation policies and practices and a reduction in petty corruption has resulted in more government funds getting to farmers.
- In 2006 African Initiatives started training and supporting 12 farmer based organizations in advocacy skills and strategies to strengthen their work. A successful pilot project has introduced sustainable agriculture into adult literacy classes.
- Community leader Zakaria Arango describes an array of community and social benefits: "There has been an increase in the number of trees, zinc roofs, donkeys, carts and bikes. People now have a wide range of knowledge especially things like female genital mutilation and Aids. Here people talk. The Assemblyman has been challenged, even the MP. People are listening to the news more. In family compounds different people support different political parties and discuss them. And there has been no conflict over land, politics or tribe. There is unity."

Project Agency (Gov., NGO): African Initiatives, in partnership with Zuuri Organic Vegetable Farmers' Association (ZOVFA) and the Community Self-Reliance Centre (CSRC).

Sources:

Ghana Sustainable Livelihoods and Women's Rights Programme
(<http://www.african-initiatives.org.uk/projects/ghana.htm>)

⁴⁹ Threatening current progress in sustainable farming, land policies have enabled huge farmland purchases by foreign investors. As one report noted, "Hunger and severe poverty could hit some parts of the Afram Plains area of the Eastern Region owing to a decision by Kwahu traditional authorities to sell large tracts of farmland stretching several miles to a foreign investor." See "Afram Plains Sold to Foreign Investor," Frederick Asiamah, Public Agenda, April 4, 2008. <http://allafrica.com/stories/200804040440.html>.



Environmental Action Team, Kenya

Challenge: In the North Rift and western regions of Kenya, despite generally high rainfall levels, much of the farmland is characterized by soils that are low in fertility. Crop diversity is minimal as well – 95 per cent of cultivated land is covered with maize, usually intercropped with beans. Farmers use late maturing hybrids, which remain in the ground for 89 months. But due to low soil fertility and farmers inability to purchase fertilizers, yields are low – less than two tons/ha for maize and less than 0.1 tons/ha for beans. Pests and diseases (especially root rot and bean fly) further contribute to low bean yields, main source of household protein. This has led to protein mal nutrition amongst poorest households while the area suffers widespread food insecurity – experiencing an average 3.3 months of hunger each year.

Response: With the goals of enhancing household food security by promoting soil health and crop productivity, Environmental Action Team (EAT)⁵⁰, worked with smallholder-farming communities of Trans Nzoia, west Pokot, Lugari, and Bungoma districts in North Rift and western regions of Kenya, to improve crop yields and introduce sustainable farming practices.

Through participatory farmer trainings, including field days, demonstrations, farmer verification trials, farmer follow-ups, and farmer-to-farmer visits, the initiative focused on helping forge collaborative partnerships, providing instruction on soil fertility management, crop diversification, improved crop management, and improved farm planning. More specifically, the following agricultural techniques/practices were promoted:

- Adoption of legumes and green manures: In 1994 EAT started working with legume green manures first on-station and then on-farm. A two-year on-station screening work resulted in the identification of *Mucuna pruriens* and *Lablab purpureus* as the most promising species.⁵¹ Consequent trials focused on identifying the most suitable strategy for relaying the legumes into an existing maize crop. In 1995, on-farm work on legume green manures was initiated on the basis of the following premises:
 - Farmer collaborators were trained to understand the processes and practices associated with biological soil fertility management
 - Farmers' criteria played the key role in guiding the direction of the research
 - The best potential niche for growing a green manure legume is the 4-5 month dry season when the land is idle.
 - In the early phases of the research, testing focused on the potential of green manure to produce maize without adding any other organic or inorganic fertilizer during the crop cycle.

Further research on green manuring work continued in 1997 with both original farmer collaborators and new farmers. Work involved harvesting part of lablab seed vs. leaving all as mulch, and incorporation vs. mulching of the residues. In 1999 more detailed residue management experimentation was conducted on station, examining various management possibilities (mulching/incorporation of legume only, legume and stover, stover only). Other on-station work on green manures included harvesting leaves and seeds vs. leaving them on field, and timing of lablab residue incorporation and subsequent maize planting, and spacing of lablab.

⁵⁰ EAT, an NGO based in Kitale, was led by two researcher-development specialists and staffed by a number of research assistants and extensionists, and worked with area's small-scale farmers on food security and soil fertility management.

