Replacing Chemicals with Biology:

Phasing out highly hazardous pesticides with agroecology

by Meriel Watts
with Stephanie Williamson

PAN Pesticide Action Network International

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Using slashed weeds and other waste foliage to cover soil in organic ginger field

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Purpose of book

Adverse effects of highly hazardous pesticides (HHPs) on people and the environment have been a global concern for many years. In 2006, this was clearly expressed by the FAO Council when it recommended a progressive ban on HHPs. The concern crystallized at UNEP's Fourth International Conference on Chemicals Management (ICCM4) in Nairobi in 2012, with the submission of a conference room paper supported by at least 65 countries and organizations. The proposed resolution included supporting "a progressive ban on HHPs and their substitution with safer alternatives". While the resolution was not immediately adopted, countries participating in subsequent regional meetings of the Strategic Approach to International Chemicals Management (SAICM) have reiterated concern about HHPs and called for more information on ecosystem-based alternatives. At SAICM's Open-Ended Working Group in December 2014, following a call by the entire African region for a global alliance to phase-out these chemicals, it was agreed a proposal would be developed for ICCM4.

The purpose of this publication is to provide information drawn from all regions to assist countries in replacing HHPs with ecosystem-based approaches to pest[1] and crop management – replacing chemicals with biology. It draws together previously published and new material in a form that is accessible for policy- and decision-makers at the national and international level, as well as providing practical guidance at the farm and farm-support level.

It also points out that use, and phasing out, of HHPs must be seen in the context not only of human health and environmental impacts and costs, but also in the context of food security, poverty reduction, and climate change.

[1] In this book, the term pest is used to describe not just insect pests, but also weeds, crop diseases, and other invertebrates and vertebrates that can cause problems for farmers.

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Permaculture food forest, Malawi. *June Walker*

Executive Summary

"If we do persist with business as usual, the world's people cannot be fed over the next half-century. It will mean more environmental degradation, and the gap between the haves and have-nots will expand. We have an opportunity now to marshal our intellectual resources to avoid that sort of future. Otherwise we face a world nobody would want to inhabit."

Professor Robert T. Watson, Director of the IAASTD

Pesticides, designed to kill living organisms and deliberately released into the environment, now contaminate all parts of the world – soil, water, air, fog, snow, ice, the bark of trees, the Arctic, grasses high in the Himalayas and wildlife everywhere. They also contaminate people across the globe, and ordinary everyday exposures through use, drift and residues in food and water have resulted in a huge human toll including acute effects, chronic health problems and deaths.

Farming is at a crossroad

Recent field surveys show that a very high proportion of farmers and agricultural workers exposed to pesticides through their work are suffering acute health effects: in Pakistan, 100 percent of women picking cotton after pesticides were sprayed, in Bangladesh 85 percent of applicators, in Burkina Faso 82 percent of farmers and in Brazil 45 percent of agricultural workers surveyed. Agricultural production also suffers from loss of pollinators and the beneficial insects that provide natural control of pests.

On top of the sheer magnitude of the human suffering involved, there is a phenomenal cost to society. UNEP's 2013 "Cost of Inaction" report estimated that the accumulated health costs of acute injury alone to smallholder pesticide users in sub-Saharan Africa will be approximately US $97 billion by 2020. This is not a problem confined to low-income countries: the external cost (i.e. to humans and the environment) of pesticide use in the United States is estimated to be US $ 9.6 billion annually.

After decades of concern based on community experiences and mounting scientific evidence of the human health and environmental impacts of pesticides, the global community is now poised to take action to phase out highly hazardous pesticides. In 2006, the text of the Strategic Approach to International Chemicals Management (SAICM) recognized the need for action to reduce dependency on pesticides worldwide, including phasing out highly toxic pesticides and promoting safer alternatives. Responding to this the Food and Agriculture Organization (FAO)_ Council recommended a global phase-out of highly hazardous pesticides (HHPs).

We have reached a turning point for agriculture: it is a moment when tremendous changes can be made to address not only the damage inflicted by HHPs but also climate change, loss of biodiversity

The current model of industrial agriculture is a dead end

and lack of food security and sovereignty – all inextricably interwoven. As the FAO Director-General, José Graziano da Silva said in Paris in February 2015:

> *"The model of agricultural production that predominates today is not suitable for the new food security challenges of the 21st century. … Since food production is not a sufficient condition for food security, it means that the way we are producing is no longer acceptable."*

It is counter-productive to try to prop up this current, failing model by replacing HHPs with other toxic pesticides that also inflict harm on humans and environment. There are much safer, more beneficial and viable ecosystem-based approaches to pest management. Agroecology, long considered the foundation of sustainable agriculture, is the science and practice of applying ecological concepts, principles and knowledge to the study, design and management of sustainable agroecosystems. It replaces chemicals with biology in farming.

Agroecology makes sense

There is widespread high-level support for replacing the currently dominant chemical-input approach to agriculture that emerged in the 1960s with a biological approach. Since 2009, a number of UN agencies and reports have voiced support for moving forward with agroecology. These include the IAASTD (International Assessment of Agricultural Knowledge, Science and Technology for Development), the current and previous UN Special Rapporteur on the right to food, United Nations Conference on Trade and Development and the FAO international and regional symposia on agroecology. Over 70 international scientists and scholars working in sustainable agriculture and food systems have called for a UN system-wide initiative on agroecology as the central strategy for addressing climate change and building resilience in the face of water crises across the globe.

"Replacing Chemicals with Biology: Phasing out Highly Hazardous Pesticides with Agroecology" provides powerful evidence from

every region of the world of improved yields, greater profitability for farmers, improved health, improved food security and sovereignty, greater resilience to adverse climate events, better opportunities for women farmers, improved biodiversity and social benefits such as better cooperation between farmers and within communities. For example, farmers practicing Community Managed Sustainable Agriculture in India find that their costs have been slashed by a third whilst yields have been maintained.

There are seven core principles of agroecology which aim to develop and maintain an agroecosystem that works with nature, not against it – creating a balance that keeps pests in check. These principles involve:

- √ Adapting to local environments
- √ Providing the most favourable soil conditions for plant growth
- √ Promoting biodiversity
- √ Enhancing beneficial biological interactions
- √ Minimizing losses of energy and water
- √ Minimizing the use of non renewable external resources
- √ Maximizing the use of farmers' knowledge and skills

The core principles are reflected in a number of agroecological practices, such as integrating livestock into cropping farms, agroforestry, using leguminous cover crops to protect the soil and supply nitrogen, using compost and mulches, intercropping and optimizing times of planting and weeding. Agroecological farmers sometimes use biological controls and attractant traps to reduce pest pressure and work cooperatively with other farmers. Pesticides, whether biological or chemical, are used only as a last resort. The exact practices that farmers use depends very much on their on-farm realities and social conditions: there is no prescribed 'recipe' approach as there is with chemicals.

Case studies from Asia, Africa, Latin America and industrialized countries – on coffee, cotton, grains, legumes and vegetables – show the power

Woman farmer discussing her 'no-pesticide farm', Vietnam. *Centre for Sustainable Rural Development (SRD)*

of farmer-to-farmer transmission of knowledge and skills. Farmer Field Schools, a system of learning developed by the FAO which is based on farmer experimentation and learning in farmers' own fields, have emerged as a powerful mechanism of learning about agroecology for farmers.

National policy changes

There is much that national governments can and should do to assist the uptake of agroecology by farmers. The first big step is to challenge assumptions that current levels of dependency on synthetic chemical pesticides are necessary, and that large-scale, specialized farms highly reliant on agrochemical and fossil fuel inputs are the best way to provide food for all. On the contrary, there is clear evidence that small, diversified, agroecologically-managed farms can be just as productive overall – or more so – than input-intensive and monocultural systems. Countries need to change their policies to put agroecology at the centre of their approach to agriculture. Several countries have already taken the first steps, including Brazil, Ecuador and France.

National policies need to protect small farmers, their ownership of land and their access to water and seeds. They need to ensure equal rights for women in every sphere. An FAO report found that ensuring women farmers are adequately resourced could increase agricultural output in low-income countries between 2.5 and 4 percent, and reduce the number of undernourished people by 100-150 million. Governments need to invest in agricultural knowledge by supporting research based on farmer needs and experiences, including farmer participatory research, as well as extension services and farmer networks.

National economic policies must strengthen local food systems, re-localise markets to reduce wastage during transport and storage and improve farmers' ability to sell, and improve access to credit. Policies are needed to prevent global food retail chain domination of domestic markets. Such domination allows these chains to determine prices that result in farmers being underpaid and left struggling to survive. Full-cost accounting for agriculture would ensure the external costs of chemical-based production are taken into account. Replacing subsidies on agrochemicals with financial credits for agroecology (such as soil carbon sequestration) would level the playing field.

Changes to pesticide regulatory systems are also needed. The presumption that a pesticide should be registered if it meets certain hazard or risk criteria, regardless of whether it is needed, should be replaced by the presumption that pests, weeds and diseases should be managed by the least hazardous method – and chemicals registered only if need can be demonstrated. Existing registrations should cease when nonchemical methods or less hazardous pesticides can be substituted.

International actions

International policy action is also needed. Steps must be taken to reverse the harmful impacts of unregulated trade and redirect misguided international development policies and initiatives that hinder local, national and regional transformation towards agroecological food and farming systems. There is a need to reform, and in some cases dismantle, institutions such as regional and global trade arrangements and ownership laws that hinder the scaling up and out of agroecology. Re-structuring and re-alignment of these institutions is needed to support state and non-state actors' obligations to respect, protect, and fulfil universal human rights to food, health and a safe working environment, and to advance equitable and sustainable development goals. Intellectual property regimes that privatized seed resources – transferring ownership to commercial interests and criminalizing farmers for seed saving – need to be reoriented to protect farmers. Corporate influence over public policy and agri-food systems must be curtailed.

UN agencies, bi- and multi- lateral development institutions, international research

Organic cabbages, Alajuela Costa Rica. *Fernando Ramirez*

institutes, private and public donor agencies need to prioritize participatory community-based farmer-led agroecological research, extension and education. There needs to be an FAO and a UN-wide adoption of agroecology as the central direction of agriculture. All UN agencies can contribute in important ways in assisting governments to bring their focus to agroecology. The World Bank and international financial institutions should redirect the focus of their agricultural and poverty-reduction programs to assist countries in transitioning towards equitable and sustainable agroecological systems. International and regional research institutional arrangements should prioritize agroecological research, extension and education. Multilateral and bilateral funding agencies as well as private foundations have an essential role to play in supporting the scaling up and scaling out of agroecology.

International actors must firmly commit themselves to overcoming the political, institutional and market constraints that stand in the way of widespread adoption of agroecology. It is time to restrain corporate power and influence over public agencies and democratize the agri-food system at all levels and across all relevant institutions.

"… scaling up agroecological practices can simultaneously increase farm productivity and food security, improve incomes and rural livelihoods, and reverse the trend towards species loss and genetic erosion."

Olivier de Schutter, UN Special Rapporteur on the right to food, 2011

SECTION A:
Why Replace Chemicals with Biology?

Rice fields, China

1. Introduction

"The model of agricultural production that predominates today is not suitable for the new food security challenges of the 21st century. . . . Since food production is not a sufficient condition for food security, it means that the way we are producing is no longer acceptable."

FAO Director-General José Graziano da Silva, 2015 [2]

Ladybug larva eating aphids, a natural biological control often destroyed by insecticides

Agricultural chemicals, including fertilizers and pesticides, are among the largest volume uses of chemicals worldwide.[3] Pesticides are designed to kill living organisms and are deliberately released into the environment, mostly in a broad-scale approach that results in only a small proportion of the chemical reaching its intended target organism.[4] Adverse effects of pesticides include acute and chronic impacts on human health, livestock, wildlife, pollinators, beneficial insects such as natural enemies/biological controls,[5] and other invertebrates and microbes both terrestrial and aquatic – all of which are essential to a stable, healthy and productive ecosystem. Pesticides now contaminate environmental media across the globe, including soil, surface- and ground- waters, air, rain, fog, snow, and living organisms. Residues have been documented from grasses high on the Himalayas to the bark of trees in many countries.

The adverse effects of pesticides are sometimes very evident and sometimes invisible. Impacts are particularly widespread and concerning in low-income countries where agriculture is often the largest economic sector and pesticides account for the most significant chemical releases. The costs to society of such pesticide use are phenomenal. A 2013 UNEP report estimated that the health costs of pesticide use in Africa is greater than the total official development assistance to general health care in the region

2 International Forum on Agriculture and Climate Change, Paris February 20th 2015. http://www.fao.org/news/story/en/item/278192/icode/

3 UNEP. 2012. *Global Chemicals Outlook: Towards Sound Management of Chemicals.* http://www.unep.org/hazardoussubstances/Portals/9/Mainstreaming/CostOfInaction/Report_Cost_of_Inaction_Feb2013.pdf

4 Pimentel D. 1995. Amounts of pesticides reaching target pests; environmental impacts and ethics. *J Agric Environ Ethics* 8(1):17-29.

5 The term 'natural enemies' is used to describe organisms existing naturally in an agroecosystem and providing control of pests; the term 'biological control' is used where organisms are bred or field-collected and deliberately released to provide control of pests. The actual organisms may be the same. For example, the seven-spotted ladybird beetle, *Coccinella septempunctata*, which feeds on aphids, whiteflies, bollworms and other pests, is found naturally in the crop canopy but can also be bred and released for greater pest control.

> ***"Business-as-usual scenarios indicate a further increase in the already substantial negative contribution of agriculture in global environmental change."***
>
> *IAASTD Global Report, p257*

(excluding HIV/AIDS).[6] Even in high-income countries the cost is huge: the US alone experiences an estimated US $9.6 billion in environmental and societal damages from pesticides every year.[7]

Yet many studies show that this widespread chemical use is not necessary to "feed the world." Ecosystem-based approaches to food production, such as organics and agroecology,[8] are more than capable of producing yields to provide adequate nutrition to every person on earth, using land under current cultivation with far greater resource efficiency and reliability.[9] The world is not short of food[10] – but it is short of production and distribution systems that enable those who need food to access it fairly. In 2011-13, an estimated 842 million people were undernourished across the globe.[11] More than 70 percent of those lacking food live in rural areas in low-income countries; many of them are low paid farm workers or subsistence farmers.

About 70 percent of the food we consume globally comes from smallholder farmers.[12] In Asia and sub-Saharan Africa, that figure rises to 80 percent.[13] An estimated 84 percent of the world's farms are two hectares or less in size. These small farms produce a higher share of the world's food relative to the share of land they use, with higher yields than larger farms within the same countries and agro-ecological settings.[14] Efficient use of land, water, biodiversity and other resources enables traditional family and smallholder farms to achieve higher productivity per hectare than large industrial farms.[15]

Yet small farms occupy less than one quarter of agricultural land, and the holdings are getting smaller.[16] This represents a serious threat to food production and availability worldwide, since small family farms are vital to food security.[17] These smallholdings are under increasing pressure from market players seeking to control resources such as land, water and labour, encouraged by some government and international institutions. Enough that they have to deal with the difficulties and disasters wrought by climate change.

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6 UNEP. 2013. *Costs of Inaction on the Sound Management of Chemicals*. United Nations Environment Programme, Geneva.

7 Pimentel D, Burges M. 2014. Environmental and economic costs of the application of pesticides primarily in the United States. In: Pimentel D, Peshin R. 2014. *Integrated Pest Management: Pesticide Problems, Vol 3*. Springer, New York.

8 Agroecology may be a new concept to some readers. Long considered the foundation of sustainable agriculture, it is the science and practice of applying ecological concepts, principles and knowledge to the study, design and management of sustainable agroecosystems. It is touched on again in Chapter 2 and described more fully in Chapter 4. De Schutter O. 2013. Agroecology: A solution to the crises of food systems and climate change. In: UNCTAD, 2013, *Wake Up before it is Too Late: Make Agriculture Truly Sustainable Now for Food Security in a Changing Climate*, United Nations Conference on Trade and Development.

9 Badgley C, Moghtader J, Quintero E, Zakem E, Chappelli MJ, Avilés-Vázquez K, Samulon A, Perfecto I. 2006. Organic agriculture and the global food supply. *Renew Agric Food Sys* 22(2):86-108.

10 FAO. 2014. *The State of Food and Agriculture; Innovation in family farming*. FAO, Rome.

11 FAO, IFAD, WFP. 2013. *The State of Food Insecurity in the World 2013. The multiple dimensions of food security*. FAO, Rome.

12 Wolfenson KD. 2013. Coping with the food and agriculture challenge: smallholders' agenda. Preparations and outcomes of the 2012 United Nations Conference on Sustainable Development (Rio+20). FAO, Rome.

13 HLPE. 2013. Investing in smallholder agriculture for food security. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.

14 FAO 2014, *op cit*.

15 Parmentier S. 2014. *Scaling-up Agroecological Approaches: What, Why and How?* Oxfam-Solidarity, Belgium.

16 GRAIN. 2014. Hungry for Land: Small farmers feed the world with less than a quarter of all farmland. http://www.grain.org/article/entries/4929-hungry-for-land-small-farmers-feed-the-world-with-less-than-a-quarter-of-all-farmland

17 FAO 2014, *op cit*.

Small-scale family farms like this one in Latin America produce about 70 percent of our food.

Agricultural productivity can be better improved through agroecology than it can through continued and increasing use of pesticides and other inefficient industrial inputs. FAO experts note that sustainable increases in productivity can only be achieved through "conserving, protecting and enhancing natural resources and ecosystems, improving the livelihoods and well-being of people and social groups and bolstering their resilience – especially to climate change and volatile markets".[18] Farmers need government policies and international agreements that:

- √ Support family ownership of productive land
- √ Support innovation in agroecological practices
- √ Support access by women to land and other resources
- √ Increase local food availability
- √ Ensure equitable access to health care, clean water, sanitation and education, and access to local markets[19]

> ***"Nothing comes closer to the sustainable food production paradigm than family farming."***
>
> *FAO, 2014. The State of Food and Agriculture*

Agricultural systems, even the most traditional ones, are constantly changing over time in response to a number of external pressures.[20] Trying to address HHPs in isolation from the powerful environmental, economic and social factors intertwined with agriculture will not work. Food production is affected by, and in turn affects, climate change, biodiversity, food security and food sovereignty. There is no point producing more food if it does not reach or provide adequate nutrition to those who need it. Thus in addressing HHPs, we need to look towards agricultural policies, processes and practices that will withstand climate change and at the same time reduce contributions to climate change, that will enhance rather than

[18] FAO 2014, *op cit*.

[19] FAO 2014, *op cit*.

[20] Altieri MA, Funes-Monzote FR, Petersen P. 2012. Agroecologically efficient agricultural systems for smallholder farmers: contributions to food sovereignty. *Agron Sustain* Dev 32:1-13.

destroy biodiversity, and above all ensure that safe, nutritious food gets into the hands of all.

Food wastage – from post-harvest spoilage to consumer throw away – is a huge problem across the world. About 1.3 billion tons of food – a third of all food produced for human consumption – is wasted. Food waste by consumers in Europe and North America is estimated to be about 95-115 kg per person per year. In sub-Saharan Africa and South/Southeast Asia, in contrast, the figure is only 6-11 kg; in those regions most loss occurs from damage and spillage during harvesting, and spoilage immediately post harvest and during transfer to markets.[21] Reducing food waste at all points in the food distribution chain, particularly in high-income countries, could make a tremendous contribution to food security if combined with shifts in food distribution and access.

Participants in the 1996 World Food Summit defined food security this way:

> *"all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life".*[22]

However, as efforts to achieve food security have failed to deliver on this promise, smallholder and peasant farmers picked up the concept of food sovereignty. Originally developed by the Mexican government in 1983 as the first objective in its National Food Programme, it later became a central organizing concept for the smallholder farmer and peasant organization, La Via Campesina.[23] Food sovereignty builds on an understanding that food security cannot be achieved without meaningful active involvement of people and communities, as well as government officials, in developing food production systems that are ecologically, socially, economically and culturally appropriate to their particular circumstances. In 2004, the UN Special Rapporteur on the right to food, Jean Ziegler, introduced the concept to the UN Economic and Social Council.[24]

While this book cannot address all food and farming issues in-depth, it can draw attention to how certain agricultural policies and practices support or undermine production of safe nutritious food, accessible by all. It pays special attention to showing how phasing out HHPs can help meet

… the future of food needs to be much more than increasing production to end hunger, and … food security depends not only on food availability at the right place at the right time, but also on access, utilization, and stability.

Steve Gliessman & Pablo Tittonell, Wageningen University. 2015. Agroecology for food security and nutrition. Agroecol Sustain Food Syst 39(2):131-3

This smallholder farm produces cotton, maize, tomato and mango, *Ethiopia PAN UK*

21 FAO. 2011. Global food losses and food waste – Extent, causes and prevention. FAO, Rome.

22 FAO. 1996. World Food Summit Plan of Action. http://www.fao.org/docrep/003/w3613e/w3613e00.HTM

23 Edelman M. 2014. The next stage of the food sovereignty debate. *Dialog Human Geog* 4(2):182-4.

24 Economic, Social and Cultural Rights. The right to food. Report submitted by the Special Rapporteur on the right to food, Jean Ziegler, in accordance with Commission on Human Rights resolution 2003/25. E/CN.4/2004/10. 9 February 2004.

Endosulfan, now listed under the Stockholm Convention, illegally traded in Cambodia. *PANAP*

these goals – if the replacement is agroecology rather than another chemical pesticide. But mainly, this book will illustrate how agroecology is now supported at the highest international policy levels – and how effective it is in the field. It provides information that can assist all countries – policy and decision makers, extension agents and farmers – in replacing HHPs with ecosystem-based approaches to pest and crop management. It provides a recipe for the future.