⁵¹ Herbaceous legumes, such as *Mucuna* and *lablab*, adopted to cropping systems in sub-Saharan Africa that could be relay-cropped into maize-based cropping systems, provide an alternative to the use of commercial-nitrogen (N) sources for cereal crops and livestock production. For more information see E.M. Nyambati¹ and L.E. Sollenberger. "Nutritive Value of Top-Canopy Herbage of *Mucuna* and *Lablab* Relay Cropped in Maize in the Sub-Humid Highlands of Northwestern Kenya." *Tropical and Subtropical Agroecosystems. An International Multidisciplinary Journal*. Volume 1, No. 2-3, 2003. Universidad Autónoma de Yucatán, México.



- In addition to green manuring, research on station and on farm also focused on other crops and issues. For instance, food legume varieties (i.e., groundnut, cowpeas and pigeon peas) were screened and compared to locally available cultivars; inorganic and organic (i.e., compost) fertilization options were assessed; adoption of composts and farmyard manure, with or without diammonium phosphate fertilizers, *Tithonia* and *Sesbania* was examined; and seed bulking of maize, grain legume, and green manures species was conducted.
- Crop Diversification: The project also promoted crop diversification with emphasis on finger millet, soybean, groundnut, pigeon pea intercropping, and farmers were encouraged to grow different varieties of various species (potato, groundnut, finger millet, and CIAT-developed, root-rot-resistant bean cultivars).
- To improve household nutrition, farmers were also trained in organic vegetable production in raised beds in home gardens.

Results

- More than 1,000 farmers received direct training, and incorporated practices, such as the use of organic manures and crop diversification on their farms.
- Farmers have shared their new techniques with other growers, thus empowering both, and multiplying the benefits far beyond the original trainings.
- Compared with “traditional” agriculture, bean production has improved by 158 percent, to 258 kg/hectare, while maize yields rose by 71 percent, to 3,414 kg/hectare.
- Farmers have sold surplus produce to improve their income, affording them access to healthcare and medicine, as well as school fees for their children.
- Families have been financially empowered and have been able to adopt technological advancements such as mobile telephones, improving communication and market access.
- Unemployment has declined, helping to reduce overall poverty within households.
- As farmers have increased crop diversity, they have seen notable benefits to food and nutrition security, the natural environment, communities, education, and the economy. Crop diversification, for instance has produced more varied diets and villagers have reported improved health.
- Through conservation and the use of organic manures, farmers have reported reduced soil loss and enhanced soil health.
- While EAT has closed its offices, its extension workers have gone on to start community-based groups, for instance, Common Ground, that promote similar agricultural practices.

Project Agency (Gov., NGO): Environmental Action Team

Sources:

UNCTAD, “Organic Food Security in Africa,” 2008. Charles Wasonga, Environmental Action Team, Kenya.

Beth Kirungu, Joseph Mureithi. Land & Soil Quality Improvements. What Technical Innovations are Leading to Improvements in Food Production with SARD? FAO Corporate Document Repository.
<http://www.fao.org/docrep/006/y3951e/y3951e05.htm>

E.M. Nyambati¹ and L.E. Sollenberger. Nutritive Value of Top-Canopy Herbage of *Mucuna* and Lablab Relay Cropped in Maize in the Sub-Humid Highlands of Northwestern Kenya. *Tropical and Subtropical Agroecosystems*. An International Multidisciplinary Journal. Volume 1, No. 2-3, 2003. Universidad Autónoma de Yucatán, México.



Making a difference with soil and water conservation

Participatory agricultural extension in Chivi, Zimbabwe

The Chivi Food Security project was initiated in 1990 by Practical Action Southern Africa (then ITDG) as a response to persistent, localised chronic food insecurity and the acknowledged need to improve the extension system and service provision to subsistence farmers.

The objectives of the Chivi Project were to:

1. Help local farmers' institutions identify their priority needs and strengthen their capacity to enhance food security at household level;
2. Work with local institutions and build on their traditional knowledge to be able to identify and develop technological options for enhancing household food security; and
3. Influence government agricultural policies to be more responsive to the concerns, circumstances and needs of small scale farmers such as communal farmers in Chivi.

The project process involved many activities, including an investigation of community needs, identification of key partner institutions and development of innovative partnerships, design and implementation of community initiatives, participatory reviews and ongoing evaluations of adopted technologies. The project supported and enabled farmers to identify, generate, test and apply new techniques and practices to strengthen their experimental and technology management capacities. Farmers and supporting institutions were facilitated in a critical process of review and experimentation, working with each other to identify technical and nontechnical solutions to improve livelihood options and opportunities, and drawing on indigenous knowledge and expertise. One example was the systematic conservation of local agricultural biodiversity and sharing of seed resources at a series of annual Seed Fairs.