THE DIRTY 'DOZEN'

Obsolete

- **aldrin**
- **chlordimeform**
- **dieldrin**
- **endrin**
- **camphechlor/toxaphene**
- **DBCP**

Banned/restricted by Stockholm Convention

- **chlordane**
- **DDT**
- **HCH**
- **heptachlor**
- **lindane**
- **PCP**

On PIC List

- **2,4,5-T**
- **aldicarb**
- **ethylene dibromide**
- **methyl parathion**
- **parathion**
- **PCP**

In process

- **Paraquat (formulation) – Rotterdam**

1.1 International concern about HHPs

Global concern about the adverse effects of HHPs is clearly increasing with each passing year. The dangers of these chemicals first came to the attention of the public in 1963, when scientist Rachel Carson published her book *Silent Spring*. The book drew widespread public and policymaker attention to the environmental and health impacts of widespread use of pesticides. The concerns over HHPs continued with the formation, in 1982, of Pesticides Action Network (PAN), which focused its first international campaign on the global phase-out of the "Dirty Dozen" pesticides (see side bar).[25] Many of these highly hazardous pesticides are now obsolete; some others are banned globally under the Stockholm Convention on Persistent Organic Pollutants; some are listed under the Rotterdam Convention on Prior Informed Consent; and the remainder are in the review stages of the technical committees of the two Conventions. Those that are still in use in some places are widely banned in many other countries.

Despite this, many more HHPs remain in widespread use, and concerns continue to be voiced internationally. For example:

- In February 2006, the Strategic Approach to International Chemicals Management (SAICM), adopted at the first International

[25] Rengam SV, Nair P. 2013. *Realise, Resist, Reclaim: Celebrating 30 Years of PAN AP*. Pesticide Action Network, Penang. The original Dirty Dozen list was drawn up in 1985, with aldicarb added in 1986.

Paraquat, the only remaining 'Dirty Dozen' pesticide, recommend for listing under the Rotterdam Convention, was used on this field in the Mekong Delta, in Vietnam. *Research Centre for Rural Develeopment, An Giang University.*

Conference on Chemicals Management (ICCM1), recognized the need to reduce the use of and risk from highly hazardous pesticides, and replace them with safer alternatives.[26]

- In December 2006, the FAO Council recommended that activities to reduce risk could include a progressive ban on highly hazardous pesticides.[27]

As a result of that recommendation, in 2007 the WHO/FAO Joint Meeting on Pesticide Management (JMPM) developed criteria for identifying HHPs and recommended that a global list be developed.[28]

- The concern crystallized on the international policy stage at UNEP's Third International Conference on Chemicals Management (ICCM3), in Nairobi in 2012, with a conference room paper submitted[29] and supported[30] by at least 65 countries and organizations. The resolution proposed in the paper included supporting *"a progressive ban on HHPs and their substitution with safer alternatives".* The resolution was not adopted because some countries needed more time to consider it. However, three of the intercessional regional SAICM meetings held since ICCM3, involving more than 140 countries, reiterated concern about HHPs and called for more information on ecosystem-based approaches to pest management as alternatives to HHPs.

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26 UNEP. 2006. Strategic Approach to International Chemicals Management. SAICM texts and resolutions of the International Conference on Chemicals Management. UNEP, Geneva.

27 FAO. 2006. Report. Hundred and Thirty-First Session of the Council. Rome, 20-25 November 2006.

28 FAO. WHO. 2007. Report of the 1st FAO/WHO Joint Meeting on Pesticide Management and the 3rd Session of the FAO Panel of Experts on Pesticide Management. 22-26 October 2007, Rome. http://www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides/Code/JMPM_2007_Report.pdf

29 Draft resolution on Highly Hazardous Pesticides: submission by Antigua & Barbuda, Armenia, Bhutan, Dominican Republic, Egypt, Guyana, International Trade Union Congress, IPEN, Iraq, Kenya, Kiribati, Kyrgyzstan, Libya, Mongolia, Nepal, Nigeria, Peru, Pesticide Action Network, Republic of Moldova, St Lucia, Tanzania, Tunisia and Zambia. SAICM/ICCM.3/CRP.16.

30 Other countries that spoke in support of the resolution included Zambia on behalf of the whole African region, Burundi, Colombia, Iran, Nepal, Palestine, and Russia. Mongolia proposed replacing pesticides with biological means and bio-pesticides.

Box 1.1: SAICM texts on HHPs

Dubai Declaration:

6. The need to take concerted action is accentuated by a wide range of chemical safety concerns at the international level, including … dependency on pesticides in agriculture

Global Plan of Action:

8. … It is therefore critical for all stakeholders to take appropriate action on global priorities. These include, among others:

h. Promoting alternatives in order to reduce and phase out highly toxic pesticides

Work Areas Addressing Risk Reduction
Highly toxic pesticides – risk management and reduction:

25 Base national decisions on highly toxic pesticides on an evaluation of their intrinsic hazards and anticipated local exposure to them.

26. Prioritize the procurement of least hazardous pest control measures . . .

27 Promote development and use of reduced-risk pesticides and substitution for highly toxic pesticides as well as effective and nonchemical alternative means of pest control.

29. Promote integrated pest and vector management.

114. Improve access to and use of information on pesticides, particularly highly toxic pesticides, and promote alternative safer pest control measures through networks such as academia.

- In December 2014, at SAICM's Open-Ended Working Group the entire African region called for a Global Alliance to Phase-out HHPs. This call was widely supported, and resulted in agreement to develop a proposal for such an approach for ICCM4.

Children are very vulnerable to the effects of pesticides.

1.2 Reasons for the concern about HHPs

Despite the bans, restrictions and withdrawals of a small number of HHPs over the last few decades, many others are still in use, and damage to human health and the environment continues to occur in both low and high income countries.

Human health effects

Acute effects on health range from seemingly mild symptoms to much more severe impacts, including chronic disability or death. Long-term effects may occur with no acute symptoms and little outward effect, yet can still undermine a person's health for the rest of their life, and may also affect future generations.

Some harm results from negligence and shortage of resources, for example the death of 23 school children in India in 2013 when their free midday meal was cooked with oil contaminated by monocrotophos. This tragic incident was

> ***… "Investigations in Ecuador found that prenatal exposure to pesticides is associated with severe adverse effects on brain development in children, even at low levels of exposure."***
>
> *Laborde et al. 2015. Children's health in Latin America: the influence of environmental exposures. Environ Health Perspect 123(3):201-9*

thought to be the result of storing the oil in an empty monocrotophos container. The World Health Organization (WHO) had advised India in 2009 to consider banning monocrotophos.[31]

Some harm results from the pervasiveness of pesticides in air, drinking water and food, and there is particular concern about the exposure of the unborn foetus or newly born child to neurotoxins such as organophosphate insecticides (OPs), resulting in neurodevelopmental deficits. Numerous studies on animals have shown that in utero or neonate exposure to OPs, particularly the insecticide chlorpyrifos, adversely affects neurodevelopment.[32] Some studies show that inhibition of chlolinesterase can interfere with brain development leading to permanent brain damage.[33] One US study found that as little as 4.6 parts per trillion[34] of chlorpyrifos in umbilical cord blood during gestation was associated with a drop of 1.4 percent in a child's IQ, and 2.8 percent of its working memory.[35] Exposure in agricultural areas is pervasive; metabolites of organophosphate insecticides, for example, have been found in the urine of 94 percent of farm and non-farm children in the Bang Rieng agricultural community in Thailand.[36] There are significant societal costs of such exposures: Dr David Bellinger of the USA's Children's Hospital Boston concluded that the impact of OPs on children is responsible for a significant lowering of IQ across the whole US population;[37] there would be a similar effect in every other country where use of OPs is still widespread.

Significant harm results worldwide from intentional ingestion of pesticides with suicidal

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31 Reuters. 2013. World Health Organization had asked India to ban toxin that killed school children. July 22, 2013. http://www.ndtv.com/article/india/world-health-organisation-had-asked-india-to-ban-toxin-that-killed-school-children-395630; http://tvnz.co.nz/world-news/asked-india-ban-toxin-23-killed-children-5516941

32 For example: (i) Flaskos J. 2012. The developmental neurotoxicity of organophosphorus insecticides: A direct role for the oxon metabolites. Toxicol Lett 209(1):86-93. (ii) Muñoz-Quezada MT, Lucero BA, Barr DB, Steenland K, Levy K, Ryan PB, Iglesias V, Alvarado S, Concha C, Rojas E, Vega C. 2013. Neurodevelopmental effects in children associated with exposure to 4 organophosphate pesticides: A systematic review. Neurotoxicology 39:158-68. (iii) Eskenazi B, Marks AR, Bradman A, Harley K, Barr DB, Johnson C, Morga N, Jewell NP. 2007. Organophosphate pesticide exposure and neurodevelopment in young Mexican-American children. *Environ Health Perspect* 115(5):792-8.

33 For example: London L, Beseler C, Bouchard MF, Bellinger DC, Colosio C, Grandjean P, Harari R, Kootbodien T, Kromhout H, Little F, Meijster T, Moretto A, Rohlman DS, Stallones L. 2012. Neurobehavioural and neurodevelopmental effects of pesticide exposures. *Neurotoxicology* 33(4):887-96.

34 Although this seems to be an extremely small amount, natural hormones, and chemicals that mimic them (known as endocrine disruptors) have effects in the parts per trillion range. See Gore et al, 2014, *Introduction to Endocrine Disrupting Chemicals (EDCs), A Guide For Public Interest Organizations and Policy-Makers*. Endocrine Society and IPEN. http://www.endocrine.org/~/media/endosociety/Files/Advocacy%20and%20Outreach/Important%20Documents/Introduction%20to%20Endocrine%20Disrupting%20Chemicals.pdf

35 Rauh VA, Arunajadai S, Horton M, Perera F, Hoepner L, Barr DB, Whyatt R. 2011. Seven-year neurodevelopmental scores and prenatal exposure to chlorpyrifos, a common agricultural pesticide. *Environ Health Perspect* 119(8):1196-201.

36 Panuwet P, Siriwong W, Prapamontol T, Ryan B, Fiedler N, Robson MG, Barr DB. 2012. Agricultural pesticide management in Thailand: status and population health risk. *Environ Sci Pol* 17:72-81.

37 Bellinger D. 2012. A strategy for comparing the contributions of environmental chemicals and other risk factors to children's neurodevelopment. *Environ Health Perspect* 120(4):501-7.

Children - innocent victims of pesticides that can alter intellectual development. *Romy Quijano*

intent. The estimates of global suicide deaths from pesticides range from 186,000[38] to 371,000[39] every year, accounting for about 1/3rd of suicide deaths overall, and making pesticides the single most common means of suicide.[40] [41] In China, there are about 117,000 suicide deaths from pesticides annually.[42] The fatality rate from pesticide ingestion is high: banning HHPs in some countries has been successful in bringing down the death rate: the banning of monocrotophos, methyl-parathion, methamidophos and endosulfan by Sri Lanka, for example, resulted in a 50 percent drop in the suicide rate without reducing agricultural output.[43] Suicide poisonings with WHO Class II pesticides dimethoate, fenthion and paraquat (the latter with a case fatality rate of 42.7 percent), however, remained a problem.[44]

An FAO survey in Burkina Faso (2010), under the auspices of the Rotterdam Convention, showed that 82% of farmers have experienced symptoms of pesticide poisoning.

What is pesticide poisoning?
http://www.pic.int/Implementation/SeverelyHazardousPesticideFormulations/SHPFKit/PesticidePoisoning/tabid/3117/language/en-US/Default.aspx

Harm from occupational exposure

Considerable harm also results from ordinary occupational use, in both high- and low-income countries, but most particularly in the latter.

Pesticides have been poisoning farmworkers, their families and communities for over 60 years. Yet there is still no accurate estimate of the degree of human suffering from exposure to pesticides. The most authoritative study available today is one published in the World Health Statistics Quarterly in 1990, using data derived in the 1980s – nearly 30

38 Prüss-Ustün A, Vickers C, Haefliger P, Bertollini R. 2011. Knowns and unknowns on burden of disease due to chemicals: a systematic review. *Environ Health* 10:9.
39 Gunnell D, Eddleston M, Phillips MR, Konradsen F. 2007. The global distribution of fatal pesticide self-poisoning: Systematic review. *BMC Pub Health* 7:357.
40 *Ibid.*
41 WHO. 2014. *Preventing Suicide: A Global Imperative.* World Health Organization, Geneva.
42 Hao R, Wang Y, Wu Z, Song H. 2013. Chemical poisoning-related injury in China. *Lancet* 382:1327-8.
43 Manuweeera G, Eddleston M, Egodage S, Buckley NA. 2008. Do targeted bans of insecticides to prevent deaths from suicide result in reduced agricultural output? *Environ Health Perspect* 116:492-5.
44 Eddleston M, Adhikari S, Egodage S, Ranganath H, Mohamed F, Manuweera G, Azher S, Jayamanne S, Juzczak E, Sheriff MR, Dawson AH, Buckley NA. 2012. Effects of a provincial ban of two toxic organophosphorus insecticides on pesticide poisoning hospital admissions. *Clin Toxicol (Phila)* 50(3):202-9.

years ago. This study[45] estimated that there were possibly one million cases of serious unintentional pesticide poisonings each year, and an additional two million cases of people hospitalized for suicide attempts with pesticides. The author noted that this necessarily reflected only a fraction of the real problem, and estimated that there could be as many as 25 million agricultural workers in the developing world suffering from occupational pesticide poisoning each year, though most incidents are not recorded and most patients do not seek medical attention.[46] A more recent surveillance exercise in Central America indicated a 98 percent rate of underreporting of pesticide poisonings, with a regional estimate of 400,000 poisonings per year, 76 percent of the incidents being work related.[47]

Lack of data precludes any realistic estimate of the extent of chronic effects from exposure to pesticides. The health outcomes linked to pesticide exposure include cancers; reproductive, respiratory, immune and neurological effects; and much more. In 1990, the World Health Organization estimated an annual 735,000 cases of specific chronic effects linked to pesticides globally, and about 37,000 cases in low-income countries alone.[48] These numbers can be expected to be considerably higher now, with the phenomenal increase in pesticide use, especially in low-income countries, and our improved understanding of the links between pesticides and chronic health conditions – such as their influence on metabolic disorders.

"In Central America, PAHO has tracked a steady increase in acute pesticide poisoning cases each year for the past two decades, and this trend closely parallels upward trends in pesticide imports .... Acute pesticide poisoning is widespread in Latin America, and PAHO estimates that acute pesticide poisoning cases are under-reported by 50-80%."

Laborde et al. 2015

There is no reason to assume that the global pesticide poisoning rate has diminished. The figure of 25 million cited above was based on an average of 3 percent of agricultural workers in low-income countries suffering one episode of pesticide poisoning per year.[49] Yet figures from recent surveys and studies indicate the problem may well be much larger, with estimated rates of poisoning ranging up to 100 percent of exposed workers. Community monitoring by PAN partner organizations in 13 countries resulted in the 2010 publication of *Communities in Peril: Global report on health impacts of pesticide use in agriculture.*[50] The report identified a high rate of adverse effects from occupational pesticide exposure – up to 59 percent of respondents affected – and widespread use of HHPs. Eighty-two of the 150 active ingredients being used by surveyed farmers, and 7 of the 10 most used pesticides, were HHPs. [51]

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45 Jeyaratnam J. 1990. Acute Pesticide Poisoning: A Major Global Health Problem. *World Health Stat* Q 43(3):139-44.
46 *Ibid.*
47 Murray D, Wesseling C, Keifer M, Corriols M, Henao S. 2002. Surveillance of pesticide-related illness in the developing world: putting the data to work. *Int J Occup Environ Health* 8(3):243-8.
48 WHO. 1990. *Public Health Impacts of Pesticides Used in Agriculture*. World Health Organization, Geneva.
49 Jeyaratnam 1990, *op cit.*
50 Pesticide Action Network. 2010. *Communities in Peril: Global report on health impacts of pesticide use in agriculture.* http://www.pan-germany.org/download/PAN-I_CBM-Global-Report_1006-final.pdf
51 Based on the PAN criteria for HHPs – see Box 1.5.

Box 1.2: A snapshot of recent field surveys of pesticide poisoning

- Bangladesh, 2014 – 85% of applicators reported suffering gastrointestinal problems during and after spraying, 63% eye problems, 61% skin problems, and 47% physical weakness. Most commonly used pesticides: OPs and synthetic pyrethroids.[52]
- India, 2014 – a survey by the Calcutta School of Tropical Medicine and the NRS Medical College found that 30% of farmers using pesticides in a district in West Bengal were experiencing neurological symptoms.[53] In 2012 a survey of pesticide-exposed farmers in Punjab, India, reported 94.4% exhibited some symptoms of poisoning.[54]
- Burkina Faso, 2013 – 82.66% of farmers surveyed reported having experienced at least one ailment during or just after spraying, most commonly central nervous system effects. Of the cases reported to a health care centre, 53% were unintentional ingestion, 28% suicides, and 19% occupational use.[55]
- Pakistan, 2012 – in a small study of female workers picking cotton 3-15 days after pesticides were last used, 100% of them experienced headache, nausea and vomiting.[56]
- South Korea, 2012 – acute occupational pesticide poisoning amongst young male Korean farmers was reported to be 24.7%.[57]
- Brazil, 2012 – in a small survey in Brazil, 44.8% of rural workers involved in vegetable production reported health problems whilst using pesticides.[58] A survey of workers involved in potato production reported that 33% of them had experienced intoxication at least once.[59]
- Iran, 2012 – 12% of pesticide applicators involved in rice growing suffer acute pesticide poisoning.[60]
- Colombia, 2012 – the Public Health Surveillance System reported 6,650 poisoning cases from use of pesticides in 2008, increasing to 7,405 in 2009 and 8,016 in 2010, most commonly caused by OP and carbamate insecticides.[61]
- Sudan, 2011 – a study reported 27% poisoning rate among small vegetable farmers.[62]

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52 Miah SJ, Hoque A, Paul A, Rahman A. 2014. Unsafe use of pesticide and its impact on health of farmers: a case study in Burichong Upazila, Bangladesh. *IOSR-J Environ Sci Technol Food Tech* 8(1):57-67.

53 Banerjee I, Tripathi SK, Roy AS, Sengupta P. 2014. Pesticide use pattern among farmers in a rural district of West Bengal, India. *J Nat Sci Biol Med* 5(2): 313-6.

54 Singh A, Kaur MI. 2012. Health surveillance of pesticide sprayers in Talwandi Sabo area of Punjab, north-west India. *J Hum Ecol* 37(2):133-37.

55 Toe AM, Ouedraogo M, Ouedraogo R, Ilboudo S, Guissou PI. 2013. Pilot study on agricultural pesticide poisoning in Burkina Faso. *Interdiscip Toxicol* 6(4):185-91.

56 Tahir S, Anwar T. 2012. Assessment of pesticide exposure in female population living in cotton growing areas of Punjab, Pakistan. *Bull Environ Contam Toxicol* 89:1138-41.

57 Lee WJ, Cha ES, Park J, Ko Y, Kim HJ, Kim J. 2012. Incidence of acute occupational pesticide poisoning among male farmers in South Korea. *Am J Ind Med* 55(9):799-807.

58 Preza DLC, Augusto LGS. 2012. Farm workers' vulnerability due to the pesticide use on vegetable plantations in the Northeastern region of Brazil. *Rev Bras Saúde Ocup* (37):125.

59 Silveria-Monteiro CS, Silva JV, Vilela LP, Moraes MS. 2012.The exposure of farm workers to pesticides used in potato cultivation in Brazil. *Inj Prev* 17(Suppl 1):A163.

60 Marzban A, Sheikdavoodi MJ, Almassi M, Bahrami H, Abdeshahi A, Shishebor P. 2012. Pesticide application poisoning incident among Iranian rice growers and factors influence it. *Int Res J Appl Basic Sci* 3(2):378-82.

61 Uribe MV, Díaz SM, Monroy A, Barbosa E, Páez MI, Castro RA. 2012. Exposure to pesticides in tomato crop farmers in Merced, Colombia: human health and the environment. In: Soundarajan RP (ed). 2012. *Pesticides – Recent Trends in Pesticide Residue Assay*. InTech.

62 El-Hassan IM. 2011. Pesticide awareness in Sinnar state, case study: Abuhogar locality. *Sudan J Agric Res* 17:97-102.

Environmental impacts

Most environmental contamination with pesticides results from the very inefficient methods by which they are normally delivered to the target pests – largely spraying or seed coating. Both methods result in only a tiny fraction of the material applied reaching the target organisms, particularly in the case of insecticides, and a large proportion of the chemicals are left in the environment to affect other organisms.[63] These residues leach into groundwater, wash into streams, rivers and the marine environment, drift or, after evaporating, are carried by the air hundreds, even thousands of kilometres to be redeposited in the Arctic, Antarctic, and on the peaks of mountains such as the Himalayas. Pesticides now contaminate soil, water, air, rain, fog, snow, ice, flora, fauna, and humans throughout the world.[64]

The UN's Economic and Social Commission for Asia and the Pacific (ESCAP) reported in 2002 that in Thailand, *"an estimated 70 percent of applied pesticides is washed away and leaches into the soil and water, resulting in excessive pesticide residue contamination in the local ecology and food chain. It is not surprising to find a large amount of land and water in the country contaminated with pesticides".*[65]

Just as with humans, so too with wildlife: pesticides cause acute poisonings; disrupt their endocrine, immune and nervous systems; cause cancer, reproductive and developmental defects; and impair metabolic functioning and behaviour.[66] As a result of their widespread dispersal in the environment, pesticides result in reduced survival and reproductive rates and have been implicated in mass die-offs of marine mammals, birds, and fish,[67] and population crashes of amphibians and alligators.[68]

Unsafe pesticide spraying in Asia

These pesticide applicators are seriously exposed. Spraying cotton in Pakistan. *APP*

[63] (i) Jepson P. 2009. Assessing environmental risks. In: Radcliffe EB, Hutchison WD, Cancelado RE. 2009. *Integrated Pest Management*. Cambridge University Press. (ii) The Task Force on Systemic Insecticides. 2014. http://www.tfsp.info/worldwide-integrated-assessment

[64] See Watts MA. 2009. Endosulfan Monograph. PAN Asia and the Pacific. http://www.panap.net/sites/default/files/monograph_endosulfan.pdf

[65] UNESCAP. 2002. *Organic Agriculture and Rural Poverty Alleviation: Potential and Best Practices in Asia*. Economic and Social Commission for Asia and the Pacific, United Nations, New York.