Women with their seeds at the first seed fair in Chivi

Exchange visits to other NGOs, innovative farmers and research centres enabled farmers to investigate alternative practices in soil and water conservation. Demonstration days allowed widespread sharing of the results and also provided the opportunity for modifications to particular technologies to be explored, compared and contrasted. The farmers themselves were the principal creative originators of new ideas and primary systems modifiers and developers with Practical Action stimulating and guiding the farmers and providing a range of choices.

The technologies which were adopted by farmers in Chivi has remained a permanent physical feature; a field visit in July 2007 showed that infiltration pits are still visible and availability of water has significantly improved at certain sites because of rock catchments water harvesting. The livelihoods of farmers who have continued to utilise the water harvesting technology have permanently improved and farmers who were still utilizing the given echnology had experienced less hunger and home gardens were still thriving despite water challenges due to droughts.



Agro-ecology and peasant movement in West Africa

Small food producers are the dedicated and most often anonymous guardians of biodiversity and ecosystems and the gifted creators of many agro-ecological practices. For decades both their knowledge and their needs have been ignored by dominant agricultural policies and programmes. It is when these thousands and thousands of small producers group together into organizations capable of defending their interests that real possibilities of advancing the agroecological agenda emerge, for they represent the majority of the population of most developing countries, particularly in Africa.

Today's peasant movement in West Africa was born in the early '90s in reaction to structural adjustment and the withdrawal of state support for agriculture. From the establishment of the Senegalese National Council for Cooperation of Rural People (CNCR) in 1993 to the formation of a regional network of 10 West African national peasant platforms (ROPPA) in 2000, the construction of the movement has been rapid and its political impact significant, succeeding in enshrining family farming and food sovereignty in agricultural policies at national and regional levels.

From the outset the movement has been attentive to ensuring that West African peasant farming is not only family-based and multifunctional, but also sustainable. Participatory research has been conducted to identify and exchange traditional agroecological practices such as earth dams in Burkina Faso (zai) or compost piles in Senegal (sentaare). Cooperation has been built up between peasant-led and official research in areas like seed development and multiplication. In 1997, an FAO project supported the Senegalese national platform's efforts to develop its own agroecology-based agricultural strategy. A decade later studies demonstrate that 95% of Senegal's farms are family-based. They produce most of the food consumed in the country, employ 50% of the population and contribute to the sustainable management of natural resources even under the pressure of climate change.



Participatory plant breeding in Meso-America

In 1999, a group of Central-American farmers, NGOs and researchers met in Nicaragua to discuss how they could cooperate in order to meet challenges concerning food crops such as beans, maize and sorghums. The main problems they saw was related to pest control, low yields, genetic erosion, and the importance of conserving local varieties by combining traditional and scientific knowledge of agricultural diversity. The Participatory Plant Breeding in Meso-America program (PPBMA) was born.

In brief, the program gives small scale farmers the possibility to sustain and exchange local varieties of seeds, involve in plant breeding and have the control over the rights to their own seeds. Furthermore, the farmers learn to adapt to climate change and improve their livelihood through participatory plant breeding and improved agricultural methods.

The Participatory Plant Breeding in Meso-America (PPBMA) is a regional project spread across Nicaragua, Guatemala, Honduras, Mexico, Costa Rica, El Salvador and Cuba. The program brings together farmers, researchers and NGOs in a collaborative alliance for agro-biodiversity conservation. Farmers and local partners from Central America supported by the Development Fund's biodiversity program have succeeded in conserving biodiversity and providing economic and food security solutions for over 4000 small scale farmers in the region. The farmer's ability to adapt by using and develop a wide variety of genetic resources becomes an important coping mechanism in the region where the climate is changing rapidly.

One of the main results of the program has been to capitalize on farmer's knowledge about how to use traditional biodiversity conserved on their farms. The transition from sowing grains to producing and sowing good quality seeds is another key result. Keeping attributes of colour and taste is part of having a good quality seed. However, the most relevant factor is to have control over the process from its initial stages; provided that farmers have the proper economic incentives and the institutional collaboration required to conduct the research needed, they can recover or reproduce seed in case of a natural disaster.

Traditional knowledge meets technical expertise

Farmers have conserved their traditional varieties as a cultural and food security strategy for many years. Although special attributes such as taste and colour and resistance to pests is the most common reason for farmers to maintain their traditional farming, most farmers agree that low yield represents a challenge in many traditional varieties. In Central America beans are an important source of income and for food security.

When the PPBMA-program started in 2000, all the farmers argued that their main problem was linked to control two main plagues of beans: Mosaico Dorado (MD) and Mosca Blanca (MB). Most of the commercial seed varieties used in 2000 failed to effectively combat these two plagues, and additionally, they lacked the colour favoured by the farmers and the market. The project aims to address these problems by saving the diversity of local seeds and developing and improving seeds that are adapted to the local conditions in cooperation with the local farmer.

The project has shown numerous positive results, such as improved food security due to plants that are less vulnerable to local climate variability and changes, increased knowledge through cooperation between farmers, NGO, academic/scientific sectors and students. Several new plant varieties now contribute to agricultural biodiversity. Furthermore, the yields have been increased by at least 50% for basic grains, and major progress has been done on sorghum and bean varieties. In addition and of major importance, farmers have learned to handle and conserve seeds properly, and are now applying their knowledge from the plant breeding work on other plants as well.

Self-sufficiency and diversity in seeds results in increased flexibility under climate variability and change. The farmers are also being trained in the establishment of relations with governmental, non-governmental and academic organizations as well as cooperatives, markets and youth groups. The local cooperatives are linked with each other, and have formed a national federation. Some of the farmers have



formed a commercializing committee for seeds, credits, education and research, aiming to commercialize improved seeds from the participatory plant breeding work. The cooperatives are also investing in capital goods under collective ownership, for example wet coffee processing plant or chicken farm. The different communities are addressing environmental, social and economic aspects. Women groups make family gardens, and apply organic and agro-ecological practices – with better result.

More information:

The Development Fund (Norway) www.utviklingsfondet.no



Diverse seed production towards sustainable agriculture in Vietnam

The Community Biodiversity Development and Conservation project (CBDC) in the Mekong River Delta southwest in Vietnam in 2006. The purpose of the project was to strengthen the capacity of farmers and local institutions through implementation of activities at community level; diversify seed production towards sustainable agriculture production; involve participation of women in the programme and promote local policies that support farmers' activities, particularly in participatory plant breeding (PPB) of rice.

After three years of implementation in the Mekong River Delta, the project shows good results in terms of farmer households in increasing rice yields, income, improving knowledge and enhancing social relationships at the project site. The figure below shows the improvement in income from rice production for both members of the project and non-members.

Unit: million Viet Nam Dong (VND)/ha

1 million VND = 40 EUR

No	Communities	CBDC			Non-CBDC		
		Before project (A)	After Project (B)	Balance (B-A)	Before project (A)	After project (B)	Balance (B-A)
1	Tan Hoi Dong (TG)	23	59	36	19	39	20
2	Hau My Trinh (TG)	38	59	21	23	39	16
3	Long An (VL)	34	96	62	3	35	32
4	Zuan Hiep (VL)	10	57	47	6	23	17
5	Nhon My (AG)	20	3	13	17	17	0
6	Vinh Trach (AG)	38	46	8	36	43	7
7	Cong Doi (ST)	21	43	33	10	32	22
8	Phu Loc (ST)	15	53	38	15	28	13
9	Lang Giai (BL)	18	36	18	15	20	5
10	Vinh Binh (BL)	17	29	12	8	15	7
	Mean	23	48	28	15	29	14
	In USD/ha	1376	2829	1629	894	1712	918

Fig. 1: Comparison of profit in rice production between, before and after CBDC project

The reports are based on a Community Self Assessment (CSA). Since the beginning of the project, important achievements in capacity building for farmers, as over 10 000 farmers have been involved in training as well as hundreds of technicians from local institutions such as participatory plant breeding (PPB).

Through their work, core-farmers have made hundreds of crosses, selected and released more than 100 stable lines for rice production in which 15 promising varieties has been registered for testing at the national level. The project have considerably changed farmers' perception on access to better seeds and diversified farmers' rice varieties in agricultural production at the project sites. In 2008, the project also resulted in the first approval and certification of a farmer's rice variety in Vietnam, which proves a positive effect in terms of local policies as well.