[66] Köhler H-R, Triebskorn R. 2013. Wildlife ecotoxicology of pesticides: can we track effects to the population level and beyond? *Science* 341:759.

[67] *Ibid.*

[68] (i) Bruhl CA, Schmidt T, Pieper S, Alscher A. 2013. Terrestrial pesticide exposure of amphibians: an underestimated cause of global decline? Sci Rep 3:1135. (ii) Colborn T, Dumanoski D, Myers JP. 1996. *Our Stolen Future*. Little Brown, Boston.

Some action has been taken to reduce the environmental loading of some HHPs, for example bans on the production and use of some organochlorine insecticides via the Stockholm Convention. Some countries have banned other insecticides because of their effects on aquatic and terrestrial species. Regrettably, more often than not, these insecticides have been replaced by newer generation insecticides, such as fipronil and the neonicotinoids, which bring with them a whole new raft of environmental problems.

In 2009, for the first time, a team of scientists began to look closely at the impacts of some pesticides on the ecosystem as a whole; and in 2014 they published their findings. Known as the "Worldwide Integrated Assessment of Systemic Insecticides",[69] the study found that the class of systemic pesticides known as neonicotinoids (together with fipronil, another systemic insecticide), are posing a global threat to biodiversity and the ecosystem services on which our food production depends, including nutrient recycling, soil respiration, leaf litter decomposition, pollination, and biological pest control. These are now the most commonly used insecticides in the world, encompassing one third of the global market. As a result of this widespread use, together with these chemicals' persistence and solubility in water, systemic insecticides have contaminated agricultural soils, freshwater resources, wetlands, estuarine and marine systems, and non-target vegetation. Myriads of non-target and beneficial species are now acutely and chronically exposed to toxic concentrations of these insecticides.

They disrupt the functioning of diverse biological communities, including soil microbial communities that are the cornerstone of sustainable agriculture. They are causing a significant decline in beneficial insects, are a key factor in the decline of bees, and pose a serious risk to butterflies, earthworms and birds. Aquatic insects are also at risk. Residues found in water around the world regularly exceed toxicological limits. Some of the neonicotinoids are up to 10,000 times more toxic to insects than DDT. Through run-off and wind-blown dust from treated seeds, they have spread far beyond the farms on which they have been applied, the effects cascading through ecosystems and undermining their stability.

"The biological integrity of gobal water resources is at a substantial risk", according to a recent analysis of surface waters in 73 countries which found that levels of insecticides in the water exceeding regulatory threshold levels at 68.5 percent of the sites tested.[70]

These problems have all resulted from authorised use, based on the routine assessment

> ***"...agriculture must not compromise its ability to satisfy future needs. The loss of biodiversity, unsustainable use of water, and pollution of soils and water are issues which compromise the continuing ability for natural resources to support agriculture."***
>
> *Olivier de Schutter, UN Special Rapporteur on the right to Food, 2011*

Pesticides affect non-target organisms, reducing biodiversity. *Carina Weber, PAN Germany*

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[69] The Task Force on Systemic Insecticides. 2014. http://www.tfsp.info/worldwide-integrated-assessment

[70] Stehle S, Schulz R. 2015. Agricultural insecticides threaten surface waters at the global scale. *PNAS* 112(18):570-5.

Box 1.3: Key messages from the Task Force on Systemic Insecticides

"The systemic insecticides, neonicotinoids and fipronil, represent a new chapter in the apparent shortcomings of the regulatory pesticide review and approval process that do not fully consider the risks posed by large-scale applications of broad spectrum insecticides."

"Organophosphates have been largely withdrawn because of belated realization that they posed great risks to human and wildlife health."

"Because of the persistent and systemic nature of fipronil and neonicotinoids (and the legacy effects and environmental loading that come with these properties), these compounds are incompatible with IPM."

"The preferred options include organic farming, diversifying and altering crops and their rotations, inter-row planting, planting timing, tillage and irrigation, using less sensitive crop species in infested areas, using trap crops, applying biological control agents, and selective use of alternative reduced-risk insecticides."

"The short- and long-term agronomic benefits provided by neonicotinoids and fipronil are unclear. Given their use rates, the low number of published studies evaluating their benefit for yield or their cost-effectiveness is striking, and some recent studies … suggest that their use provides no net gain or even a net economic loss on some crops."

of risk to single species and the routine failure to assess wider ecological impacts and risk to the ecosystem as a whole. The 29 scientist authors, who reviewed over 800 scientific papers, concluded that there is need for worldwide regulatory action, suggesting *"a substantial reduction of the global scale of use"* and the *"need for policies and regulations to encourage the adoption of alternate agricultural strategies to manage pests (e.g. IPM, organic, etc.).*[71]

First global assessment of aquatic insecticide risk

The water bodies within 40% of the World's land area are vulnerable to insecticide run-off from agricultural use. Most at risk are Central America, S & SE Asia, the Mediterranean and USA.

Ippolito et al. 2015. Modeling global distribution of agricultural insecticides in surface waters. Environ Pollut 198:54-60

Accounting for the full costs of pesticides

"A significant portion of the chemicals applied [for pest control] has proved to be excessive, uneconomic or unnecessary", according to IAASTD, the International Assessment of Agricultural Knowledge, Science and Technology for Development, published in 2009.[72]

Alongside that enormous waste is the enormous cost to individuals, communities, and society as a whole from both human and environmental effects of the pesticides applied.

The health and environmental cost of pesticide use is now becoming a major international policy consideration. In 2013, UNEP published its ground-breaking report on the cost of inaction[73] on the sound management of chemicals, drawing

[71] van der Sluijs et al. 2015. Conclusions of the Worldwide Integrated Assessment on the risks of neonicotinoids and fipronil to biodiversity and ecosystem functioning. *Environ Sci Pollut Res* 22:148-54.

[72] AASTD. 2009. *Agriculture at a Crossroads: International Assessment of Agricultural Knowledge, Science and Technology for Development Global Report*. UNDP, FAO, UNEP, UNESCO, World Bank, WHO, GEF. Island Press, Washington, D.C.

[73] The concept of the costs of inaction was put forward by the Organisation for Economic Co-operation and Development (OECD) and was defined as "no new policies beyond those which currently exist", but UNEP describes it as also including "failure to enforce existing national and regional policies on sound management of chemicals or to implement international conventions and protocols"; it may also include lack of policies.

international attention to just how much current pesticide use (and other chemical problems) is costing countries in economic terms. Although all countries are affected, low-income countries bear a greater cost, in part because of poor management structures, and in part because HHPs that are banned in Europe and USA rapidly find their way to Africa, Asia and Latin America.

Box 1.4: The UNEP Cost of Inaction Report notes:[74]

- A conservative future risk scenario analysis suggests that accumulated health costs of acute injury alone to smallholder pesticide users in sub-Saharan Africa will increase to approximately US $97 billion by 2020, from US $4.4 billion in 2004.
- In 2009, the conservatively projected costs of inaction related to current pesticide use was greater than the total Official Development Assistance to general healthcare in Africa, excluding that for HIV/AIDS.
- Uganda: health costs from pesticides were estimated to be US $230 million in 2005.
- Mali: total yearly costs of US $242,861 to US $1.5 million from acute and chronic effects of pesticides.
- Zambia, Kafue basin: acute poisoning from pesticides used on cotton = US $2.1 million per year.
- In Europe, based on 2008 estimates, there is an estimated monetized value of US $15 million per year for hospitalisations, and US $3.9 million from lost work resulting from pesticide poisonings.
- The disappearance of bees and other pollinators would cost the UK economy up to £440 million per year and amount to 13% of the country's income from farming.

Studies carried out in other countries paint a similar picture, one of huge costs to human health from the use of pesticides:

- Brazil: acute poisoning, just for the state of Paraná, is estimated at US $149 million per year. For each $1 spent on pesticides, the costs from acute poisoning = $1.28.[75]
- Thailand: average external costs of pesticide use per year = US $27.1/ha, mainly costs to farm workers health (US $22.42/ha); the costs rise to US $105.75/ha for intensive horticulture.[76]
- China: the costs of pesticides in rice farming, to human health and biodiversity, were estimated in 2001 to be US $1.4 billion.[77]

Organic farming prevents pesticides entering water bodies. Kaarz, East Germany *Carina Weber, PAN Germany*

[74] UNEP 2013, *op cit*.

[75] Soares WL, de Souza Porto MF. 2012. Pesticide use and economic impacts on health. *Revista de Saúde Pública* 46(2):1-8.

[76] Praneetvatakul S, Schreinemachers P, Pananurak P, Tipraqsa P. 2013. Pesticides, external costs and policy options for Thai agriculture. *Environ Sci Pol* 27:103-13.

[77] Pretty J. 2008. Principles of agricultural sustainability: concepts, principles and evidence. *Phil Trans Biol Sci* 363(1491):447-65.

Pesticides travel far beyond their target organism resulting in significant external costs not paid by the user

> ***"…these costs – borne by all segments of society, including business, from the production, use, and disposal of harmful chemicals – are too high"***
>
> *UNEP 2013. Cost of Inaction*

- Chile: a 2014 study estimates the economic costs of the acute effects of pesticides could be as much as US $1.1 to 1.4 million per year.[78]

A number of attempts have been made to estimate the real costs of pesticide use in high-income countries as well. Based on figures originally published in 1992 and then updated in 2005, Emeritus Professor David Pimentel of Cornell University provided a comprehensive estimate of US $9.6 billion, per annum, in environmental and societal damages from pesticides in the United States (US), including public health impacts (see Table 1.1).[79] In his estimate, environmental, agricultural, and other costs to the economy are estimated to greatly exceed those of human health – by a factor of 7.46, at least in the U.S. Dr Adrian Leach and Professor John Mumford of Imperial College London estimated the costs, excluding chronic health effects, to be US $375 million for the UK and nearly US $1.5 billion for the US in 2005-06, averaging nearly US $17/kg of active ingredient in the UK, and US $3.5 in the US.[80]

Pesticides drift into waterways and homes

Climate change is expected to increase the costs associated with pesticide use. In 2009, Nikolinka Kovela and Uwe Schneider of Hamburg University calculated that the current average external cost of pesticide use in US agriculture was US $42 per hectare, but that under projected climate change this would increase to $72 per hectare by 2100.[81]

78 Ramírez-Santana M, Iglesias-Guerrero J, Castillo-Riquelme M, Scheepers PT. 2013. Assessment of Health Care and Economic Costs Due to Episodes of Acute Pesticide Intoxication in Workers of Rural Areas of the Coquimbo Region, Chile. *Value Health Regional Issues* 5:35-9.

79 Pimentel D, Burges M. 2014. Environmental and economic costs of the application of pesticides primarily in the United States. In: Pimentel D, Peshin R. 2014. *Integrated Pest Management: Pesticide Problems*, Vol 3. Springer, New York.

80 Leach AW, Mumford JD. 2008. Pesticide Environmental Accounting: A method for assessing the external costs of individual pesticide applications. *Environ Pollut* 151:139-47.

81 Koleva N, Schneider UA. 2009. The impact of climate change on the external cost of pesticide applications in US agriculture. *Int J Agric Sustain* 7(3):203-16.

Table 1.1: Estimated external costs of pesticides in the US[82]

IMPACT	US $ billions
Public health impacts	1.14
Domestic animal deaths and contaminations	0.03
Loss of natural enemies	0.52
Cost of pesticide resistance	1.50
Honeybee and pollination losses	0.33
Crop losses	1.39
Fishery losses	0.10
Bird losses	2.16
Groundwater contamination	2.00
Government regulations to prevent damage	0.47
TOTAL	**9.64**

One study in the Philippines found that *"the value of crops lost to pests is invariably lower than the cost of treating pesticide-related illness and the associated loss in farmer productivity. When health costs are factored in, the natural control option is the most profitable pest management strategy".*[83]

Of the 124 major commodity crops used for human consumption, 87 percent are dependent on pollinators for good yields. These crops provide

Of the 124 major commodity crops used for human consumption, 87 percent are dependent on pollinators for good yields

35 percent of global food production volume. In tropical regions, 70 percent of 1,330 tropical crops have varieties that have enhanced yields with animal pollinators. In Europe 84 percent of crop species and 12 percent of total production area depend on pollinators, representing 31 percent of EU income from crop production. The cost of a complete world loss of insect pollinators has been calculated to be about US $205 billion, 9.5 percent of the total value of crops produced globally for direct human consumption.[84] What, then, is the point in trying to increase food production with the use of pesticides that kill or harm the insect pollinators?

Table 1.2: Benefits and health costs of three pest management strategies in irrigated rice, Philippines (pesos/hectare)

Strategy	Returns	Health costs	Net benefit
Complete protection: standard 9 sprays/season	11,850	7,500	4,350
Economic threshold: treat only when this is passed, usually no more than 2 sprays	12,800	1,190	11,610
IPM: predator preservation, habitat management, resistant varieties, etc	14,000	0	14,000

82 Based on figures originally published in 1992, then updated in 2005, and republished in 2014 in Pimentel & Burges 2014, *op cit*.

83 Pingali PL, Roger PA. 1995. *Impact of Pesticides on Farmers' Health and the Rice Environment.* Kluwer Academic Press, Dordrecht. Cited in Pretty J, Bharucha ZP. 2015. Integrated pest management for sustainable intensification of agriculture in Asia and Africa. *Insects* 6:152-82.

84 Chagnon M, Kreutzweiser D, Mitchell EA, Morrissey CA, Noome DA, Van der Sluijs JP. 2015. Risks of large-scale use of systemic insecticides to ecosystem functioning and services. *Environ Sci Pollut Res Int* 22(1):119-34.

1.3 Replacing HHPs with ecosystem approaches to pest management

Replacing HHPs with ecosystem approaches to pest management rather than more pesticides makes sense.

Replacing one pesticide with a slightly less hazardous will not solve the myriad problems described in the preceding sections. In many countries the persistent organochlorines, like endosulfan and the highly toxic organophosphates, have been replaced by the neonicotinoids – trading one set of problems for another. This just keeps farmers trapped on the decades-old pesticide treadmill, perpetuating the endless cycle of replacing one chemical with another.

In March 2015, for example, several pesticides that had not been considered HHPs were assessed by the International Agency for Research on Cancer (IARC) and found to be problematic. IARC scientists determined that the herbicide glyphosate, for years widely regarded as 'safe', is in fact a 'probable human carcinogen'.[85] It is now on the PAN list of HHPs (see Box 1.5 for criteria for HHPs established by the FAO/WHO Joint Meeting on Pesticide Management (JMPM) and those of PAN).

IARC also found malathion to be a probable human carcinogen. This insecticide had not previously met the JMPM criteria[86] for an HHP, even though it is the pesticide most commonly involved in poisonings in Bangladesh. Data show it to be responsible for 25.8 percent of the identified pesticide poisoning admissions to hospital, with a mortality rate of 20 percent.[87] Carbosulfan, chlorpyrifos and cypermethrin have all caused acute poisoning of children in Nicaragua,[88] but they do not meet the JMPM criteria. Nor do the neonicotinoid insecticides and a range of other pesticides highly hazardous to bees. Replacing HHPs with any of these pesticides will not appreciably reduce the human and environmental costs to countries.

37 million bees dead after planting GMO maize in Canada

This is why many international organizations have been calling for some time for the replacement of HHPs with ecosystem approaches to pest management. As countries begin to phase out HHPs, if they can assist their farmers to change over to ecosystem approaches to agriculture instead of reaching for other pesticides, it will be better for the farmers, their community, the environment, the economy, and the country as a whole. Many studies demonstrate that farmers make more profit when they shift away from dependence on pesticides, and in addition the environment and their health improve.[89] The following chapters will describe various ecosystem approaches and give examples of how successful they are proving to be in terms of crop productivity, economic returns and improved social circumstances for farmers.

[85] Guyton KZ, Loomis D, Grosse Y, El Ghissassi F, Benbrahim-Tallaa L, Guha N, Scoccianti C, Mattock H, Straif K. 2015. Carcinogenicity of tetrachlorvinphos, parathion, malathion, diazinon, and glyphosate. *Lancet Oncol* 16(5):490-1.

[86] It did however meet the PAN criteria, but only for bee toxicity. Now it also meets PAN criteria for carcinogenicity.

[87] Dewan G. 2014. Analysis of recent situation of pesticide poisoning in Bangladesh: is there a proper estimate? *Asia Pac J Med Toxicol* 3:76-83.

[88] Corriols M, Aragón A. 2010. Child labour and acute pesticide poisoning in Nicaragua: failure to comply with children's rights. *Int J Occup Environ Health* 6(2):193-200.

[89] For more information on these benefits see Chapter 3.

Box 1.5: JMPM Criteria for HHPs

The JMPM criteria were established by an FAO/WHO group of experts in 2007, as follows:[90]

- Pesticide formulations that meet the criteria of classes Ia or Ib of the WHO Recommended Classification of Pesticides by Hazard; or
- Pesticide active ingredients and their formulations that meet the criteria of carcinogenicity Categories 1A and 1B of the Globally Harmonized System on Classification and Labelling of Chemicals (GHS); or
- Pesticide active ingredients and their formulations that meet the criteria of mutagenicity Categories 1A and 1B of the GHS; or
- Pesticide active ingredients and their formulations that meet the criteria of reproductive toxicity Categories 1A and 1B of the GHS; or
- Pesticide active ingredients listed by the Stockholm Convention in its Annexes A and B, and those meeting all the criteria in paragraph 1 of Annex D of the Convention; or
- Pesticide active ingredients and formulations listed by the Rotterdam Convention in its Annex III; or
- Pesticides listed under the Montreal Protocol; or
- Pesticide active ingredients and formulations that have shown a high incidence of severe or irreversible adverse effects on human health or the environment.

PAN International Criteria

The PAN criteria for HHPs were first established in 2008 and most recently updated in 2014. PAN chose to establish its own criteria because it regarded the JMPM criteria as having some important shortcomings, particularly the failure to include pesticides with endocrine disrupting properties, eco-toxicity, or inhalation toxicity. PAN then developed a full list of pesticides that qualify as HHPs under the hazard classifications selected (FAO/WHO have not yet provided a list of HHPs that meet JMPM criteria). Several private standards, including 4C Coffee, Rainforest Alliance and UTZ Certified, and at least one European retailer, now use the PAN criteria as a decision-making tool in their own pesticide policies. More information on the development of PAN's list can be found in the preamble to the list – refer footnote for internet location.[91] PAN criteria, in addition to the JMPM criteria:

- Fatal if inhaled (H330) according to GHS; or
- Endocrine disruptor, 'Suspected human reproductive toxicant' (Category 2) AND 'Suspected human carcinogen' (Category 2) according to GHS; or
- High environmental concern where two of the three following criteria are met:
  - i) **P** = 'Very persistent' half-life > 60 days in marine or freshwater or half-life > 180 days in soil ('typical' half-life), marine or freshwater sediment (indicators and thresholds according to the Stockholm Convention); and/or
  - ii) **B** = 'Very bioaccumulative' (BCF >5000) or Kow logP > 5 (existing BCF data supersede Kow log P data) (indicators and thresholds according to the Stockholm Convention); and/or
  - iii) **T** = Very toxic to aquatic organisms (LC/EC 50 [48h] for Daphnia spp. < 0.1 mg/l); or
- Hazard to ecosystem services, 'Highly toxic for bees' according to U.S. EPA (LD50, µg/bee < 2).

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[90] FAO, WHO. 2007. Report of the 1st FAO/WHO Joint Meeting on Pesticide Management and the 3rd Session of the FAO Panel of Experts on Pesticide Management. 22-26 October 2007, Rome. http://www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides/Code/JMPM_2007_Report.pdf

[91] PAN International List of Highly Hazardous Pesticides (PAN List of HHPs). June 2015. http://www.pan-germany.org/download/PAN_HHP_List_150602_F.pdf

2. Ecosystem approaches

It is becoming clear that small-scale agricultural units are best able to meet this challenge [climate change]: agroecology, organic farming and some other sustainable production methods that are respectful of nature show the way towards producing more and better quality food, but with less inputs, which are mostly locally available and based on closed nutrient cycles.

Jean Feyder, Ambassador, Former Permanent Representative of Luxembourg to the UN and WTO

Ecosystem approaches to pest management include agroecology, organics and ecosystem-based IPM. Whilst these approaches differ in some respects, they share a number of features including prevention of pest damage and diseases through maintenance of a healthy agroecosystem, prioritization of soil health as the key ingredient in a healthy agroecosystem, and use of pesticides of any sort only as a last resort.

Ecosystem approaches take a whole-systems approach to the management of the farm or agroecosystem, including but not limited to pest management. These approaches are based on established ecological principles and processes rather than reliance on chemical inputs. The resulting suite of sustainable practices includes the ways in which farmers manage their crop plants, soil, water and other natural resources, as well as the addition or conservation of useful ecological features in and around agricultural fields. Ecologically-based farm design and practices can support and amplify natural processes for keeping insect pests, plant diseases and weeds in check.