The survey this article is based on found that there are differences in CBDC farmers and non-CBDC farmers depending of which area they are located. Some areas has a big amount of farmers that are considered



rich (almost 80%), whereas other areas have mostly moderate to fair rich farmers. Furthermore, the differences in the economic situation for the farmers are pure rice production and rice seed production, although the prosperity is not very high due to high price input of materials. As compared to prior to the project, farmer's economy have increased significantly through increasing rice yield and selling rice seeds instead of grains, as figure 1 shows.

Knowledge and skills gained

Through the experience of training, conferences, variety evaluation workshops, demonstration plots and on-farm study organized by the cooperations and CBDC projects, at ten survey sites, 90% of the farmers who participated in the project report that they have gained useful knowledge in different aspects, such as farming techniques, social relationships, management and policy. The Farmers' Field School has enabled farmers to teach their methods to other farmers and thereby increase the knowledge at village level.

Due to the CBDCs relevance to agricultural development, it has been constantly developed and broadened in the Mekong Delta. The farmers have understood more about biodiversity conservation and are now taking part in variety selection and production activities at surveyed sites. Furthermore, the connection between government-scientists and farmers has been strengthened and farmers now have better possibilities to meet local authorities and experts. At the same time, the local authorities have the opportunity to listen to suggestions of farmers in agricultural production sector.

The CBDC project met the farmers' expectations and it is suitable for the local development. Farmers were able to improve their knowledge and to choose and develop seeds for themselves. The experience they have gained has put them in the position to develop the model of diverse cultivation as well as application for technical improvements in production, contributing to increased productivity, food security, ensuring good sources of seed for production and improvement in household economy. Up to 30,8% of the farmers involved could report on less negative environmental impacts by using organic fertilizers and practicing Integrated Pest Management (IPM) to control diseases.

Source: The article is based on Vietnam CSA consolidated report Community self-assessment CBDC-BUCAP Vietnam, May 2009. Contact www.utviklingsfondet.no for more information.



Biodiversity productivity: a case study from Uttarakhand, India

The state of Uttarakhand in the Himalaya has a long heritage of subsistence economy with agriculture as the core component involving over 80% of its population. A majority of the farmers are marginal and possess less than 1.0 ha of agricultural land, in a scattered form. As a supplement to the small and scattered land holdings, livestock is considered as a capital asset, and animal dung bedding material is important as manure for the crops in traditional agriculture.

The project study aimed to validate the premise that biodiversity based agriculture is more remunerative than traditional agriculture. The survey that was carried out in the identified agro-ecological zones indicated that mixed farming was traditionally practiced. The traditional mixed farming systems have higher biodiversity that invariably resulted in higher economic returns and indicated sustainability in the long run. Sustainable farming in all the regions by adoption of mixed farming would insure household food security. Further, it has been observed that in the small and marginal land holding in all agro-ecological zones a variety of crops were cultivated and distributed in temporal and spatial dimension. This distribution was maintained by the farmer by adopting different crop rotations and different crop compositions on a unit of land. As the agriculture in the earlier time depended totally on the local resources and was at the mercy of vagaries of nature, this distribution of crop in terms of crop composition and harvesting was spread as insurance. This temporal and spatial distribution insured that in the event of either drought or flooding in a particular month affected only a part of the total cropping and eliminated the chance of total crop failures thereby securing food security at household level. It was seen that in the case of surplus, the produce was traded in the local market thereby increasing the farm income.

	Mono cropping	Mixed cropping
Field preparation	Rs. 300	Rs. 300
Seeds	Rs. 180	-
Fertilizers	Rs. 200	-
Harvesting	Rs. 400	Rs. 400
Total yield	12 Qt/acre	Mandua= 6 Qt Foxtail millet= 3 Qt French beans= 3Qt Amaranth= 2Qt Total= 14Qt
Market price	Rs 650/Qt	Mandua: Rs. 6.50/kg= Rs. 3900 Foxtail millet: Rs. 12/kg= rs. 3600 French beans:Rs. 20/kg= Rs. 6000 Amaranth: Rs. 15/kg= Rs. 3000
Total income	Rs. 7800	Rs. 16500
Net profit	7800-1080= Rs. 6720	16500-700= Rs. 15800

Fig 1. The table illustrates the difference in income between monocropping and traditional mixed cropping with use of a diversified variety of cereal.

A conclusion from this study is that family farmers in this area regularly achieve higher and more dependable production from their land than large farms practicing monoculture in similar environments. Labour-intensive practices such as manuring, limited tillage, ridging, terracing, composting organic matter and recycling plant products into the productive process enhance soil conservation and fertility.



Furthermore, this represents a powerful argument that using land reform to create a small farm economy is not only good for local economic development, but is also a more effective social policy than allowing business-as-usual to keep driving the poor out of rural areas and into burgeoning cities.

The superior goal of farm production is to reduce the farmer's dependence of the market in terms of food security and nutrition for the household and at community level. In most cases, the farm resources are seen to generate wealth for the overall improvement of rural life – including better housing, education, health services, transportation, local business diversification, and additional more recreational and cultural opportunities. The organically managed biodiverse farms embody a diversity of ownership, cropping systems, landscapes, biological organization, culture and traditions. A varied farm structure contributes to biodiversity, a diverse and aesthetically pleasing rural landscape and open space.

An overview over the system in the area has revealed that the mixed farming as a value-based system has been evolved over centuries through the process of trial and error. Unlike modern agriculture which greatly relies on external inputs of energy resources and disturbs the energy equation which causes many environmental perturbations, the traditional agriculture is low input based, depending solely on the renewable natural resources and is therefore sustainable. Until a few decades back; the agriculture of the region surveyed was self-reliant to a large extent due to the availability of the vast natural base. Yet, because of population pressure, overexploitation of natural resources in the name of economic prosperity and rapid socio-economic changes, agriculture is predictably heading to a disastrous future. The listed indicators above can be observed in terms of declining productivity, loss of crop diversity, land abandonment and degradation, and a large number of young migrates. The researches argue that in this context, redevelopment of agriculture would only be possible if the techniques built over inherited and empirical knowledge of the local people are generated and employed particularly to strengthen the traditional land use system, water harvesting and value addition of the agriculture produce.

Source:

This article is based on case study 4 in the report “A new Paradigm for Food Security and Food Safety. Biodiversity based organic farming” by Navdanya, 2006. More information can be found at www.navdanya.org.



The power of indigenous knowledge

Traditional farming techniques bring coastal land in Sri Lanka back into production after failure of modern varieties of rice seeds

In Sri Lanka Practical Action has been working with marginalized farmers who could generally be described as having no capital funding, owning less than 1 acre of farming land (often with very poor soil), and reliant on rainfall supplemented by only very minor irrigation schemes. The tsunami in 2004, which led to the salinisation of the soil in many coastal areas, added to the numbers of these marginalised farmers. One such farmer from Manajjawa, Ambalanthota takes up the story:

"I am Ranjith. I took up paddy farming just like my forefathers before me. Our paddy lands have always had a high level of salinity due to the proximity to the sea and harvests have been low. The sea water that gushed with the Tsunami of 2004 got deposited in the paddy fields in this area and further aggravated this condition. Due to the high level of salinity in the field, paddy seedlings started dying. Little by little, with each season, the harvest reduced. After the third season it became almost impossible to plant paddy. The modern varieties of paddy which we were used to growing were unsuccessful in this high saline condition. We were on the verge of abandoning the only form of livelihood we knew.

It was at this crucial juncture (2005 September) that two organizations, namely Practical Action and the National Federation for the Conservation of Traditional Seeds and Agricultural Resources (NFCTSAR) came forward to help us. This problem had been highlighted in the participatory rural appraisal (PRA) which was conducted in our village following the Tsunami. These organizations suggested that we grow 10 traditional rice varieties on a trial basis. They said according to indigenous knowledge there are certain traditional rice varieties suitable for growing in saline conditions and they had done some trials which proved this. NFCTSAR provided us the required seed paddy. They also trained us on appropriate cultivation methods. Sixteen farmers in this area (including myself) tried out these traditional varieties for 3 seasons. At first we were rather sceptical. However to our surprise and delight, seven of the varieties did in fact flourish in the saline conditions.

We used organic fertilizer instead of chemical fertilizers for growing these traditional varieties, as recommended by the above organizations. During the same period, a modern hybrid paddy variety was cultivated in the paddy field adjoining mine. This paddy field was fertilized with costly chemical fertilizer. Pesticides had to be sprayed as well to safeguard the crop from pest attacks. Finally this was largely unsuccessful. I on the other hand used only organic fertilizer, the raw material for which could be easily sourced within the village with minimal cost. Pesticides were unnecessary since the indigenous seed paddy was capable of resisting pest attacks. I realized that If I grew these varieties commercially, the cost of production could be reduced significantly.