Modern agriculture has failed to alleviate hunger; soybean harvest at a farm in Campo Verde, Brazil. *Shutterstock*

2.1 International support for ecosystem approaches

Since 2009 a number of high-level international bodies and studies have confirmed that the current model of intensive agriculture, based on high use of external inputs such as pesticides, synthetic fertilizers, fossil fuels and irrigation, must change if the global community is to feed itself and future generations. The 2002 Millennium Development Goal of reducing by half the proportion of people who suffer from hunger by 2015, has not been met by high-input intensive agricultural production. According to UNCTAD, *"the current system of industrial agriculture … still leaves about 1 billion people undernourished and poverty*

stricken".[92] Recognising this, the outcome document from the Rio + 20 United Nations Conference on Sustainable Development ("The Future We Want") stated that in *"affirming the necessity to promote, enhance and support more sustainable agriculture… [we] recognize the need to maintain natural ecological processes that support food production systems".*[93]

A number of landmark international conferences, global assessments and expert reports highlight the critical role of agroecology in addressing hunger and advancing sustainable development. The most recent event to underscore the necessity for a global shift in agriculture was the International Symposium on Agroecology for Food Security, hosted in Rome by the FAO, in September 2014.[94] Key findings from several of these international expert convenings are summarized below.

> ***"… agriculture ensures the delivery of a range of ecosystem services. In view of a globally sustainable form of development, the importance of this role may increase and become central for human survival on this planet."***
>
> *IAASTD Global Report, p15*

"Business as usual is not an option"; *Iowa, US*

2009: IAASTD – International Assessment of Agricultural Knowledge, Science and Technology for Development

The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) was initiated in 2002 by the World Bank and six UN agencies as a global consultative process to provide decision makers with the information they need to:

- Reduce hunger
- Improve rural livelihoods, human health and nutrition
- Promote equitable and socially, environmentally and economically sustainable development[95]

The IAASTD was a truly multi-stakeholder process involving FAO, GEF, UNDP, UNEP, WHO, UNESCO and representatives of governments, civil society, private sector, and scientific institutions from around the world.[96] The final report, "Agriculture at a Crossroads", was authored by over 400 of the world's scientists and development experts who assessed the evidence from the past

96 History of the IAASTD. http://www.unep.org/dewa/agassessment/

92 Hoffmann U. 2014. Agriculture at a crossroads: assuring food security in developing countries under the challenges of global warming. UNCTAD Secretariat. In: UNCTAD, 2013, *Wake Up Before it is Too Late: Make Agriculture Truly Sustainable Now for Food Security in a Changing Climate.* United Nations Conference on Trade and Development.

93 http://www.uncsd2012.org/content/documents/727The%20Future%20We%20Want%2019%20June%201230pm.pdf

94 FAO. 2015. Final Report for the International Symposium on Agroecology for Food Security and Nutrition. 18 and 19 September 2014, Rome, Italy. http://www.fao.org/3/a-i4327e.pdf

95 McIntyre BD, Herren HR, Wakhungu J, Watson RT (eds). 2009. Agriculture at a Crossroads. IAASTD International Assessment of Agricultural Knowledge, Science and Technology for Development Global Report. UNDP, FAO, UNEP, UNESCO, The World Bank, WHO, GEF. Island Press, Washington, D.C. http://www.unep.org/dewa/Assessments/Ecosystems/IAASTD/tabid/105853/Default.aspx

> ***"Under a business-as-usual scenario, we can anticipate an average of 2 per cent productivity decline over each of the coming decades, with yield changes in developing countries ranging from -27% to +9% for the key staple crops."***
>
> *Olivier de Schutter, Final Report to the UN Human Rights Council, January 2014*

50 years of agriculture and evaluated prospects for the next 50 years.

The IAASTD concluded that *"Business as usual is no longer an option"*[97] and that the current energy-intensive industrial model of agriculture is outdated, unsustainable and exacerbates social inequality.

The IAASTD documented how global and national food insecurity is likely to worsen if market driven industrial agricultural production systems continue to grow in 'a business as usual mode' (p24), while neither environmental sustainability nor social equity will be achieved (p. 28), continuing the cycle of hunger and poverty.

Looking towards the future, the report concluded that a shift from current farming practices to sustainable agricultural systems capable of providing significant productivity increases, social equity and enhanced ecosystem services is not only urgently required, but also eminently possible. Productivity per unit of land and per unit of energy use is much higher in small-scale and diversified farms than in large intensive farming systems.[98] Political, economic and institutional support for peasant farmers and their organizations, including in particular women farmers, can help rebalance power in the food system and improve small-scale farmers' access to and control over resources (e.g. seeds, land, water, energy), ensuring the advances in social equity that are a foundational requirement of sustainable development.

2011, 2013, 2014: UN Special Rapporteur on the right to food

In 2011, Olivier de Schutter, the UN Special Rapporteur on the right to food, delivered a report to the 16th Session of the UN Human Rights Council on agroecology and the right to food.[99] Based on an extensive review of recent scientific literature, the report demonstrated that agroecology is highly productive and, if sufficiently supported, could double food production in entire regions within 10 years, at the same time mitigating climate change and alleviating rural poverty. It can increase farm productivity and food security, improve incomes and rural livelihoods, and reverse the trend towards species loss and genetic erosion. The main challenge, he said, is scaling up successful experiences with agroecology, to become the mainstream form of agriculture.

In 2013, de Schutter reiterated in the UNCTAD report "Wake Up Before it is Too Late" his view that agroecology is the solution to the dual crises of food systems and climate change, that it can significantly increase agricultural productivity where it is most needed, while at the same time improving livelihoods of smallholder farmers and conserving ecosystems.[100]

In his final report as UN Special Rapporteur on the right to food in 2014,[101] Olivier de Schutter

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97 IAASTD Synthesis report pp 3, 8, 28, 65.

98 *ibid*, p22.

99 De Schutter O. 2011. Agroecology and the Right to Food. United Nations Special Rapporteur on the Right to Food. A/HRC/16/49. http://www.srfood.org/index.php/en/component/content/article/1174-report-agroecologyand-the-right-to-food

100 De Schutter O. 2013. Agroecology: A solution to the crises of food systems and climate change. In: UNCTAD 2013, *Wake Up Before it is Too Late: Make Agriculture Truly Sustainable Now for Food Security in a Changing Climate,* United Nations Conference on Trade and Development.

101 De Schutter O. 2014. Report of the Special Rapporteur on the right to food. Final report: the transformative potential of the right to food. Human Rights Council, Twenty-fifth session. United Nations General Assembly. A/HRC/25/57.

"…agroecological / organic farming can achieve high production efficiencies on a per area basis and high energy use efficiencies and on both these criteria they may out perform conventional industrial farming.."

IAASTD Global Report, p67

Trees within cotton and maize fields provide fruits, fodder for livestock and prunings that can be used for compost or mulch; smallholder farm, Ethiopia. *PAN UK*

concluded that, "as a way to improve the resilience and sustainability of food systems, agroecology is now supported by an increasingly broad part of the scientific community."

> *"There are strong environmental arguments in favour of agroecology. But agroecology also provides other social and health benefits. Diverse farming systems contribute to more diverse diets for the communities that produce their own food, thus improving nutrition. Because agroecology reduces the cost of farming by minimizing the use of expensive inputs, it improves the livelihoods of farming households, particularly the poorest households. And it supports rural development: because it is knowledge-intensive and generally more labour-intensive, it creates employment opportunities in rural areas. Though easier to implement on smaller-sized farms, agroecological techniques can be disseminated on a large scale, and should also inspire reforms in how large production units operate."*

In her debut speech in September 2014 as the new UN Special Rapporteur on the right to food, Professor Hilal Elver reiterated the message that governments must shift their focus from industrial agriculture to agroecology, which she described as offering far more environmentally and socially sustainable methods of production that can still meet the rapidly growing demand for food. *"Agroecology is a traditional way of using farming methods that are less resource oriented, and which work in harmony with society. New research in agroecology allows us to explore more effectively how we can use traditional knowledge to protect people and their environment at the same time." …*[102]

MASIPAG organic farmers using wooden weeders in rice fields. *Achim Pohl*

[102] Ahmed N. 2014. UN: Only small farmers and agroecology can feed the world. Ecologist Sept 23rd. http://www.theecologist.org/News/news_analysis/2566719/un_only_small_farmers_and_agroecology_can_feed_the_world.html

2011, 2013: UNCTAD

In 2011, the United Nations Conference on Trade and Development (UNCTAD) published a discussion paper on agriculture, food security and trade by its secretariat member, Senior Economic Affairs Officer Ulrich Hoffmann.[103] Hoffmann stated that:

> *"What is required is a rapid and significant shift from conventional, industrial, monoculture-based and high-external-input-dependent production towards mosaics of sustainable production systems that also considerably improve the productivity of small-scale farmers. The required transformation is much more profound than simply tweaking the existing industrial agricultural systems."*

Hoffmann goes onto say that *"one of the most effective ways of halving both the number of hungry and poor … is to take the necessary steps towards more sustainable forms of agriculture that nourish the land and people and provide an opportunity for decent, financially rewarding and gender equal jobs."* He gives as examples of these sustainable forms of agriculture organic farming, low external input sustainable agriculture, and agroecological and biodynamic production systems. He concluded that, agricultural greenhouse gas emissions are predicted to rise by almost 40 percent by 2030, and that further chemicalization and industrialization of agricultural production will exacerbate this. He also commented that:

"Undoubtedly, there are very powerful vested interests by large globally active companies that dominate the agricultural input markets to keep the status quo of high external input dependent agricultural production methods. … To profoundly transform agriculture towards the above-outlined mosaic of sustainable (regenerative) practices takes bold and visionary measures."

> ***"Agroecology simultaneously addresses food production and security and provision of ecosystem services and maintenance of natural resource base."***
>
> *FAO. 2015. Report for the International Symposium on Agroecology*

In 2013, UNCTAD published a set of papers, titled "Wake Up Before it is Too Late: Make Agriculture Truly Sustainable Now for Food Security in a Changing Climate".[104] One of the key messages, was, as in 2011:

"The world needs a paradigm shift in agricultural development from a 'green revolution' to an 'ecological intensification' approach."

Numerous papers in the UNCTAD report identified that the best way to feed the malnourished and the best way to meet the challenge of climate change is to base agricultural production on ecosystem approaches. For example:

- *"The only agricultural system that will be able to cope with future challenges is one that will exhibit high levels of diversity and resilience while delivering reasonable yields and ecosystem services. Many traditional farming systems still prevalent in developing countries can serve as models of sustainability and resilience."* Miguel Altieri, University of California, Berkeley, and Parviz Koohafkan, FAO.
- *"The case for a change in paradigm is well documented. Merely fine-tuning the present*

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[103] Hoffmann U. 2011. *Assuring Food Security in Developing Countries under the Challenges of Climate Change: Key Trade and Development Issues of a Fundamental Transformation of Agriculture*. United Nations Conference on Trade and Development.

[104] UNCTAD 2013, *op cit*.

systems or redefining the status quo with new terms such as "sustainable crop production intensification: or "climate smart agriculture", among others will not bring about the paradigm shift needed. … Agroecology has the proper foundations to support the needed transition from where we are today to where we need to be by 2050, with all our agriculture, whether it is small or large-scale, both at the local and global levels." Hans Herren, President, Millennium Institute and Co-Chair, International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD).

- *"Industrial agriculture is unsustainable, and technological adjustments based on genetic engineering have not been able to achieve the relevant Millennium development goals… Alternative agricultural models, such as agroecology, demonstrate potential to reduce poverty, increase food security, lower external inputs, boost farmers' incomes and are based on technologies that, for the most part, can be understood, implemented and further modified by poor and subsistence farmers."* Jack Heinemann, Centre for Integrated Research in Biosafety and School of Biological Sciences, University of Canterbury, New Zealand.

2012-13: FAO – Rio+20

In reference to global agricultural production, the Rio +20 document produced by FAO as part of the preparations and follow up to the 2012 UN Conference on Sustainable Development, stated that:[105]

There is wide recognition that business-as-usual is not an option, that things need to change to attain food security while allowing future generations to meet their own needs. Agro-ecology, practiced by small-scale farmers, has demonstrated empirically its potential to achieve sustainability aims. It is not based on agronomic and technological fixes but rather on the ecological processes that underlie food production, involving in-depth knowledge of the interactions between what is produced, the soils and associated biodiversity.

"Agroecology has been proven to deliver sustainable livelihoods to smallholders."

Director General of FAO, at the International Symposium on Agroecology, 2014

Dungbeetles, part of the ecosystem service of nutrient recycling. *PAN UK*

2013: UNEP – Stockholm Convention On Persistent Organic Pollutants (POPs)

In 2012, the POPs Review Committee of the Stockholm Convention analysed both chemical and nonchemical alternatives to endosulfan. In all, 110 insecticides were studied; some were found to have POPs properties; some met the criteria for HHPs. In 2013, the Conference of the parties to the Stockholm Convention agreed that priority

105 Wolfenson KD. 2013. Coping with the food and agriculture challenge: smallholders' agenda. Preparations and outcomes of the 2012 United Nations Conference on Sustainable Development (Rio+20). FAO, Rome.

should be given to ecosystem-based approaches to pest management in replacing endosulfan.[106] This is the first time a UN chemicals convention has made such a recommendation and it is seen as an important step in recognizing that pesticides are inherently hazardous and there is a better approach to managing pests and producing food.

2014, 2015: FAO International and Regional Symposium on Agroecology

FAO hosted the first International Symposium on Agroecology for Food Security in Rome in September 2014.

The combination of farmers' stories of transformation told at the symposium, and the wealth of scientific evidence from decades of research, point us towards agroecology as the most promising way forward — the best option for building a truly equitable, resilient and sustainable food and farming system.

In his plenary address, FAO Director-General José Graziano da Silva agreed with the 400-plus scientists and experts attending the symposium that agroecology has been *"proven to deliver"* and offers *"win-win solutions to increase productivity, improve resilience and make more efficient use of natural resources."* He said: *"Agroecology continues to grow, both in science and in policies. It is an approach that will help to address the challenge of ending hunger and malnutrition in all its forms, in the context of the climate change adaptation needed."*[107]

In a letter to the FAO, over 70 international scientists and scholars working in sustainable agriculture and food systems called for a UN system-wide initiative on agroecology as the central strategy for addressing climate change and building resilience in the face of water crises.

"The Symposium has opened an alternative window within the FAO Headquarters, the 'Cathedral of the Green Revolution'; today, the paradigm of the Green Revolution is showing weaknesses and for this reason, we are seeking new alternatives."

Director General of FAO

Organic vegetables, Costa Rica. *Fernando Ramirez*

The symposium generated a call for FAO to lead a global process for enabling the adoption of agroecology. The Director General of FAO responded by stating that he will propose to the United Nations Secretary General to *"launch a United Nations system-wide initiative on agroecology"*.[108]

Director-General Da Silva also announced FAO's commitment to launching regional symposia on agroecology in Latin America, Africa and Asia, in 2015. The first such symposium took place in Brasilia, in June 2015, co-hosted by the Brazilian government.

The participants at the Latin American symposium including representatives of the

106 UNEP. 2012. Evaluation of non-chemical alternatives to endosulfan. Persistent Organic Pollutants Review Committee. UNEP/POPS/POPRC.8/INF/14/Rev.1.

107 In: Ahmed 2014, *op cit*.

108 FAO. 2015. Final Report for the International Symposium on Agroecology for Food Security and Nutrition. 18-19 September 2014, Rome. http://www.fao.org/3/a-i4327e.pdf

> ***"An organization like FAO should lead a global process in Agroecology."***
> *– H.E. EU Agriculture Commissioner Ciolos*

governments of Latin America and the Caribbean, as well as of social movements and the academic sector, united in urging all governments of the region, and all relevant intergovernmental and international organizations, to take 17 concrete actions to promote agroecology at all levels.[109] These recommendations included action to, among other things:

- *"Promote public policies which boost agroecology and food sovereignty; defined, implemented and monitored with active participation of social movements and civil society groups, assuring the necessary budget for its implementation"*
- *"Formulate and implement legal frameworks and regulations which are favorable to agroecology, in order to achieve food sovereignty"*
- *"Create conditions which restrict the practice of monoculture, the use of agro chemicals and concentration of land, in order to foster the increase of agroecological production by smallholder farmers in the region of Latin America and the Caribbean"*
- *"Recognize the multifunctional role that rural small-holder agroecology plays in preserving soils, water, biodiversity as well as other ecological functions, guaranteeing environmental preservation in a socially inclusive and economically just manner"*

The recommendations were agreed by the Government of Brazil, FAO, the regional organization Community of Latin Amercia and

Agroecological coffee grove with plantain, ground cover and diverse vegetation, Central America. *Stephanie Williamson*

Caribbean (CELAC), the sub-regional family farming forum Reunião Especializada sobre Agricultura Familiar (REAF) and the alliance for food sovereignty, Alianza por la Soberanía Alimentaria de los Pueblos.

2.2 What are ecosystem approaches?

As stated at the beginning of this chapter, there are a number of approaches to pest management that can be described as ecosystem approaches, including agroecology, organics and ecosystem-based IPM. Other terms are also in use. This section does not aim to describe them all or to

109 FAO, CELAC, REAF, ASAPALC, Ministério do Desenvolvimento Agrário & Governo Federal Brasil. 2015. *Final recommendations of the Regional Seminar on Agroecology in Latin America and the Caribbean*. June 26, 2015. http://www.fao.org/americas/eventos/ver/en/c/287503/

make a detailed comparison but to give a flavour of the different approaches and identify common principles where these exist. Chapters 5 to 9 describe in detail, through real-world examples, how different approaches have been put into practice in specific contexts.

Agroecology

Agroecology has been described as *"a well-grounded science, a set of time-tested agronomic practices and, when embedded in sound socio-political institutions, the most promising pathway for achieving sustainable food production".*[110] Possibly the most widely used definition is that coined twenty years ago by Miguel Altieri, an entomologist at the University of California Berkeley: agroecology is ***"the application of ecological science to the study, design, and management of sustainable agriculture".***[111]

Agroecology, the science behind sustainable agriculture, combines scientific inquiry with indigenous and community-based research in farmers' fields.[112] It brings together formal science with farmers' local knowledge and experimentation, emphasizing technology and innovations that are knowledge-intensive, low cost, ecologically sound and practical. By listening to farmers, and using the most up-to-date science, agroecology provides a modern framework for thinking broadly about agriculture in terms of its four key systems properties: productivity, resilience, equity and sustainability.

Agroecological farming encourages the cultivation of resilience and maintenance of healthy ecosystem function instead of reliance on external inputs of synthetic chemical pesticides, fertilizers and fossil fuels that have high energy, environmental and health costs. The approach is thus well-suited to withstanding environmental and economic stresses posed by climate change, shifting pest pressures, and volatility in petroleum and commodity prices. These methods are also considered likely to advance social equity, sustainability and agricultural productivity over the long term.[113]

"In the Nilgiris mountains of Southern India, where food security is highly dependent on rainfall patterns, agroecological practices such as soil conservation, integrated management of pests and micro-irrigation have contributed to reducing dependency of the farming system on weather events."

Report of the FAO Symposium on Agroecology, 2014

The mosaic of a diverse mix of crops and natural vegetation in smallholder farms can host many useful natural enemies and wildlife, Ethiopia. *PAN UK*

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110 Scientists' support letter for the International Symposium on Agroecology, 18-19 September, 2014. http://www.iatp.org/documents/scientists%E2%80%99-support-letter-for-the-international-symposium-on-agroecology-18%E2%80%9319-september-

111 Altieri MA. 1995. *Agroecology: The Science of Sustainable Agriculture.* 2nd ed. Westview Press, Boulder, CO. In: Parmentier S. 2014. *Scaling-up Agroecological Approaches: What, Why and How?* Oxfam-Solidarity, Belgium.

112 PANNA. 2009. Agroecology and Sustainable Development: Findings from the UN-led International Assessment of Agricultural Knowledge, Science and Technology for Development. http://www.panna.org/resources/iaastd-agriculture-crossroads

113 PANNA 2009, *op cit.*

Agroecological farming supports the multifunctional dimensions of agriculture, which include not only food, jobs and economic well-being, but also culture, social and environmental benefits, and ecosystem services like pollination, natural pest control, nutrient and water cycling and erosion control. Perhaps most critically, agroecology strengthens ecological and economic resilience in the face of today's climate, water and energy crises, and encourages democratic, decentralized decision-making by farmers.[114]

<u>*Agroecology as explained by Olivier de Schutter*</u>[115]

From a biological standpoint, agroecology supports improvement of agricultural systems by mimicking or augmenting natural processes, thus enhancing beneficial biological interactions and synergies among the components of agro-biodiversity. The common principles of agroecology are:

- Adapting to the local environment
- Assuring favourable soil conditions for plant growth and recycling nutrients
- Diversifying species and genetic resources in the agroecosystem over time and space, from the field to landscape level, including integrating crops and livestock
- Enhancing biological interactions and productivity throughout the agricultural system, rather than focussing on individual species
- Minimizing losses of water and energy
- Minimizing the use of non renewable external resources (e.g. for nutrients and pest management)
- Maximizing the use of farmers' knowledge and skills

Making botanical preparations for agroecological pest management. *Alter Vida Comunicación*

Organic agriculture and food security in Africa:

"The evidence presented in this study supports the argument that organic agriculture can be more conducive to food security in Africa than most conventional production systems, and that it is more likely to be sustainable in the long term."

Supachai Panitchpakdi, Secretary General of UNCTAD, and Achim Steiner, Executive Director of UNEP. 2008. Foreward to Organic Agriculture and Food Security in Africa. UNEP-UNCTAD Capacity-building Task Force on Trade, Environment and Development.

From a social, cultural, and institutional standpoint, agroecology is highly knowledge-intensive, based on techniques that are not delivered top-down but developed on the basis of farmers' knowledge and experimentation.

Agroecology also embraces social dimensions such as gender justice, access to land

114 *ibid*.