Our trials revealed another unexpected result. In the case of certain saline resistant traditional rice varieties such as "Rathdel", "Dahanala", "Madathawalu" and "Pachchaperumal" the yields were high. Earlier when we grew modern paddy varieties, we got only 15 to 20 bushels (1 bushel = 36,4 litre) from an acre. Now with these traditional indigenous varieties of paddy, yields can be as high as of 60 to 70 bushels per acre. We were used to modern varieties and thought that these would bring forth a better yield. However after receiving training and observing the results I am now convinced that growing traditional rice varieties is a good option for saline affected paddy fields such as mine."

For more information: Contact Practical Action, <http://practicalaction.org>



Small scale agriculture for the future

Ole-Jacob Vikabråten

The small scale farm of Vikabråten is located in Vestre Slidre, 460 meters above sea level, approximately 200 kilometers north-west of Oslo, the capital of Norway. The farm was previously a smallholding from the beginning of the 19th century, and the farmers bought themselves free in 1926. The field was expanded by land reclamation of a little less than 1 hectare to 1.7 hectare. Thereafter the farmers were cultivating fields of a total of 2 hectare and build two new buildings. Briefly: freedom to dispose of their own farm and freedom from compulsory work launched a significant activity, and from what we have heard, the farm was counted as very successful until it was closed down as an independent unit in 1976.

At the time my wife and I took over the farm in 1993, the soil had been rented out to the previous main farm as a grazing land. With the exception of the flat field the soil had not been fertilized, sowed or ploughed since the 1970s. The first year we had a yield of eight loads for the horse, approximately 1.6 ton hay on the field at home, which is about 0,15 hectare of meadow. The field at the farmhouse in the mountain where we bring the animals in the summer, Langstøljordet, was exclusively existing of mounds, and had to be renovated. We have gradually renovated the meadow at home. For the last decades we have on average yielded 40 loads of hay at home, which is approximately 8 tonnes, and additionally 5 tones on the farm in the mountain, Langstølen.

There are many farms as Vikabråten spread around Norway – in Europe – in the world. Farms that are split up, poorly rounded off and too steep for big, heavy machines. In rich countries, those farms in the worst case i crowded with thicket, and in the best case they are being used as grazing areas. The buildings are decaying. The agricultural authority in the municipality expressed with 4 to 1 vote that the outbuilding on Vikabråten was unusable. Never the less it is still in use to this day!

At generational change it has almost been a saying in the countryside that “no one can live off such a farm today” – no matter if the farm - as Vikabråten - could feed 4 cows, 10, 15 or maybe 20 cows. A farm that 10 years ago was seen as modern and robust, is today easily written off as without a future. Farmers who “goes for it” and who appear over two pages in the poshy magazines and farmer’s newspapers, buys a robot for a million Norwegian crowns (NOK) , approximately 120 000 Euro, keeps 40-100 cows. Happily not knowing that they are preparing for a competition they are born to loose – for Swedes and Danes with 2000-3000 cows, flat coherent fields and 20-30% longer season.

That the farms which has feeded its families throughout generations can no longer be drifted, is not always something that the farmers have come up with themselves. We often hear this from politicians of agriculture, supervisors at agricultural offices and from the slaughter- and diary industry. And if one goes to agricultural expositions, it is always the heaviest and most expensive equipment that is being showed. Agriculture is about to disappear in a macho-culture which seems totally obsolete in the rest of the society.

The economic results are speaking for themselves: several of the biggest cowsheds give an hour based salary at about 70 NOK (8.5 Euro). This is approximately 50 NOK (6 Euro) below the average of Norwegian agriculture. The terrible result comes in spite of the fact that these farms have received a considerably amount of public support, favourable loans, that the loan rent is historically low and the price on milk is increasing.

Debts of several millions NOK, heavy mechanics, livestock producing on the edge of what is biologically possible, and dependency of huge masses of grain feed, was not what we sought when we bought Vikabråten back in 1993. Rather the complete opposite. We wanted to take care of the sustainable aspects of the traditional small scale farming. When small scale farmers for centuries had managed to live from this way, we should also be able to, when we in addition could enjoy full public support?

The outbuilding (the useless...) was rapidly filled up with 4 cows, 8-10 sheep and a working horse. The leaky, and for that reason the illegal manure basement, could after normal public advice been total



renovated for 100-200 000 NOK (12-24 000 Euro). Instead, I bought a tank made of glassfibre which could room 10 000 liters to accumulation of water (urine), and moulded a new floor in the basement. Price: 17 000 NOK (2100 Euro). Amount of working time: 3 days. This system is fully tried out, especially on the westcoast from the 30-40- and 50'ies. The premise for this to work out is that one feeds with dried fodder, have the calves in the spring and use little grain feed. Then you get fast muck which doesn't drain. The absolute best would be to get hold of sufficient with straw to get fast manure and in that way avoid anaerobic fermentation and development of methane.

Gradually, we have build on the hay barns on the farm in the mountains to get room for bigger crops and space for both cheese-making and storage rooms both at home and on the farm in the maintains. Most of the materials come from our own forest, and all labour, except a couple of hours electricity work at home is build by the do-it-yourself-method.

So, the starting point is the old economic (in the meaning of oikos=household) model: as big production as possible of goods and services (riding with the children, foot – and skiing tours in the mountain, an interesting work mixed with hobby...) with a minimum effort of bought resources, as well as selling the surplus in most possible processed and direct form:

- The main production is milk and meat. We process the milk into cheese, cream and butter. What we don't eat ourselves is sold locally, directly to costumers. We slaughter at home for household use. The rest of the meat goes through the local butchery and refined mainly as smoked and salted sausage. We also sell the smoked and salted sausage ourselves.

- Potatoes cultivated on 0,01 hectare (1000 m2) are mainly to ourselves and for animal fodder, but we do sell some locally as well.

- The vegetable garden only covers our own needs. Running the farm in the mountains in the summer makes it impossible manage more.

- The location at 460 meters above sea level limits what kind of fruit which is suitable to grow, but we have planted some cherry – and apple trees. First and foremost for ourselves, but maybe one day there will be enough surplus for sale. For this purpose, we have made use of some steep hills with the use of terracebuilding. There, the steep slopes used to be filled with thicket and unsuitable both for forest use and agriculture.

- Over the past years we have planted approximately 1200 black currant bushes – partly on terraces. Gradually, as they bear fruit, we will start pressing juice, as this is one of the ingredients in the recipe for smoked and salted sausage in the area, Valdres.

- Wild plants, blueberries, moor berries and crowberry makes out 100 litres each year for making and preserving juice.

Conclusion: life on a small scale farm is not as bad as a lot of people (not small scale farmers) imagine. The small scale farms does not disappear by themselves, but are being victims of an extermination campaign which involves reducing public support and dismantle investment schemes as well as consequent misinformation about the economical realities on small and big scale farms.

Consequently, we need an antidote in the form of information and underlining that the small scale farmer will play a key role in transforming the world to a greener and a more just place to live.

For more information: <http://vikabraaten.e-monsite.com/>



ANNEX 5: Recommended literature on some issues

The list of references is very long, so to help the reader to find some important reports and papers on some of the issues dealt with in *A Viable Food Future*, we have in this annex listed a few. Below are some recommendations from the editor. Several issues are listed below, but they are all interlinked and most of the books, reports and papers are dealing with more than one of the issues..

Overall literature

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- Via Campesina. 2009. Industrial Agrofuels Fuel Hunger and Poverty. The Via Campesina Notebookss No 1 November 2009. (<http://viacampesina.net/downloads/AGROFUELS/EN/LVC-AGROFUEL7.pdf>)



Biotechnology

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- Swedish Society for Nature Conservation. 2009. Retooling the planet.
(http://www.etcgroup.org/upload/publication/pdf_file/Retooling%20the%20Planet%201.2.pdf)
- Friends of the Earth International. 2010. Who benefits from GM crops?
(www.foei.org/en/resources/publications/pdfs/2010/who-benefits-from-gm-crops-2010)

Climate change and agriculture

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A Viable Food Future

PART II

What kind of food production can

drastically reduce poverty,

reduce climate change and cool the planet,

restore biodiversity, soil fertility and water resources,

improve livelihoods and provide employment for billions of people,

produce enough, good, and nutritious food for 9 billion people or more ...



Organisations that have contributed directly to this report:

Canada: USC; India: Forum for Biotechnology & Food Security, and Navdanya; Italy: Terra Nuova; Spain: Veterinarios sin Fronteras; USA: Food First, Oakland Institute; UK: Practical Action; and International organisations: ETC-group, Friends of the Earth, GRAIN, More and Better, La Via Campesina and The International Commission on the Future of Food and Agriculture.

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