115 De Schutter O. 2013. Agroecology: A solution to the crises of food systems and climate change. In: UNCTAD 2013, *op cit*, citing Altieri MA, 2002, Agroecology: the science of natural resource management for poor farmers in marginal environments, *Agric Ecosys Environ* 93:1-24.

and productive resources, access to markets, and greater farmer empowerment in the global food system.[116] As such it is endorsed by the IAASTD, the former and current UN Special Rapporteurs on the Right to Food, the 10,000-member Ecological Society of America, the Latin American Society for Agroecology, La Vía Campesina (the world's largest organization of farmers),[117] research institutions, and others including the over 70 scientists and experts who endorsed the letter to the FAO in support of its symposium on agroecology,[118] and those who have signed the open letter spearheaded by the US-based Union of Concerned Scientists calling for public investment in agroecological research.[119]

Agroecologists recognise the major forces[120] that shape current agricultural changes, and use agroecological principles to re-design small farming systems so that they can respond to these forces in a way that gives farmers the best chances of being sustainable. Being sustainable means:[121]

- Long-term economic viability, social equity, and cultural diversity
- Enhanced resilience to absorb climate shocks and other external forces
- Enhancement of biodiversity and ecosystem services, and conservation of natural resources
- Optimization of natural cycles and reduced dependency on non-renewable resources
- Prevention of land and general environmental degradation

Organic agriculture

Organic agriculture only accounts for a very small proportion of total global production at present. However, the share is increasing every year, and growth rates are excellent in some sectors and countries; for example, although the area of organic cocoa cultivation represents only

Organic potato cultivation, Zarcaero, Costa Rica.
Fernando Ramirez

116 See for example: (i) Castillo GE, Parmentier S, Chinotti E, Munoz E, Ninh L, Tumusiime E. 2014. *Building a New Agricultural Future: Supporting agro-ecology for people and the planet.* Oxfam Issue Briefing. (ii) Altieri MA, Toledo VM. 2011. The agroecological revolution in Latin America: rescuing nature, ensuring food sovereignty and empowering peasants. *J Peasant Studies* 38(3):587-612.

117 La Via Campesina is an international movement which brings together millions of peasants, small and medium-size farmers, landless people, women farmers, indigenous people, migrants and agricultural workers from around the world. It comprises about 150 local and national organizations in 70 countries in Africa, Asia, Europe and Latin America, representing about 200 million farmers in total; and is recognised as a main actor in food and agricultural debates (Wolfenson 2013, *op cit*).

118 Scientists' support letter 2014, *op cit.*

119 Allen et al. 2014. Scientists Call for Public Investment in Agroecological Research. Union of Concerned Scientists. http://www.ucsusa.org/our-work/food-agriculture/solutions/advance-sustainable-agriculture/scientists-call-public-investment-agroecology#.VPYrKcZWX5k

120 These include: population increase and dynamics, global market forces, advances in science and technology, climate change and variability, consumer demands, agricultural subsidies and pressures from social movements demanding food sovereignty, land reform and poverty reduction (Altieri MA, Funes-Monzote FR, Petersen P. 2012. Agroecologically efficient agricultural systems for smallholder farmers: contributions to food sovereignty. *Agron Sustain Dev* 32:1-13.

121 Altieri et al 2012, *op cit.*

Table 2.1 Organic Indicators

Indicator	World	Leading countries
Organic agricultural land	43.1 million ha	Australia (17.2 mill) Argentina (3.2 mill)
Share of total agricultural land certified organic	0.98%	Falkland Is (36.3%) Liechtenstein (31%)
Certified for organic wild collection (berries, honey, herbs, nuts, etc)	35.1 million ha	Finland (9 mill) Zambia (6.1 mill) India (5.2 mill)
Number of producers	2 million	India (650,000) Uganda (189,610) Mexico (169,703)

Source: Willer H, Lernoud J. 2015. The World of Organic Agriculture. Statistics and Emerging Trends 2015. FiBL-IFOAM Report. Research Institute of Organic Agriculture (FiBL), Frick, and IFOAM-Organics International, Bonn.

2.3 percent of total cocoa cultivation, the growth rate is 10 percent per annum. Australia had a 53 percent growth rate in organics between 2011 and 2014, and has the largest area of organic farmland in the world, reflecting the huge size of its certified organic beef rangeland. In 2013, 170 countries had organic producers, with 11 of them having more than 10 percent of total farmland in certified organic production. Key organic crops in Africa are coffee, olives, nuts, cocoa, oilseeds, and cotton.[122]

Children deserve organic food; David Dapon says 'no to pesticides'. *Romy Quijano*

Organic agriculture differs from agroecology mainly in that it has a set of prescribed standards and auditing processes to ensure those standards are met by farmers before they can carry a certification mark, which usually earns premium prices in markets. Additionally, it prohibits the use of synthetic chemical and genetically engineered inputs, and restricts some other inputs. Organic production relies on ecological processes, biodiversity, natural cycles and adaption to local conditions, striving for ecological balance through the design of farming systems, and maintenance of genetic and agricultural diversity.[123]

Although many farmers practice organic agriculture in a manner consistent with agroecology, in other places, particularly some high income countries, organics has become more like industrial agriculture minus the chemical inputs and GE, and with greater use of biological controls; perhaps the two approaches could be described as biodiverse organics, and monocultural organics. In either approach, farmers can make significant profits over and above those of chemical-input farmers.

122 Willer H, Lernoud J. 2015. The World of Organic Agriculture. Statistics and Emerging Trends 2015. FiBL-IFOAM Report. Research Institute of Organic Agriculture (FiBL), Frick, and IFOAM-Organics International, Bonn.

123 IFOAM. Principles of Organic Agriculture. http://www.ifoam.org/sites/default/files/ifoam_poa.pdf

Organic standards do not embrace all the social dimensions of agroecology, although they do embody the principle of fairness as *"characterized by equity, respect, justice and stewardship of the shared world, both among people and in their relations to other living beings"*.[124] And, as with agroecology, organics fosters beneficial interactions with the natural ecosystems and cycles, focusing on enhancing the life-supporting capacity of the soil, and minimising the use of external inputs.[125] Biodiverse organics, like agroecology, enhances resilience and adaptivity. In fact, the two systems are not mutually exclusive: many of those practising agroecology could also be certified organic; many of those practising organic agriculture are using agroecological practices.

A 2008 study of organic agriculture and food security in Africa concluded that organic agricultural methods can increase agricultural productivity and raise incomes among farmers on the continent. The researchers found that organic production is ideally suited to any poor, marginalised smallholder farms in Africa, and can make a significant contribution to the reduction in poverty and food insecurity, whilst building up natural resources, strengthening communities and improving human capacity.[126]

Box 2.1: Organic cotton production in India – more profitable than conventional

A comparison of agronomic data from 60 organic and 60 conventional farms over 2 years, 2004-2005, concluded that:

* variable production costs were 13-20% lower on organic farms
* costs of inputs were 40% lower
* yields were 4-6% higher
* gross margins were 30-43% higher

Although there was no price premium for the crops grown in rotation with cotton, organic farmers earned 10-20% higher incomes than conventional farmers.[127]

A survey of 125 organic cotton farmers found an average of 15% increase in income for 95% of the respondents, mainly due to reduced costs of production and increased prices.[128]

A survey in Andhra Pradesh found that the average net income of organic cotton farmers was +US $32/ha whereas that of conventional cotton farmers was – US $74/ha.[129]

Permaculture

Permaculture is an internationally applied system of agricultural design based on modelling ecosystem processes. It is defined by one of its originators, David Holmgren, as *"Consciously designed landscapes which mimic the patterns and relationships found in nature, while yielding an abundance of food, fibre and energy for provision of local needs".* Permaculture emphasizes perennial

124 The IFOAM Norms for Organic Production and Processing Version 2014. International Federation of Organic Agricultural Movements.

125 Principles of Organic Production, Module 1, BioGro Organic Standards. BioGro New Zealand. http://www.biogro.co.nz/import/default/files/module-1.pdf

126 Hine R, Pretty J, Twarog S. 2008. Organic Agriculture and Food Security in Africa. UNEP-UNCTAD Capacity-building Task Force on Trade, Environment and Development. United Nations Conference on Trade and Development and United Nations Environment Programme. http://unctad.org/en/docs/ditcted200715_en.pdf

127 Nemes N. 2013. Comparative analysis of organic and non-organic farming systems: a critical assessment of farm profitability. In UNCTAD 2013, *Trade and Environment Review 2013: Wake Up Before it is Too Late*. Citing Eyhorn, Ramakrishan and Madder, 2007. The viability of cotton-based organic farming systems in India. *Int J Agric Sustain* 5(1):25-38.

128 Nemes 2013, *op cit*. Citing MacDonald 2008. Agri-impact assessment – II: more from the cotton fields. Agrocel Industries Ltd.

129 Nemes 2013, *op cit*. Citing Raj et al 2005. Case study on organic versus conventional cotton in Karimnagar, Andhra Pradesh, India. Second International Symposium on Biological Control of Arthropods.

crops as opposed to annual crops, aiming for the diversity, stability and resilience of natural ecosystems. It employs many of the approaches of agroecology, such as agroforestry, integrating landscape, people and production into a whole system.[130]

Sustainable Crop Intensification

Sustainable crop intensification involves *"techniques that produce more output from the same area of land while reducing negative environmental impacts and enhancing natural capital and the flow of environmental services".*[131] In 2011, FAO published "Save and Grow: A Policymakers Guide to the Sustainable Intensification of Smallholder Crop Production", in order to assist the shift from the homogenous model of crop farming dependent on pesticides ('business-as-usual') to farming systems that conserve the natural resource base while intensifying production.

As with agroecology and organics, it relies on ecosystem management rather than external inputs, with the first line of defence against pests being a healthy agroecosystem. It embraces knowledge-intensive, location-specific farming systems based on improved plant health through sound ecosystem management, in particular through the application of ecologically-based Integrated Pest Management (IPM) systems. An ecosystem-based IPM approach to pest management uses inputs such as land, water, seed and fertilizer to complement the natural processes that support plant growth including pollination, natural predation for pest control, and the action of soil biota that allows plants to access nutrients. FAO's Community IPM approach reflects its emphasis on the development of sustainable management by rural communities of their agricultural and ecological resources. The broad philosophy of the Community IPM approach is to assist farmers to act on their own initiative and analysis, and to identify and resolve problems themselves in a manner that promotes a sustainable agricultural system.

Many agroecological agronomic practices can be used in this approach. Indeed, FAO's perspective is very much ecosystems focused, incorporating experiences from Farmer Field Schools (FFS) and community-centred conservation agriculture. However, the sustainable intensification agendas of many other organizations appear to have hijacked the terminology and have focused on 'business-as-usual' technology-based approaches consistent with input intensive agriculture, with a few small changes, rather than on proper ecosystem approaches.[132]

Organic Cotton Production, Uganda

In Uganda, the majority of cotton farmers are small-scale resource-poor farmers. In 1994 there were only 200 organic cotton farmers; by 2000, there were 24,000. Organic cotton producers were achieving yields of 1,000-1,250 kg/ha of seed cotton, giving them approximately 300-320 kg of cotton lint. They have started to obtain cotton yields comparable to conventional farming systems, and in addition they get an average price premium of 15-20% at the farm gate. The economical viability has tempted many farmers into organic production.

Hine R, Pretty J, Twarog S. 2008 Organic Agriculture and Food Security in Africa. UNEP-UNCTAD Capacity-building Task Force on Trade, Environment and Development

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130 Fergusson RS, Lovell ST. 2014. Permaculture for agroecology: design, movement, practice, and worldview. A review. *Agron Sustain Dev* 34:251-74.

131 FAO. 2014. The State of Food and Agriculture. Based on Pretty J, 2009. Agricultural sustainability: concepts, principles and evidence. *Phil Trans Royal Soc B: Biol Sci* 363(1491):447-65.

132 Parmentier S. 2014. *Scaling-up Agroecological Approaches: What, Why and How?* Oxfam-Solidarity, Belgium. Parmentier provides a number of examples of organizations including the Royal Society, IFAD, the Bill and Melinda Gates Foundation, USAID, etc.

> ***"Agroecology also puts agriculture on the path of sustainability by delinking food production from the reliance on fossil energy (oil and gas). It contributes to mitigating climate change, both by increasing carbon sinks in soil organic matter and above-ground biomass, and by avoiding carbon dioxide or other greenhouse gas emissions from farms by reducing direct and indirect energy use."***
>
> *Olivier de Schutter, UN Special Rapporteur on the right to food, 2011*

This permaculture food forest in Malawai mimics natural forest sytems: the baobab tree forms a protective canopy over a grapefruit tree, which provides shade to the layer below. *June Walker*

Additionally, sustainable intensification does not necessarily embrace the distributive and procedural justice[133] aspects of agroecology which are regarded as vital to ensuring sustainability of food production and distribution systems, and food security.[134]

Climate-Smart Agriculture

Climate-smart agriculture (C-SA)[135] was defined by FAO in 2010 as addressing three objectives:

- Sustainably increasing agricultural productivity to support equitable increases in incomes, food security and development
- Increasing adaptive capacity and resilience to shocks at multiple levels (from the farm to national)
- Reducing greenhouse gas emissions and increasing carbon sinks where possible

Again, many agroecology practices fit well with these three objectives, and agroecology is the best way to meet the objectives. For example, emissions of greenhouse gases can be reduced by the use of cover crops between rows and between successive crops, rotations including legumes which capture atmospheric nitrogen and improve soil fertility, reduced tillage and reducing inputs of mineral fertilizers and synthetic pesticides. Improved soil carbon through use of compost, mulch, and crop residues, and the enhancement of mycorrhizal fungi in the soil assist with carbon sequestration. Selecting varieties that are resilient and increasing biodiversity can improve the ability of the agroecosystem to cope with unpredictable weather conditions resulting from climate

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133 Distributive justice refers to socially just allocation of resources, harms and benefits – including adequate and equitable access to food – within and between different generations. Procedural justice refers to the types of governance, laws, institutions and participatory decision-making that are needed to make this happen. In this context it means putting food sovereignty into practice, including aspects such as land tenure, training for farmers, equitable access and resources for women. See Loos J, et al. 2014. Putting meaning back into "sustainable intensification". *Front Ecol Environ* 12:356-61.

134 Scientists' support letter, 2014, *op cit*.

135 The acronym C-SA is used here to differentiate it from CSA, Community Supported Agriculture, which has been in existence for very much longer than the recent concept of Climate-Smart Agriculture.

Farmer Field School in Kuruvai, India. *Resmi Deepak*

Farmer Field Schools (FFS)

The FFS is an empowering group-based training process bringing together agroecology, experiential learning and community development. The methodology was developed by FAO in 1989 in Indonesia, and has been used since in many countries throughout Africa, Asia and Latin America, training millions of farmers to reduce pesticide use and improve yields and sustainability.

The broad philosophy is to assist farmers to act on their own initiative and analysis, and to identify and resolve problems themselves in a manner that promotes a sustainable agricultural system. Farmers learn in their own and each others' fields, and a top-down approach of blanket recommendations is specifically avoided.

change, such as temperature and water variations, reducing the pressure from pests and enhancing productivity. Improved soil organic matter helps to buffer temperature and moisture extremes, acting as a water reservoir in times of drought, as well as reducing erosion from high rainfall events. Farmer knowledge is key to adaption to climate change, and ecosystem-based approaches to pest management foster improved farmer knowledge.[136]

But not all proposals for climate smart agriculture are agroecological. For example, direct seeding/no-tillage systems (also called conservation agriculture) are widely promoted as being 'climate-smart'; and indeed in some cases they are, if the practices involved are agroecological. However, no-tillage systems are most commonly associated with heavy pre-seeding herbicide use,[137] yet this is not ecologically sustainable by any measure. The focus of C-SA on carbon sequestration in agricultural soils, and the trading of soil carbon offset credits in financial markets, should not divert attention from the primary need to reduce or prevent emissions from soil in the first place.[138]

The agroecological approaches of increased complexity and diversity and reduced disturbances not only render these systems less susceptible to pest attack and a slower rate of spread of invasive species, but also provide greater resilience to climate variations.[139] A good example of climate resilience is the ability of small-scale farmers using agroecological methods to withstand the adverse effects of Hurricane Mitch. In the aftermath of the hurricane, agroecologically-managed farms in Guatemala, Honduras and Nicaragua retained

136 Niggli U, Fließbach, Hepperly P, Scialabba N. 2009. Low Greenhouse Gas Agriculture: Mitigation and Adaptation Potential of Sustainable Farming Systems. FAO. Rev 2.

137 See for example (i) FAO, World Bank. 2013. Conservation Agriculture/No till. A Climate Smart Agriculture Solution: the Kazakhstan and Ukraine experiences. (ii) Friedrich T [FAO]. 2005. Pesticides and no-till farming: Does no-till farming require more herbicides? *Outlooks Pest Manag* 16(4):188-91.

138 Gattinger A, Jawtusch J, Muller A, Mäder P. *No-till agriculture – a climate smart solution?* Climate Change and Agriculture, Report No. 2. Bischöfliches Hilfswerk MISEREOR e.V.

139 Castillo GE, Parmentier S, Chinotti E, Munoz E, Ninh L, Tumusiime E. 2014. *Building a New Agricultural Future: Supporting Agro-ecology for People and Planet.* OXFAM.

> ***"Agroecology also puts agriculture on the path of sustainability by delinking food production from the reliance on fossil energy (oil and gas). It contributes to mitigating climate change, both by increasing carbon sinks in soil organic matter and above-ground biomass, and by avoiding carbon dioxide or other greenhouse gas emissions from farms by reducing direct and indirect energy use."***
>
> *Olivier de Schutter, UN Special Rapporteur on the right to food, 2011*

The increased complexity and diversity of agroecology reduces pest problems. *Alter Vida Comunicación*

more topsoil, field moisture and vegetation and suffered less erosion than conventionally managed resource-extractive farms. Agroecological farmers also experienced lower economic losses as a result than conventional farmers.[140] A study of the vulnerability of coffee agroforestry systems to disturbances related to Hurricane Stan in Chiapas, Mexico found that increasing vegetation complexity within farms – for example by growing under native forest shade canopy as opposed to a lower density, diversity and height of shade trees and higher density of coffee bushes – may be an efficient strategy to reduce some susceptibility to hurricane disturbance.[141]

> ***"… on-farm experiments in Ethiopia, India, and the Netherlands have demonstrated that the physical properties of soils on organic farms improved the drought resistance of crops."***
>
> *Olivier de Schutter, UN Special Rapporteur on the right to food, 2011*

Traditional farming based on indigenous knowledge

Many traditional forms of smallholder farming are essentially based on agroecological approaches with a natural symbiosis between farm and ecosystem. In fact the science of agroecology was based initially on researchers 'rediscovering' traditional approaches used for millennia by Central American farmers who plant beans with their maize crop. In a helpful partnership, nitrogen 'fixed' in the soil by bacteria living in the nodules on the roots of leguminous plants, like beans, helps feed the maize, whilst the maize provides physical support for the beans to grow up.

Many traditional farming systems have fed people throughout the ages. But they can also be strengthened and yields improved with the application of modern agroecological practices, including those farms where the introduction of synthetic inputs has weakened their symbiosis with ecological processes on which they depend, (e.g. by destroying soil microbial communities or harming

[140] Holt-Gimenez E. 2002. Measuring farmers agroecological resistance after Hurricane Mitch in Nicaragua: a case study in participatory, sustainable land management impact monitoring. *Agric Ecosys Environ* 93(1-3):87-105.

[141] Philpott SM, Lin BB, Jha S, Brines SJ. 2008. A multi-scale assessment of hurricane impacts on agricultural landscapes based on land use and topographic features. *Agric Ecosys Environ* 128(1-2):12-20. In: Oxfam, 2014, *Building a New Agriculture Future: Supporting agroecology for people and the planet.*

natural enemies). Although not all traditional practices are environmentally benign, the global indigenous agricultural heritage and those who hold its knowledge through continual practice and innovation, are highly relevant for meeting today's and tomorrow's needs, in a far more sustainable way than using intensive chemical inputs has been able to achieve.[142] Many traditional systems evolved to help farmers spread risk in inherently risky climates, for example by using a diversity of varieties and providing a diversity of products. One result of this sensible risk-spreading strategy is that yields of some individual crops may be less than those of a single focus crop in good seasons - but overall, this approach provides a better chance of harvesting some food in poor seasons. Combining indigenous knowledge with modern agroecological techniques can improve yields but still retain the resilience and hedge-betting aspects of traditional systems.

> ***"Agroecological systems are deeply rooted in the ecological rationale of traditional small-scale agriculture, representing long established examples of successful agricultural systems characterized by a tremendous diversity of domesticated crop and animal species maintained and enhanced by ingenious soil, water, and biodiversity management regimes, nourished by complex traditional knowledge systems."***
>
> *Miguel Altieri, 2012*

Some varieties of Mexican maize

2.3 Which one? Agroecology? Organic? Permaculture? Sustainable Crop Intensification? Climate-Smart? Traditional? IPM?

The multitude of terminologies can be confusing. All of these approaches rest on agroecological practices to a greater or lesser extent. All of them, theoretically, apply a chemical or biological spray only as a last resort after other methods of prevention and management have failed to provide necessary control of a pest, disease or weed causing economic damage to the farmer. But there needs to be a word of caution about some versions of IPM.

IPM is a term that has been somewhat abused: in its true form it is ecosystem-based and focuses on agroecological practices, using pesticides as a last resort. However, it has also been massaged into a form of 'business-as-usual' application of chemicals, in which pests are monitored and thresholds applied before spraying begins. Regard may or may not be taken of the impacts on beneficial insects of the pesticides used, but scant regard is paid to agroecological approaches. This is the type of IPM promoted by the pesticide industry. Even the use of the now globally-banned organochlorine endosulfan, which is highly toxic to beneficials, has been promoted as part of IPM by the pesticide industry in India. Chemical-focused IPM programmes, or IPM strategies that assume pesticides will always be used (even if in slightly reduced amounts) do NOT constitute an ecosystem approach to pest management.

[142] Parmentier 2014, *op cit.*

However, strategies that focus on agroecological practices first and use a pesticide only as a last resort when other methods have failed, do take an ecosystem approach. In these ecosystem-based IPM strategies, farmers will take care to only use pesticides with the least side-effects on beneficial organisms and in minimised and targeted ways because they want to conserve natural pest control and soil health processes as much as possible.

Box 2.2: Checklist to identify ecosystem-based IPM programmes:
Positive answers to these questions should help distinguish IPM programmes with a genuine ecosystem approach from those that merely continue reliance on chemical strategies

- Does it encourage farmers to move beyond improving the effectiveness of pesticide application?
- Are farmers specifically supported to reduce their use of pesticides?
- Is there a specific aim to phase out use of hazardous pesticides?
- Does it promote use of biological controls and measures to conserve natural enemies?
- Does it look for ways to use physical methods to control pests or weeds?
- Does it adapt fertilization and crop husbandry practices to reduce the level of pests, diseases or weeds?
- Do farmers have access to independent advice (i.e. not from pesticide salesmen) on pest control?
- Does the programme aim to reduce health and environmental problems related to pesticide use?

"Unfortunately with some groups in the USA, IPM is being used as a means of justifying pesticide use."
Professor David Pimentel, Department of Entomology, Cornell University


Composting, Tamil Nadu Women's Forum, India

There is also a difficulty with Sustainable Intensification, in that its proponents accept, or in some cases promote, genetically modified organisms (GMOs) as part of this approach.[143]

Yet there are a number of features of GMOs that make them incompatible with ecosystem-based approaches. For a start, they are designed to depend on, even to increase the use of external inputs, and to increase farmers' reliance on those inputs rather than on their own on-farm resources. The current proliferation of GM herbicide-tolerant crops in a few countries has led to huge increases in use of herbicides,[144] and resulted in the emergence of weeds resistant to the herbicides the crops were designed to tolerate. This situation is rendering the genetic modification useless and driving farmers to use even more toxic herbicides. The rising economic impact of uncontrollable levels of resistant superweeds, in systems that are

143 For example, The Montpellier Panel report *Growth with Resilience: Opportunities in African Agriculture*, 2012.
144 Benbrook C. 2012. Impact of genetically-engineered crops on pesticide use in the U.S. – the first sixteen years. *Environ Sci Europe* 24:24.

Why GM crops are at odds with agro ecology:

* **Seeds are not bred to be context specific, they cannot be tailored to fit the ecological, climatic and socio-economic conditions of a farm and community**
* **Designed to work with chemical inputs rather than nature**
* **Increase vulnerability to external influences such as seed and chemical companies, markets and climate**
* **Restrict farmers ability to experiment, innovate and work cooperatively with their community**
* **Bt cotton as widely promoted does little to solve the problem of a range of pests facing farmers, as it only confers tolerance to bollworms**

Parmentier 2014

designed to control weeds only by spraying, is making US arable farms less productive and less profitable.[145]

In addition, there are problems with crops genetically modified to target and kill certain pests. Pest resistance to genetically modified Bt cotton has recently been recorded for American bollworm *(Helicoverpa zea)* in USA, pink bollworm *(Pectinophora gossypiella)* in India, and cotton bollworm *(Helicoverpa armigera)* in Australia. Additionally, secondary pests have developed on Bt cotton, such as plant bugs *(Lygus sp)* in USA, and mirid bugs in China, the latter requiring increased use of insecticides to control them, resulting in decreased net revenue compared with non-Bt cotton.[146]

Despite the agroecological basis of the FAO version of Sustainable Crop Intensification as described earlier, the reality is most of the global funding under the name of Sustainable Intensification is reputed to have gone to the further development of chemical and GM agriculture rather than to agroecology.[147]

The term agroecology is well defined and backed up by a huge database of science and case studies, whereas the terms, 'sustainable crop intensification' and 'climate-smart agriculture' are more amorphous, not well defined, and not supported by an extensive literature and years of global experience. Because all of these approaches rest, to a greater or lesser extent, on agroecological practices, from here on the terms "agroecology" and "agroecological practice" will be used as they represent the most scientifically rigorous, concrete in terms of practical application, and well-established articulation of ecosystem-based agriculture. The exception will be where the system being described is organic, because the use of synthetic chemical inputs is prohibited altogether under organic standards but not under agroecology.

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145 See for example: (i) Barker T. Midwestern farmers wage war against superweeds. *St Louis Post-Dispatch*, July 13,2014. [Refers to increasing herbicide costs, yield loss, declining land values.] (ii) Eller D. 'Superweeds' choke farms. *Des Moines Register*, June 23rd 2014. [Refers to a 69% loss of corn and soy yields.] (iii) NBC News. 'Superweeds' sprout farmland controversy over GMOs. October 2014. [Refers to US $1 billion in lost crops.]

146 UNEP. 2012. Evaluation of non-chemical alternatives to endosulfan. Persistent Organic Pollutants Review Committee. UNEP/POPS/POPRC.8/INF/14/Rev.1.

147 Parmentier 2014, op cit.

3. Agroecology makes sense: economically, socially and environmentally

"… agroecosystems of even the poorest societies have the potential through ecological agriculture and IPM to meet or significantly exceed yields produced by conventional methods, reduce the demand for land conversion for agriculture, restore ecosystem services (particularly water), reduce the use of and need for synthetic fertilizers derived from fossil fuels, and the use of harsh insecticides and herbicides." *IAASTD Synthesis Report*

Organic greenhouse vegetables, Cartago, Costa Rica. *Fernando Ramirez*

Efficacy of agroecological approaches needs to be understood in a multi-faceted manner, reflecting the multi-functionality of agroecology. In some cases the yields of individual crops are higher than those obtained through input-intensive farming; in some cases they are not. However, the total agricultural output of an agroecological farm is greater when the diversity of crops, livestock and outputs is taken into account. Additionally, agroecological approaches have shown greater ability to withstand climatic variations and extreme weather events, and to resist pests and other environmental stresses, reducing the variability of yields and income over time. Agroecology is particularly of benefit to smallholder farmers, women with poor access to resources, and those living in poverty because it hugely reduces production costs, especially the upfront money, or credit, necessary for buying external inputs.

Reduced exposure to toxic chemicals has important benefits for health, as does the greater availability of a wider range of safe and nutritious foods. It cuts the external costs generated by chemical-input farming and provides a range of environmental benefits such as reduced contamination and improved ecosystem services. Social benefits are also reported, including reduced indebtedness and greater food security. Olivier De Schutter concluded that scaling up agroecological practices can increase farm productivity and food security, improve incomes and rural livelihoods, reverse the trend towards species loss and genetic erosion, and assist adaptation to climate change.[148]

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[148] De Schutter O. 2011. Agroecology and the Right to Food. United Nations Special Rapporteur on the Right to Food. A/HRC/16/49. http://www.srfood.org/index.php/en/component/content/article/1174-report-agroecologyand-the-right-to-food

3.1 Yield increases or yield reductions?

A considerable body of evidence shows that agroecological practices can increase both yields and income. According to Altieri, production increases of 50-100 percent are fairly common when farmers adopt agroecological methods.[149]

In industrialized countries, organic yields are often slightly lower than their counterparts in chemical-input farming.[150] An analysis of 133 comparisons of yields of organic farming systems and conventional farming systems in low income countries, however, found that agroecological organic systems were producing 80 percent more than conventional farms. In high-income countries, 160 comparisons showed organic yields averaged 92 percent of conventional farms.[151]

In 2004, the German Institute for Technical Cooperation (GTZ) undertook an evaluation of an organic rice-growing programme in Cambodia, based on the practices of Sustainable Rice Intensification (SRI).[152] They found that farmers practising SRI techniques recorded 41 percent higher yields than those that did not – from 1629 kg per hectare to 2289 kg per hectare. This increase was recorded across all five provinces over four years and a range of different agroecosystems. Where the natural resource base was better, the yield increase was greater. These yield increases were accompanied by a 75 percent increase in profit, from US $120 per hectare to $209 per hectare. GTZ concluded that *"if just 10 percent of Cambodian rice farmers would convert just 42 percent of their rice area to SRI, the economic benefit to the nation would be $36 million, more than enough to justify an extensive program of training for SRI within the agricultural extension system"*.[153]

The Cambodian Organic Agriculture Association has since reported that, whilst conventional rice farmers achieved a nationwide average yield of 2.4 metric tonnes per hectare in the 2007/08 rainy season, organic farmers obtained 3.5 metric tonnes.[154]

Sustainable Rice Intensification:
a methodology to increase the productivity of irrigated rice by using agroecological approaches to the management of plants, soil, water and nutrients. See Chapter 5 for an in-depth discussion.

SRI rice growers in Cambodia record higher yields than conventional growers. *CEDAC*

[149] Altieri MA, Funes-Monzote FR, Petersen P. 2012. Agroecologically efficient agricultural systems for smallholder farmers: contributions to food sovereignty. *Agron Sustain Dev* 32:1-13.

[150] Ponisio LC, M'Gonigle LK, Mace KC, Palomino J, de Valpine P, Kremen C. 2014. Diversification practices reduce organic to conventional yield gap. *Proc R Soc B* 282:20141396.

[151] Badgley C, Moghtader J, Quintero E, Zakem E, Chappelli MJ, Avilés-Vázquez K, Samulon A, Perfecto I. 2006. Organic agriculture and the global food supply. *Renew Agric Food Sys* 22(2):86-108.

[152] Refer Chapter 5 for more information on SRI.

[153] Markandya A, Setboonsarng S. 2008. Organic Crops or Energy Crops? Options for Rural Development in Cambodia and the Lao People's Democratic Republic. ADBI Discussion Paper 101. Tokyo: Asian Development Bank Institute.

[154] Prospects of Cambodian Organic Rice. Cambodian Organic Agriculture Association (COrAA). 2011. http://www.coraa.org/userfiles/file/COrAA%20Factsheet%20Cambodian%20Organic%20Rice%202011%2010%2013.pdf

In 2006, a Participatory Farmer Network project in Brazil reported that approximately 100,000 agroecological family farms were showing an increase in average yields of 300% for black beans and 100% for maize, as well as being more resilient to irregular weather patterns.[155]

Global assessment of yields: The University of Essex analysis

A decade ago Professor Jules Pretty and colleagues at University of Essex, UK, conducted an analysis of 286 sustainable agriculture projects in 57 countries, involving 12.6 million farmers on 37 million hectares (three percent of the total cultivated land in low-income countries) in the process of transitioning to sustainable agriculture. The analysis demonstrated an average yield increase of 79 percent across a wide variety of systems and crop types, ranging from 18 percent to over 100 percent (see Table 3.1). Of the projects for which there was data on pesticide use, 77 percent reported an average decline in pesticide use of 71 percent, with an average yield increase of 42 percent. Average yield increases of over 200 percent were gained in Madagascar (rice), China (cotton, wheat, maize), and Ethiopia and Lesotho (sorghum, teff, sweet potato).[156]

The crops covered in the Essex study were rice, cotton, cassava, sweet potato, tree fruit, coffee, groundnut, cocoa, maize, millet, sorghum, other legumes, potato, soybean, wheat, banana, and vegetables. Although many agroecological techniques were employed, the ones thought to have given rise to the greatest benefits were:

√ Increased agricultural biodiversity

√ Improved water management

√ Increased organic matter in soils

√ Pest and weed control emphasising in-field biodiversity with minimum to zero pesticide use

Table 3.1 Summary of adoption and impact of sustainable agricultural practices in 286 projects in 57 countries[157]

Farm system	*No. of farmers*	*No. of hectares*	*average % yield increase*
Smallholder irrigated	177,287	357,940	129.8
Wetland rice	8,711,236	7,007,564	22.3
Smallholder rain-fed humid	1,704,958	1,081,071	102.2
Smallholder rain-fed highland	401,699	725,535	107.3
Smallholder rain-fed dry/cold	604,804	737,896	99.2
Dualistic mixed	537,311	26,846,750	76.5
Coastal artisanal	220,000	160,000	62.0
Urban-based and kitchen garden	207,479	36,147	146.0
All projects	**12,564,774**	**36,952,903**	**79.2**

155 Cohn A, Cook J, Fernández M, Reider R, Steward C. 2006. Agroecology and the Struggle for Food Sovereignty in the Americas. International Institute for Environment and Development (IIED), the Yale School of Forestry and the Environmental Studies (Yale F&ES) and the IUCN Commission on Environmental, Economic and Social Policy (CEESP).

156 Pretty JN, Noble AD, Bossio D, Dixon J, Hine RE, Penning de Vries FW, Morion JI. 2006. Resource-conserving agriculture increases yields in developing countries. *Environ Sci Technol* 40(4):1114-9.

157 *ibid.*

Organic peanut field Benin. *OBEPAB*

The global average yield increase was 79% across a wide variety of systems a crop types: for Africa alone, the average yield increase rose to 116% and to 128% for East African projects alone.

A further analysis of a subset of the data, for projects in Africa alone, showed that the average yield increase rose to 116 percent for the whole of Africa and to 128 percent for East African projects.[158]

A common feature of the projects featured in the Essex study is that yield increases are strongly linked to an increase in agricultural biodiversity. This had been brought about by a number of techniques including crop diversification, agroforestry, integrated nutrient management and integrating livestock into farming systems. Higher levels of soil organic matter and water harvesting also contributed to greater yields. The study found that while yields were sometimes reduced in the short term, any losses were out-weighed by long-term gains.[159]

Summary from case studies

Many of the case studies reported in Chapters 5-9 show unchanged or increased yields with the adoption of agroecological methods. For example, Community Managed Sustainable Agriculture in Andhra Pradesh, India has resulted in little overall change in crop yields, with red gram production slightly increased and rice yields slightly decreased. In Kerala, the adoption of agroecological practices and nutrient management lead to an average yield increase of 30 percent, from 4,250 to 5,500 kg per hectare. In China, the agroecological rice-fish-frog system increased rice yield by 10.1 percent, with an additional yield of fish and frogs of 1,177.5 kg per hectare. Organic rice in the Philippines had similar

MASIPAG organic rice growers in the Philippines get similar yields to conventional farmers but overall higher farm output. *Achim Pohl*

158 Hine R, Pretty J, Twarog S. 2008. Organic Agriculture and Food Security in Africa. UNEP-UNCTAD Capacity-building Task Force. United Nations Conference on Trade and Development and United Nations Environment Programme.

159 Parmentier 2014, *op cit.*

yields to conventional rice but overall farm output was increased. In Kenya, the push-pull system of weed management has resulted in dramatic yield increases, from 350 percent for maize to 250 percent for sorghum, and more than 100 percent for finger millet. The introduction of a tiny parasitic wasp in the West Sahel resulted in millet yield increases of 40 percent.

3.2 Profitability

Numerous studies also document increased profitability for farmers using agroecological methods.

Organic farming

A comparison of organic with conventional cotton on 34 farms in Andhra Pradesh, India, under later season drought conditions demonstrated cotton yields on a par, but profitability dramatically increased for organic growers. This was mainly because of reduced pest management costs. Pest management in the organic systems was based on prevention through balanced nutrient management, intercropping and early season use of the biological control nuclear polyhedrosis virus (NPV), resulting in significantly less bollworm and other pests. Pest management in the organic fields cost US $12 per hectare compared with US $92 per hectare for the conventional cotton. As a result organic farmers made approximately US $32 per hectare, and the conventional farmers lost an estimated US $74 per hectare.[160]

Another comparison of organic and conventional systems in Andhra Pradesh focussed on the three major crops – paddy (rice), red gram and groundnuts – came to similar conclusions. Based on 350 organic and 200 conventional farms, small (<2 hectares), medium (2-4 ha) and large (>4 ha), the study found that the returns from organic farming were greater than from conventional farming, and the net profitability was even greater (see Table 3.2).[161]

Table 3.2 Organic vs conventional crop profitability, Andhra Pradesh

	paddy	red gram	groundnut
Gross income	5%	10%	7%
Farm investment income[i]	16%	27%	53%
Profit	37%	33%	59%

[i]farm investment income was described as net income + rental value of own land + interest on owned fixed capital

In 2009, FAO published a review of more than 50 studies on organics, mostly from the US, concluding:[162]

- The overwhelming majority of cases show organic farms are more profitable, despite frequent yield decreases
- Organic crop yields are consistently higher than conventional ones where there is bio-physical stress such as drought
- The higher profits of organic agriculture are generally due to higher product prices and lower production costs

FAO also noted that economic comparisons are heavily biased against organic farms because

160 Raj DA, Sridhar K, Ambatopudi A, Lanting H, Brenchandran S. 2005. Case study on organic versus conventional cotton in Karimnagar, Andhra Pradesh, India. Second International Symposium on Biological Control of Arthropods. http://www.bugwood.org/arthropod2005/vol1/6c.pdf

161 Sudheer SK. 2013. Economics of organic versus chemical farming for three crops in Andhra Pradesh, India. *J Organic Systems* 8(2):36-49.

162 Nemes N. 2009. Comparative Analysis of Organic and Non-Organic Farming Systems: A Critical Assessment of Farm Profitability. FAO, Rome.

Mixed organic vegetable crops in greenhouse in Zarcero, Costa Rica. *Fernando Ramirez*

> ***"If the 1.5 million Malawian farmers currently using chemical fertilizer were to switch to agroforestry they could earn a combined extra income of $209 million per year."***
>
> *Greenpeace Africa, 2015*

they do not internalize negative externalities of nonorganic farming inputs and methods, nor do they include the environmental benefits of organic farming, such as carbon sequestration and enhanced biodiversity. Nonorganic farms also receive significantly higher governmental support and better research and extension services, which is also overlooked.

The 2009 reviews concluded that profitability of a farming system must balance economic costs against environmental, social and health costs, as these costs have delayed impacts and indirect implications on farm economics.

Profitable agroecology in Kenya and Malawi

Two recent studies on agroecological practices in Malawi and Kenya have found significant increases in profits for participating farmers.[163]

In Malawi, farmers planting the nitrogen-fixing *Faidherbia* trees amongst their maize crop in place of chemical fertilizer, achieved greater profitability than those using only nitrogen fertilizer, This held true even among those buying the fertilizer at government subsidized rates:

√ Average maize/agroforestry net income = US $640/ha

√ Average maize/chemical fertilizer net income = US $410/ha

The increased profitability resulted from both increased yields of maize (2,808 kg per hectare for agroforestry compared with 2,045 kg per hectare for conventional farmers) and lower farm costs, including less labour.

In Kenya, farmers using the push-pull technology for pest and weed management (see Chapter 7 for an explanation of this technology) achieved profitability three times greater than conventional farmers:

√ In Kitale, average net income for push-pull farmers was US $1452/ha, whilst that of conventional farmers was only US $477.

√ In Mbita, average net income for push-pull farmers was US $1070/ha, compared with US $351/ha for conventional farmers.

As in Malawi, the increased profitability resulted from both increased yields and lower production costs, including lower labour requirements.

This Malawi study also found that many more farmers would switch to agroecology if the government supported the transition, making a more profitable use of the 43 percent of the government's agriculture budget that goes to subsidizing chemical fertilizers. Similarly for Kenya, which spent US $34.3 million subsidizing fertilizers and seeds in 2012-13, and is currently planning to build a US $442 million fertilizer factory.

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163 Curtis M. 2015. *Fostering Economic Resilience: The Financial Benefits of Ecological Farming in Kenya and Malawi.* Greenpeace Africa, Johannesburg.

Growing rice by the Sustainable Rice Intensification method in Cambodia; hand weeding between the widely spaced plants. *CEDAC*

Economic analysis thus shows that investments would achieve more for farmers and the national economies if redirected to assisting farmers to implement agroecology.

Summary from case studies

Additionally, a number of case studies reported in this book show greater profitability for agroecological than conventional farmers. For example:

- Sustainable Rice Intensification (SRI) showed net income increases across Asia of between 59 and 773 percent.
- Agroecological practices on a large number of farms in the Philippines returned net incomes on average 50 percent higher than conventional farms, making the difference between a profit and a loss.
- Community Managed Sustainable Agriculture in Andhra Pradesh, India showed significant net income increases, with yields much the same but costs of pest management dropping by 70-80 percent.

> ***"If the same results were applied across Kenya, farmers incomes would more than double and the gains for Kenya's four million farmers would total $2.7 billion."***
>
> *Greenpeace Africa, 2015*

- Kerala, India, the increased yields and decreased pest management costs in agroecological rice growing resulted in increased net incomes.
- A rice-duck cultivation system in China returned increases of US $323.52/ha compared with conventional rice; for organic growers that increase rose to US $6,478.2/ha.

3.3 Pesticide reduction

Reducing the adverse effects of pesticides on human health and the environment is a key concern of all – from farmers to NGOs, from governments to international agencies such as FAO, WHO and UNEP. Reducing use of pesticides – and especially HHPs – is the most effective way to achieve this goal. So one important measure of the benefits of agroecology is the degree to which it reduces pesticide use.

In the Greenpeace study[164] on using the push-pull technology for weed and pest management in maize growing in Kenya, there was a 100 percent decrease in pesticide use, compared with farmers not using this technique.

West Africa

FAO's West African Regional Integrated Production and Pest Management Programme (IPPM) was established in four countries to "improve farming skills and raise smallholder farmers' awareness of alternatives to toxic chemicals", using Farmer Field

164 Curtis 2015, *op cit.*

School (FFS) training. The programme began in Ghana in 1996, and then spread to Senegal, Mali and Burkina Faso. In 2006, a second phase began in Benin, followed in 2009 in Guinea, Mauritania and Niger. By the end of 2010, the programme was estimated to have reached 116,000 farmers and resulted in increased yields and incomes and substantial reductions in the use of chemical pesticides (particularly WHO Class Ia, Ib and II). The crops involved included cotton, rice, mango, cowpea, market gardens (vegetables), as well as sesame, shea nut, dryland cereals, jatropha and henna.[165]

Strategies used in cotton growing in Burkina Faso included growing of leguminous cover crops, diversification with cereal crops and rotation or interplanting with soil-improving crops, and improved seeds. There was a large shift towards botanical and biological pesticides (including neem seed extract, *Metarhizium flavoviride* and Bacillus thuringiensis for vegetables) and additions of compost or rice straw to the soil to increase water penetration and water- and nutrient- holding capacity, improve biological activity by microbes and reduce soil erosion.[166]

Dramatic reductions in pesticide use were achieved, particularly in vegetable and cotton production, and especially in Mali and Senegal.

<u>*Mali*</u>

Over an eight-year period, about 20 percent of the 4,324 cotton-growing farm households in one sector of southern Mali had undergone IPPM training through the FFS. Hazardous insecticide use fell by 92.5 percent across the entire sector (not just the 20 percent who were trained). The new practices learned through the IPPM training – scouting for presence of pests at an early stage of

Identifying pests in organic crops, Latin America. *Alter Vida Comunicacion*

the crop and applying a biopesticide such as neem if found – apparently diffused to non-participants. The cotton yields in both sectors were highly variable over time, but there was no evidence linking yield reductions to shifts away from the hazardous insecticides.[167]

Prior to the IPPM programme, farmers applied insecticides according to one of three systems:

(i) Calendar treatments (CT)

(ii) 'Stage-specific treatment' or the Lutte Etagée Ciblée (LEC)

(iii) Threshold sprays (TS)

Table 3.3 demonstrates the dramatic saving in costs associated with the reduced use of pesticides under IPPM.

Table 3.3 Cost of pesticide use in cotton in southern Mali (US $ per hectare)

CT	LEC	TS	IPPM
71.43	35.72	8.93	1.79

165 Settle W, Hamma Garba H. 2011. *The West African Regional Integrated Production and Pest Management Programme.* FAO, Rome. www.fao.org/fileadmin/templates/agphome/documents/IPM/WA_IPPM_2011.pdf

166 Settle and Hamma Garba 2011, *op cit.*

167 Settle W, Soumaré M, Sarr M, Hamma Garba M, Poiset AS. 2014. Reducing pesticide risks to farming communities: cotton farmer field schools in Mali. *Phil Trans R Soc B* 369: 20120277

The financial benefit to farmers from reduced use of insecticides was estimated at US $386,000 – outweighing the cost of training by three to one. 'Non-economic' benefits to human health and the environment were recognized but were not able to be measured.

The natural plant extract neem was able to control a wide variety of pests. Such is its success, that the neem trees growing widely in the region are insufficient to meet demand and communities have begun to organize the planting of more trees, meanwhile purchasing some imported neem.

<u>*Senegal: Positive impacts on agrochemical reduction, costs and yields*</u>

Senegalese IPPM vegetable farmers have reduced their pesticide use by 92 percent, averaging reductions of 3.2 litres per hectare and saving US $60 per hectare in production costs. The percentage of farmers using synthetic pesticides dropped from 97 to 12 percent, replacing these with commercial biopesticides and/or locally produced neem seed extract. The proportion of farmers using biopesticides 'Biobit' (based on the bacterium *Bacillus thuringiensis*) and 'Green Muscle' (based on the fungus *Metarhizium flavoviride*) increased from 3 to 75 percent, while those using neem extract rose from 3 to 82 percent. They gained an average 61 percent increase in net overall crop value after calculating input costs (but excluding labour).[168]

Insectivorous birds can be useful predators of cotton pests. IPM plots at a large cotton farm, Ethiopia. *PAN UK*

"Not using pesticides allows us to conserve aquatic wildlife and clean up water and our living environment. The improvement of water quality is obvious now and IPPM smallholders have set up fish farming directly in the water courses, to diversify the diet of the Senegalese people."
Djiery Gaye, IPPM farmer/trainer and General Secretary of the Niayes Federation of Horticulture Growers, Senegal

Summary from case studies

All of the cases studies described in this book have shown dramatic reductions in the use of pesticides with the adoption of agroecological practices, many of them stopping the use of synthetic chemical pesticides altogether. For example, 107 rice farmers in Cambodia, who had been implementing Sustainable Rice Intensification (SRI) techniques for roughly five years, had an average 61 percent increase in yields and 72 percent decrease in pesticide use.

The case study of vegetable growing in Costa Rica shows how farmers using high levels of HHPs were able to reduce their overall use of pesticides by incorporating some agroecological practices into their system, including several composting techniques and organic foliar sprays. This case study demonstrates how farmers are able to incorporate agroecological techniques into their growing systems, gradually reducing their use of pesticides until they may reach a point where they no longer need them.

168 Settle and Hamma Garba 2011, *op cit.*

3.4 Resilience in the face of climate change

Studies show that farms adopting agroecological approaches suffer less and recover more quickly from climatic stress and disasters.

Drought

During increasingly frequent droughts in southern Brazil, maize producers who had incorporated agroecological practices into their production systems suffered only 20 percent loss compared with their conventional counterparts who experienced on average 50 percent losses, demonstrating the resilience of their agroecological methods (use of local seeds, green manures, rock dust, and minimum tillage), compared with reliance on agrochemicals. Although average productivity was lower, the costs for these farmers were significantly lower – enabling them to maintain economic gains in the face of adverse climatic conditions.[169]

Studies in Bolivia (Cuchumuela community, Cochabamba), China (Karst mountain area), and Kenya's coastal communities have found that farmers in these regions are breeding and planting diverse crops from local seeds to cope with climate change. Crop diversity, and particularly using traditional varieties, has proven key to enabling farmers to adapt to worsening pests, drought, and increased climatic variability. For example, in Guangxi most farmer-improved landraces and open pollen varieties survived the big spring drought in SW China in 2010, while most of the hybrids were lost.[170]

Agroecological growers are at a distinct advantage in times of drought. The many practices they undertake to build healthy soil with high organic matter content result in good structure, fertility, and – most important in the face of climate stress – moisture retention capacity. The addition of compost, use of green manure crops and cover crops, turning in or planting through crop stubble, and application of mulches all help to keep the moisture in the soil. High organic matter soil also keeps plant nutrients in solution and available to be taken up by plants with the assistance of the soil microbes that thrive in humus-rich soil. So even under drought conditions plants can still access the nutrients they need. In contrast, in soils with low organic matter content which do not retain moisture, even with high application of fertilizers delivering a range of chemical elements, the microbes are not there to assist their uptake, and the elements are not in solution unless water is added.

Increasing organic matter in the soil and mulching the surface, as in this organic ginger plot, helps agroecological growers cope with drought. *Stephanie Willamson*

169 Altieri MA, Funes-Monzote FR, Petersen P. 2012. Agroecologically efficient agricultural systems for smallholder farmers: contributions to food sovereignty. *Agron Sustain Dev* 32:1-13.

170 Silicia L. 2014. *Agroecology: What it is and what it has to offer.* Issues paper, June. International Institute for Environment and Development, London.

Making use of flood plains, farmers first harvest fish, and then drain the plains for rice growing, Bangladesh. *SHISUK*

The Tigray project, established in 1999 in Northern Ethiopia by the Ethiopian Institute for Sustainable Development, demonstrated the advantages of agroecology during times of drought. Researchers found that crops grown in soils to which compost had been added resisted wilting (when the rains stopped early) for two weeks longer than those treated with chemical fertilizer. This may be a critical window for getting seedlings established or mature crops harvested. In 2002, rainfall was very poor resulting in a severe drought, but one farmer in Adi Aw'ala who had applied compost to a field of sorghum harvested two tonnes per hectare of grain and three tonnes per hectare of straw, whereas a field untreated with compost yielded only 0.8 tonnes of grain and 1.5 tonnes of straw per hectare.[171]

Floods

Severe flooding in parts of Benin in 2010 and 2011 resulted in some cotton crops being lost completely, while the water-logging of fields adversely affected soil structure and fauna, compromising the yields on both conventional and organic farms. Nevertheless, there were signs that organic farmers were less affected than their conventional neighbours, and remained more food secure as they were able to harvest some crops before the flooding. The floods also have led to greater indebtedness on the part of conventional growers who lost their cotton and had little recourse to compensation or insurance against adverse weather.[172]

Hurricanes

Farmers of the Central American hillsides using agroecological methods such as cover crops, intercropping and agroforestry suffered less damage from Hurricane Mitch in 1998 than their conventional counterparts. A study spanning 360 communities in Nicaragua, Honduras and Guatemala found that the agroecological farms had 30-40 percent more topsoil, greater soil moisture and 47-69 percent less soil erosion than their conventional neighbours. The agroecological farmers averaged 193 percent higher incomes.

The agroecological methods included a wide range of soil conservation and management practices that had been tested and promoted by smallholders in Central America for decades (see Table 3.4).[173]

[171] Edwards S, Egziabher T, Araya H. 2011 Successes and challenges in ecological agriculture: Experiences from Tigray, Ethiopia. In: Li Ching L, Edwards S, Scialabba N, (eds). 2011. *Climate Change and Food Systems Resilience in Sub-Saharan Africa*. FAO, Rome.

[172] Cotton trade – building an environmentally friendly route to poverty reduction. Unpublished project report to TRAID for period Sept. 2010 - Jan. 2011. PAN UK, London.

[173] Holt-Giménez E. 2002. Measuring farmers' agroecological resistance after Hurricane Mitch in Nicaragua: a case study in participatory, sustainable land management impact monitoring. *Agric Ecosyst Environ* 93(1-3):87-105.

Table 3.4 Agroecological practices in Central America[174]

Type	*Practice*	*Function*
Mechanical practices	Contour ploughing Rock and vegetative bunds Contour ditches Terraces	Soil and water conservation
Agronomic practices	Cover/inter/relay cropping with grains and legumes Intensive, in-row tillage Reduced use of chemical inputs Compost, vermiculture, animal manure Pest traps Organic pesticides and repellents Beneficial insects	Fertility, soil building and protection, water conservation, weed and pest management
Agroforestry	Living fences, windbreaks Woodlots Multi-storey cropping Alley cropping Vegetative strips	Fuel, fodder, timber, fruit, reduction of runoff, nutrient pumping/cycling, habitat for beneficial insects, shade

When Hurricane Ike hit Cuba in 2008, agroecological biodiverse farms in the provinces of Holguin and Las Tunas suffered losses of only 50 percent compared to the 90-100 percent losses in neighbouring monocultures. They also experienced a faster recovery than industrial monoculture farms, achieving 80 percent recovery of vegetation after two months, compared with the six months taken by the monocultures to recover to the same extent.[175]

3.5 Food security and food sovereignty

Based on model estimates developed using data from 293 comparisons of organic and conventional production systems, a team from the University of Michigan, USA, concluded that organic and agroecological agriculture could feed the world's current population – and potentially a substantially larger one – without increasing the agricultural land base.

Studies they reviewed showed that although the adoption of Green Revolution methods in low-income countries has increased yields, so too has conversion to organic agriculture, for example in the 'System of Rice Intensification' (see Chapter 5 for more detail). Consistently higher yields were found in low-income countries with organic/agroecological systems compared with chemical-input systems. They also found that leguminous cover crops could fix enough nitrogen to replace the synthetic fertilizer currently in use. They concluded that if research efforts comparable to those focused on conventional agriculture over the

174 Holt-Giménez 2002, *op cit.*

175 Rosset PM, Sosa BM, Jaime AM, Lozano DR. 2011. The Campesino-to-Campesino agroecology movement of ANAP in Cuba: social process methodology in the construction of sustainable peasant agriculture and food sovereignty. *J Peasant Studies* 38(1):161-91.

Box 3.1: On the Impacts of Hurricane Ike in Cuba, 2008

"We observed large areas of industrial monoculture where not five percent of the plants were left standing. We visited numerous agroecological peasant farms with multi-storied agroforestry farming systems where Ike had only knocked down the taller 50 percent of the crop plants (tall plantain varieties and fruit trees), while lower story annual and perennial crops were already noticeably compensating for those losses with exuberant growth, taking advantage of the added sunlight when upper stories were tumbled or lost leaves and branches.

We also saw tremendous new leaf growth on branches that had been stripped. And perhaps most impressive of all, a substantial portion of the trees that had been blown down had been saved by peasant families who stood them back up and covered their roots the first morning after the storm. We also saw many newly transplanted seedlings already growing in the spots left by the trees that were killed. In contrast, there was no evidence of trees having thus been 'saved' by the workers on industrial agriculture plantations, and replanting was well behind the pace observed on peasant cooperatives. It is worth noting that the farmers we visited assured us that the moisture-conserving mulches and ground covers in the agroecological systems also made them more resistant to drought."

Peter Michael Rosset, Braulio Machín Sosa, Adilén María Roque Jaime and Dana Rocío Ávila Lozano

last 50 years were applied to organic production there could be further improvements in yields as well as soil and pest management.[176]

There are numerous documented examples[177] of improved food security through adoption of agroecological farming. This derives from a combination of increased income in the household and increased diversity of crops being grown, which provide a wider range of food over a longer part of the year, with improved nutritional value. Putting farmers, and particularly women, at the centre of production and marketing decisions forms a key facet of agroecology – which helps ensure the family gets fed.

A study of 57 farmers in seven communities in Cambodia practicing organic agriculture found that farmers reported greater nutritional diversity, a higher level of food security, yield increases, improvements in health (mainly due to less use of pesticides), and increased incomes (mainly due to lower input costs).[178]

Based on the evidence that SRI farmers in Cambodia were making a 75 percent increased profit, the Asian Development Bank Institute estimated that if only 20 percent of poor Cambodian households used SRI methods, the

"The uneven distribution of productive natural resources coupled with the lack of access to resources and fair markets for small-scale producers and women in agriculture results in extreme inequality and increasing poverty."

IAASTD Synthesis Report, p24

176 Badgley C, Moghtader J, Quintero E, Zakem E, Chappell, MJ, Aviles-Vazquez K, Samulon A, Perfecto I. 2007. Organic agriculture and the global food supply. *Renew Agric Food Sys* 22(2):86-108.

177 For example: (i) FAO. 2015. Final Report for the International Symposium on Agroecology for Food Security and Nutrition. 18-19 September 2014, Rome, Italy. (ii) De Schutter O. 2011. Agroecology and the Right to Food. United Nations Special Rapporteur on the Right to Food. A/HRC/16/49 (iii). Silicia 2014, *op cit.* (iv) EAA. 2012. *Nourishing the World Sustainably: Scaling up Agroecology.* Ecumenical Advocacy Alliance. (v) Parmentier 2014, *op cit.*

178 Curtis 2012, *op cit.*

Food security requires having access to a sufficient quantity of a variety of nutritious foods.

number living in poverty would fall by 21,300 people, reducing the rural poverty rate by 3 percent. Food security would be increased.[179]

Summary from case studies

Organic agriculture in the Philippines has also resulted in improved food security: a study of 840 farmers published in 2009 found that twice as many organic farmers as conventional farmers had increased their food security since 2000. They also had a more diverse diet:

√ Organic farmers ate 68% more vegetables, 56% more fruit, 55% more protein-rich staples and 40% more meat than in 2000.

√ The increases in consumption among organic farmers were double those for conventional farmers for vegetables, 2.7 times higher for fruit, 3.7 times higher for protein rich staples and 2.5 times higher for meat.

Other cases have specifically reported improved food security, including Community Managed Sustainable Agriculture in Andhra Pradesh, India, where average household expenditure on buying grains fell by 44 percent. Collective farming by Tamil Nadu Women's Forum, the push-pull weed management technology in Kenya and agroecological methods in Tanzania also resulted in improved food security.

3.6 Benefits to women

Since FAO published its land-mark report "State of Food and Agriculture 2010-211: Closing the Gender Gap",[180] addressing gender inequality in food production has garnered significant international attention. The World Bank,[181] and the International Food Policy Research Institute[182] have published reports on the topic, and UNEP's "Gender and the Global Environment Outlook" is forthcoming.[183] Of course many other organizations have been calling for attention and improvements to the lot of women in agriculture for years. PAN Asia and the Pacific has had a programme addressing the roots of inequality and discrimination against women in agriculture since 1994, with a special rural women's leadership training programme for the last eight years.[184]

Yet women remain largely invisible. This is certainly at the national policy level, and often also in the community – despite the fact that women

179 Markandya A, Setboonsarng S. 2008. Organic Crops or Energy Crops? Options for Rural Development in Cambodia and the Lao People's Democratic Republic. ADBI Discussion Paper 101. Tokyo: Asian Development Bank Institute.

180 FAO. 2011. 2010-2011 The State of Food and Agriculture. Women in Agriculture: Closing the gender gap for development. FAO, Rome.

181 World Bank. 2012. World Development Report, 2012: Gender Equality and Development. The World Bank, Washington, DC.

182 IFPRI. 2013. 2012 Global Food Policy Report. International Food Policy Research Institute, Washington, D.C.

183 http://www.ipsnews.net/2015/03/opinion-a-major-push-forward-for-gender-and-environment/

184 http://www.panap.net/issues/womens-empowerment; http://www.panap.net/campaigns/women-assert-our-rights

are the main agricultural producers in many countries. They often work the most degraded land, have less secure tenure, lower incomes and less access to credit, and face the greatest difficulty accessing inputs and assistance. In Asia, women are responsible for about half the tasks in rice cultivation. In some regions, their home gardens are some of the world's most complex agricultural systems. They also provide labour and make decision-making on post-harvest operations such as storage, handling and marketing.[185]

The UN's Economic and Social Commission for Asia and the Pacific (ESCAP) has noted the marginalising of women farmers by conventional and export agriculture in Asia, pointing out that:

> *"As countries have moved towards cash crops, however, and commercial farming has become more mechanised, women have been steadily displaced as farmers and reduced to being agricultural workers."*[186]

FAO has pointed out the need to ensure that women farmers are adequately resourced. They conclude that to do so would increase agricultural output in low-income countries between 2.5 and 4 percent, and could bring down the number of undernourished people by 100-150 million.[187] A recently published study[188] of agroecological techniques applied to maize growing in Kenya showed that, on average, women farmers produced higher yields than their male counterparts. Whilst women farmers using chemicals also produced greater than average yields, the differential was significantly greater for those using agroecological techniques. In Malawi, agroforestry in maize did not close the gender gap, with women's yields still less than men's, although significantly greater than for those women relying on chemical fertilizers.

Project site for 'Putting Lessons into practice: Scaling up people's biodiversity mangament for food security', Vietnam. *Centre for Sustainable Rural Development (SRD)*

> ***"In principle, agroecology can benefit women most, because it is they who encounter most difficulties in accessing external inputs or subsidies. But their ability to benefit should not be treated as automatic; it requires that affirmative action directed specifically towards women be taken."***
>
> *Olivier de Schutter, UN Special Rapporteur on the right to food, 2011*

Hence, to close the gender gap in yields, evidence suggests that it would be better to provide agroecology training and inputs to women farmers than resources supporting chemical farming.

The UN Special Rapporteur on the right to food pointed out that women farmers receive only five percent of agricultural services worldwide, and that gender issues are incorporated into less than 10 percent of development assistance in agriculture.[190]

185 UNESCAP. 2009. *Sustainable Agriculture and Food Security in Asia and the Pacific.* UNESCAP, Bangkok.
186 *Ibid.*
187 FAO 2011, *op cit.*
188 Curtis 2015, *op cit.*
189 *Ibid.*
190 De Schutter 2010, *op cit.*

Table 3.5 Greater yields by women farmers in Kenya[189]

Average yield maize (kg/ha)	Push-pull farmers, Kitale, Kenya	Push-pull farmers, Mbita, Kenya
All farmers	5,632	1,840
Women farmers	5,797	2,196

Women tending rice seedlings after fish are harvested and field drained in Bangladesh. *SHISUK*

Because of women's roles as transmitters of traditional knowledge, particularly about on-farm seed conservation and biodiversity management, a transition to agroecology has enormous potential to empower women. The adoption of SRI in Cambodia has resulted in greater involvement of women in farming.[191] But this does not happen automatically, and men may continue to dominate, as, for example, happened in Brazil until women took action to ensure their own participation.[192]

"Furthermore, proper recognition of women's right to use common property resources is also an insurance against misuse and overuse of these vital resources and mismanagement of biodiversity and ecology."

UNESCAP 2009

Agroecological projects can and should put women at the centre of ongoing efforts, reinforcing gender equity and women's rights, livelihoods and income.[193] Cuba's National Association of Small farmers (ANAP), the farmer-to-farmer movement for agroecology in that country, states that agroecology must include equal participation of men and women, according to their capacities and conditions, in both work and decisions on the farm.[194]

Women's groups have been at the centre of organizing the Community Managed Sustainable Agriculture in Andhra Pradesh, India (Chapter 6.1). As they previously performed most of the spraying and consequently suffered numerous health effects, they are strong supporters of the agroecological approach now used.[195]

191 Markandya A, Setboonsarng S. 2008. Organic Crops or Energy Crops? Options for Rural Development in Cambodia and the Lao People's Democratic Republic. ADBI Discussion Paper 101. Tokyo: Asian Development Bank Institute.

192 Parmentier 2014, *op cit.*

193 FAO 2015 symposium report

194 Sosa BM, Jaime AM, Lozano DR, Rosset PM. 2013. *Agroecological Revolution: The Farmer-to-Farmer Movement of the ANAP in Cuba.* Asociación Nacional de Agricultores Pequeños (ANAP) and La Vía Campesina, Ciudad de la Habana and Jakarta.

195 Kumar TV, Killi J, Pillai M, Shah P, Kalavakonda V, Lakhey S. 2009. *Ecologically Sound, Economically Viable: Community Managed Sustainable Agriculture in Andhra Pradesh, India*. World Bank. Washington, DC.

Box 3.2: The Deccan Development Society

The Deccan Development Society, a 25-year-old community organization working in 25 villages in Andhra Pradesh, India, has 5,000 women members representing the poorest of the poor in their communities. They have created a community grain fund in 60 villages for procurement, storage and distribution, managed entirely by women. The women are responsible for disbursing loans that are used primarily to support marginal and small farmers to bring fallow lands into production, using agroecological techniques and local knowledge.

As a result of this programme, over 10,000 acres of degraded land has been bought into production, six times as much food has been produced, and agri-biodiversity has increased by reviving over 80 traditional varieties of cereals, legumes, pulses and oilseeds, and other crops, providing a more nutritious range of food. The community grain fund also provides emergency food needs at critical times for the poorest. They have even established 'Café Ethnic' in the town of Zaheerabad to help adapt urban consumers to traditional grains and organic food culture.

The programme also focuses on health care, empowerment and education. [196]

Agroecological techniques can also help relieve women of time spent dealing with household chores, freeing them to become more productive on the farm. A soil conservation and agroforestry project in the West Africa Sahel region, for example, has resulted in the average time women spend collecting fuelwood each day falling from 2.5 to 0.5 hours, and the abundance of fodder from the trees has enabled 80 percent of women to own livestock, an important source of both food and income for them.[197]

Efforts to improve extension services in agroecology to women farmers, plus assistance in marketing and business management, would go a very long way to reducing global poverty and malnutrition.

Watering of market gardening crops by women from the Yakar women association in the Niayes region, Senegal. *PAN Africa*

3.7 Other socio-economic and environmental outcomes

Some of the most extensive documentation of socio-economic and environmental benefits of adopting agroecology comes from the Community Managed Sustainable Agriculture in Andhra Pradesh, India. A wide range of benefits are reported, including fewer pesticide health problems, lower debt, reduced suicides, social empowerment, new livelihood opportunities, business innovation, improved soil ecology, water conservation and less polluted water, increased biodiversity and reduced carbon footprint.

196 (i) http://ddsindia.com/www/default.asp. Accessed April 2015. (ii) UNESCAP. 2009. Sustainable Agriculture and Food Security in Asia and the Pacific. UNESCAP, Bangkok.

197 Pretty J, Toulmin C, Williams S. 2011. Sustainable intensification in African agriculture. *Int J Agric Sustain* 9(1):5-24.

FAO's Regional Integrated Pest Management (IPM) Programme in the Near East reported a number of social benefits, in addition to a 60-70 decrease in pesticide use and improved net returns. The programme was implemented in Egypt, Iran, Jordan, Lebanon, the Palestinian territories, Syria, Algeria, Morocco, Tunisia and Iraq between 2004 and 2012. Crops involved were tomato, apple, grape, peach, mint, pistachio, cucumber, watermelon, wheat, strawberry, date palm, citrus and olive. Social benefits reported included:

- √ Increased confidence of farmers
- √ Improved decision-making capacity
- √ Awareness of the need to organize themselves into groups or associations in their areas, improving social relations at the community level[198]

Stronger farmer co-operation and community action

A common thread running through agroecological studies, projects and farming communities is the role of co-operation and collaboration in translating ecological approaches into positive outcomes for farming households in terms of income, welfare or food security. By joining together in village groups, formal farmer associations or co-operatives, smallholder farmers can achieve much better results than working alone. Such relationships can contribute to successful implementation of day-to-day management practices and can be particularly invaluable in times of crises – including climatic events. Social benefits of the 2000-2004 FAO-EU Integrated Pest Management Programme for Cotton in Asia, which conducted training for 93,700 farmers through FFS in Bangladesh, China, India, Pakistan, Philippines and Vietnam, included

Market gardening in a community farm without chemicals at Malen Hodar in the Tambacounda region, East Senegal. *PAN Africa*

higher collaboration between villagers and stronger connection with agricultural officers and village authorities.[199]

<u>*Co-operating to manage difficult pests*</u>

Managaing certain pests, crop diseases or weed problems on a single field or small farm basis is difficult, especially when avoiding use of pesticides. For example, it can be hard to control whiteflies in tomato production using biological control on a single farm if neighbouring farmers are spraying harmful insecticides that kill the natural enemies. Rats are a good example of a very mobile, clever and rapidly reproducing pest where the local pest population affects several farms and households, and joint tactics are needed. Community-based rodent control in Eastern and Southern Africa used intensive trapping, where hazardous and often inappropriate pesticide use by single households failed to prevent rat damage to stored food (see Box 3.3).

198 Beniwal S, Sharaf N, Ceccarelli S. 2011. Regional Integrated Pest Management Programme in the Near East (GTFS/REM/)&)/ITA). External Evaluation Mission Report. 20 February – 15 March 2011. Office of Evaluation, FAO, Rome.

199 Mancini F. 2006. Impact of Integrated Pest Management Farmer Field Schools on Health, Farming Systems, the Environment, and Livelihoods of Cotton Growers in Southern India. PhD Thesis. Wageningen University, Netherlands.

Box 3.3: Ecorat: community-based rodent management in southern Africa[200]

The *Ecorat* project, co-ordinated by the University of Greenwich, UK, piloted a community-based alternative to poisons in eastern and southern Africa, based on mass trapping by villagers. It requires training on understanding rodent ecology and a commitment from villagers to work together to carry out fairly labour intensive methods over long periods. However, the cost of family labour is much lower than that of poisons. Rat traps require an initial outlay to buy, but can last many years, killing many more rats than would have been killed by the equivalent cost of poison. The main challenge is to trap intensively enough over a large enough area to significantly reduce the rat population.

Villages involved in the project compared their usual poison-based approach with the *Ecorat* method of intensive trapping and preventing rodent access to food sources. Kill-trapping was organized at the community level, with traps rotating around the community to share the costs. Households normally had plenty of labour on hand to set one or two traps each evening and check the traps each morning, delegating the role to a particular member of the family. Simple tracking tools using a soot-covered tile on the floor to record footmarks and regular checking of stored grain sacks for signs of damage and rat faeces helped households assess rat damage levels and whether trapping was effective. Intensive trapping worked very well in reducing rodent populations and damage levels in villages where homesteads are close together and all involved in trapping. Where households are more scattered, there is more chance of rodents migrating in from elsewhere, although mass trapping still provides some benefit.

A cost-benefit analysis carried out with the communities indicated that the benefits of trapping (more food, less disease, fewer people bitten by rats, less damage to household goods) far outweighed the costs of the *Ecorat* scheme (labour, traps, and logistics). Good community organization was key to successful rodent control.

Co-operating to train and support more farmers

Experiences from a whole range of agroecological projects have shown that farmers trained in these methods are often willing to train other farmers. For example, organic cotton farmers in Benin have proven very willing to share their expertise with their neighbours.

Farmer Field Schools and similar experiences show that building the technical competence of individuals and small groups through hands-on learning leads to increased self-determination and the confidence to explore and innovate. Confident and motivated farmer groups can then develop social networks, which generate collective action to improve their livelihoods and welfare. Case studies in Chapters 6-9 demonstrate how this works and how valuable it is to rural communities.

Co-operating for better marketing and enterprise development

Where farmers have trained together and work cooperatively on agroecology projects, they have also often grouped together to assist each other with selling produce or provision of farming inputs. In India, the Community Managed Sustainable Agriculture (CMSA) groups have gone on to develop community seed banks and farming equipment centres, which hire tools out

200 Belmain S. 2010. Developing pesticide-free rodent control for southern Africa. *Pesticides News* 87 9-11.

Training on organic production and agroecology. *Alter Vida Comunicación*

to members. CMSA has helped create at least 2,000 jobs in villages through the establishment of shops for supplying bio-pesticides, organic nutrients, seeds and tool sharing. The 'magic ingredient' has been building confidence and trust, and fostering effective collaboration among farmers and village co-operatives. Also in India, the farmers of the Kuruvau case study are planning to organize themselves into a sellers' cooperative to seek better bargaining power for their produce.

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SECTION B:
How to Replace HHPs with Agroecology

Rice-duck system of insect and weed control and fertility enhancement, China

4. Agroecology: Key principles and practices

"Above all, though, I think agroecology is a mind-set, a desire to do better, and a form of optimism and trust in both our natural resources and our intelligence as human beings. .... Agroecology is an investment in the future. It also provides a means of meeting the needs of society as a whole."

Stéphane Le Foll, Minister for Agriculture, Agrifood and Forestry, France. Agroecology: A Different Approach to Agriculture. Huffington Post, 18th September, 2014.

Agroecology, and ecosystem approaches generally, do not consist of one particular set of defined practices that can be applied to farming around the world. This is a fundamental point of departure from the current dominant model of chemical-intensive production in which the chemical inputs are more or less the same globally, irrespective of local situations. Because the basic approach of agroecology is to work with nature and farmers' needs, it follows that practices must be tailored to each local situation. So this approach can best be understood in terms of a series of scientific principles that give rise to practices which sustainably meet local needs, varying case by case based on the agroecosystem, climate and geography, local knowledge, and socioeconomic conditions.

Adapting to local environments: contour planting, Zarcero, Costa Rica. *Fernando Rameriz*

4.1 Agroecological principles

The basic elements of agroecological approaches revolve around mimicking natural processes and creating beneficial biological interactions. Agrocecology involves managing ecological relationships and promoting key ecological processes, while diversifying, conserving resources and minimising toxic inputs.[201]

[201] (i) Parmentier S. 2014. *Scaling-up Agroecological Approaches: What, Why and How?* Oxfam-Solidarity, Belgium. (ii) Silicia L. 2014. *Agroecology: What it is and what it has to offer.* Issues paper, June. International Institute for Environment and Development, London.

The seven core principles of agroecology are:[202]

- Adapting to local environments
- Providing the most favourable soil conditions for plant growth by enhancing soil biological activity and soil organic matter, recycling nutrients through organic matter decomposition
- Promoting biodiversity within the system, over time and space, at the field and landscape level; promote complexity not simplicity
- Enhancing beneficial biological interactions and synergies to promote, especially, those that regenerate soil fertility and provide pest management without resorting to external inputs
- Minimizing losses of energy and water from the system
- Minimizing the use of non renewable external resources through nutrient recycling;
- Maximizing the use of farmers' knowledge and skills

Following these principles goes a long way to establishing a growing environment that is resilient to climate variations, works with nature not against it and requires minimal intervention for pest management. Pest management means managing the agroecosystem to avoid build up of pests using, wherever possible, cultural, biological and mechanical methods instead of synthetic materials. Improving soil health, not just nutrient status, is the fundamental principle of agroecology and all ecosystem approaches to farming. These principles are expanded on below in a manner that recognizes the need to first and foremost adapt techniques to the local environment; actual practices must be context specific and are not prescribed.[203] Section 4.2 looks at brief examples of how farmers are putting these agroecological principles into practice.

Principle 1. Adapting to local environments

i. Use a holistic approach to identify, analyse and resolve farm issues – the agroecosystem is regarded as a whole and its health is valued more than the productivity of single crops.

ii. Harmonize the farming system and crops to the productive potential and physical limitations of the farm and surrounding landscape.

iii. Employ functional landscape management around field perimeters (use windbreaks, shelterbelts, and undisturbed areas that act as buffer zones, provide food and habitat for natural enemies of pests), across multiple fields (mosaics of crop types and land-use practices), and at the landscape level (buffers along rivers, woodlots, pastures and natural or semi-natural areas).[204]

iv. Choose suitable plants and animals for the ecological conditions of the farm rather than modifying the farm to meet the needs of the crops and animals.

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202 (i) Altieri MA, Nicholls C, Funes F, SOCLA. 2012. Scaling Up Agroecology: Spreading the Hope for Food Sovereignty and Resilience. A contribution to discussions at Rio+20 on issues at the interface of hunger, agriculture, environment and social justice. SOCLA. www.agroeco.org/socla (ii) Pretty J. 2006. Agroecological Approaches to Agricultural Development. Background Paper for the World Development Report 2008. Rimisp-Latin American Center for Rural Development. (iii) De Schutter O. 2011. Agroecology and the Right to Food. United Nations Special Rapporteur on the Right to Food. A/HRC/16/49. http://www.srfood.org/index.php/en/component/content/article/1174-report-agroecologyand-the-right-to-food

203 (i) Principles of Agroecology and Sustainability. http://www.agroecology.org/Principles_List.html (ii) Silicia 2014, op cit. (iii) UNEP. 2012. Evaluation of non-chemical alternatives to endosulfan. Persistent Organic Pollutants Review Committee. UNEP/POPS/POPRC.8/INF/14/Rev.1. (iv) Parmentier 2014, op cit. (v) Altieri et al 2012, *op cit.*

204 Boller EF, Häni F, Poehling HM (eds). 2004. Ecological Infrastructures: Ideabook on Functional Biodiversity at the Farm Level Temperate Zones of Europe. International Organization for Biological Control (IOBC) Western Palaearctic Regional Section.

Healthy soils have large numbers of earthworms as well as many other beneficial organisms

v. Save seed, maintain local varieties and landraces and use heirloom varieties to enhance adaptation to changing biotic and environmental conditions.

Principle 2. Providing favourable soil conditions

i. Enhance soil health and nutrient availability by increasing organic matter and biological activity especially of mycorrhiza, rhizobia,[205] and free-living nitrogen fixers to achieve a balance in nutrient flow.
ii. Return crop residues and manures to soils.
iii. Make plenty of good compost.
iv. Keep soil covered with green manure crops, cover crops and mulches to reduce erosion, reduce compaction from rain, reduce desiccation by the sun and provide nutrients to the soil.
v. Maximize biological nitrogen fixation through use of legumes (as crops in rotations, inter-crops, and/or as green manure crops), and minimize or eliminate chemical fertilizers.
vi. Minimize erosion by keeping soil covered, using contours, and careful management of water.
vii. Minimize soil disturbance: using reduced tillage or no-till methods improves soil structure (including aeration, water infiltration and retention capacity), soil biota and organic matter.

Principle 3. Diversifying species and genetic resources

i. Use intercropping and poly-culture, i.e. mixing two or more crops in a single plot: biological complementarities improve nutrient and input efficiency, use of space and pest regulation, and result in enhanced crop yield stability.
ii. Employ crop rotation, such as a cereal-legume sequence, and fallowing: nutrients are conserved from one season to the next, and the life cycles of insect pests, diseases, and weeds are interrupted, preventing their build up to economically damaging levels.
iii. Use agroforestry. Trees grown together with annual crops, or in pastures, modify the microclimate and improve soil fertility (especially if they are nitrogen fixing species). They can also contribute to soil fertility by nutrient uptake from deep in the soil, and their leaf litter helps replenish soil nutrients, maintain organic matter, and support complex soil food webs.
iv. Use multiple species, varieties and landraces of crops and animals on the farm, appropriate to the locality and especially those that are resistant to diseases and pests. Crop-livestock mixtures provide optimal nutrient recycling. Livestock production that integrates fodder shrubs planted at high densities, intercropped with highly-productive pastures and timber trees – all combined in a system that can be directly grazed by livestock – enhances total productivity without need of external inputs.

[205] Mycorrhiza and rhizobia are naturally occurring beneficial soil microorganisms in association with plant roots that assist with nutrient uptake.

Principle 4. Enhancing beneficial biological interactions

i. Re-establish ecological relationships that occur naturally on the farm instead of reducing and simplifying them. Enhance beneficial interactions amongst the agro-biodiversity to promote key ecological processes (e.g. nutrient recycling), rather than undermining these processes by focusing on individual species.
ii. Prevent or manage pests, diseases and weeds instead of trying to 'control' or eliminate them.
iii. Integrating crops, pastures, trees and livestock, including aquaculture, allowing optimal nutrient recycling and high total productivity through biological interactions.
iv. Use cover cropping to help manage weeds and enhance predation of pests.
v. Promote biological management of pests, diseases and weeds through enhancement of beneficial insects, use of pheromones, push-pull methods, and allelopathy (in which an organism produces one or more biochemicals that influence the growth, survival, and reproduction of other organisms).
vi. Optimize timing of planting and weed management.
vii. Manage crop nutrient levels to help reduce pest and disease pressure (high nitrogen input can make plants more susceptible).

Principle 5. Minimizing use and loss of water and energy

i. Use mulches to reduce fluctuations in soil temperature and moisture.
ii. Use efficient water harvesting and irrigation systems.
iii. Use renewable sources of energy and energy efficient technologies; use local, naturally-occurring materials instead of synthetic, manufactured inputs.

Coffee interplanted with bananas and leguminous plants to increase biodiversity, Central America. *Stephanie Williamson*

Principle 6. Minimizing use of non renewable external resources

i. Use on-farm resources as much as possible: by substituting external inputs with biological processes not only are the costs of farming reduced, but biodiversity is increased.
ii. Reduce or eliminate the use of materials that have the potential to harm the environment or health of farmers, farm workers, other workers or consumers.
iii. Use farming practices that reduce or eliminate environmental pollution with nitrates, toxic gases or other materials generated by burning or overloading agroecosystems with nutrients.
iv. Use chemical inputs only as a last resort and at the lowest level possible.

Principle 7. Maximizing the use of farmers' knowledge and skills

i. Take advantage of essential local knowledge and traditional systems and wisdom.
ii. Work cooperatively with other farmers.
iii. Take part in Farmer Field Schools.

A fundamental feature of agroecology is the continual, systematic search for the best combinations of techniques and strategies for optimising sustainable production in a given context, instead of relying on a few standardized 'best practices' to fit all.[206]

Finally, agroecological farming promotes community-oriented approaches that are sustainable and resilient, and that look after the needs of its members, in terms of both production and consumption.

> ***"In West Africa, stone barriers built alongside fields slow down runoff water during the rainy season, allowing an improvement of soil moisture, the replenishment of water tables, and reductions in soil erosion. The water retention capacity is multiplied five- to ten-fold, the biomass production multiplies by 10 to 15 times."***
>
> *Olivier de Schutter, UN Special Rapporteur on the right to food, 2011*

Box 4.1: Check list of the key agroecological characteristics

promote key ecological processes – diversify – conserve resources – minimise inputs

1. ***Adapting to local environments***
   - √ harmonize farm with the environment
   - √ choose suitable plants and animals
   - √ use locally adapted seeds
2. ***Providing favourable soil conditions***
   - √ maximize organic matter
   - √ maximize biological nitrogen fixation
   - √ keep soil covered
   - √ minimize tillage
   - √ maximize biological nitrogen fixation
3. ***Diversifying species and genetic resources***
   - √ intercrop, poly-crop, agroforestry
   - √ crop rotations, cover crops
   - √ multiple species, varieties and landraces of plants and livestock
4. ***Enhancing beneficial biological interactions***
   - √ prevent pests, weeds, diseases
   - √ enhance biological controls
   - √ optimize timing of planting and weeding
5. ***Minimizing use and loss of water and energy***
   - √ mulches
   - √ efficient water harvesting and irrigation
   - √ renewable energy
   - √ local resources
6. ***Minimizing use of non renewable external resources***
   - √ substitute biological process for inputs
   - √ eliminate environmental pollution
   - √ use chemical as a last resort only
7. ***Maximizing the use of farmers' knowledge and skills***
   - √ local knowledge
   - √ traditional systems
   - √ work cooperatively

[206] Parmentier 2014, *op cit*.

Box 4.2: Community-based integrated inland fisheries and rice growing in Bangladesh

The Bangladesh fisheries sector, directly and indirectly, offers livelihood to over 12 million people, and contributes about 17% to the total agricultural earnings of the country. Fish forms about 73% of the total animal protein intake. Fisheries production in the inland waters, however, was declining because of over-fishing, flood control and irrigation projects and heavy insecticide use in rice fields, and the consequent insecticide contamination of the land and inland waters.

The Pankowri Fisheries Project, initiated in 1995 by the NGO SHISUK (Shiksha Shastha Unnayan Karzakram or Education, Health and Development Programme), in Illiotgoing, Comilla District, integrated fisheries with agriculture to make optimum and integrated use of the resources available in a sustainable and ecologically sound manner through a community-based development process. The project involved more than 350 families and covered an area of 285 acres of flood plain land around six villages. Most people were small and marginal farmers, and 80% of the people lived below the poverty line and were in debt.

Fish were reared by the community for the seven months of the year when the plains were flooded. They were harvested in December; the floodwater was gradually drained during the harvest, and drainage was completed just before the time for transplanting paddy for the rice crop in January. Farmers could go straight into paddy transplanting without having to plough the land. The fishery resulted in the land remaining clear of weeds, eliminating the previous cost to rice farmers of preparing and clearing the fields.

Improved methods used in the fishery to increase its productivity, including liming, fertilization (compost and a small amount of urea), and addition of fish feeds (mustard cake and rice bran), together with the fish excreta, resulted in improved soil fertility. This reduced the need for chemical fertilizer and increased rice yield. Some of the species of fish ate insect pests, controlling their populations and avoiding pest outbreaks.

Poverty was reduced: income from fisheries alone rose substantially, with the annual community income from this source increasing by about 500%. In addition:

- √ Rice yields increased about 20% – from about 5900 kg/ha to 6900-7400 kg/ha
- √ Chemical fertilizer reduced by 25%, and pesticides by 50%
- √ Ploughing, land preparation and weeding
- √ New employment opportunities arose
- √ Migration during the off-season stopped
- √ Community interaction and cohesiveness improved;
- √ Better social and educational facilities opened up, with better roads and transport, and more children going to school

In 2006, SHISUK established the Field Learning Site of the Community Enterprise Approach, known as the 'Daudkhandi model', for community-based floodplain fisheries management. This model has shown that fish production can be increased by more than 3 tonne/ha/year by stocking in seasonal floodplain, with no reduction in wild fish catch, and the cost of rice production lowered by 30-40%.

Extracted from: (i) Morshed, SM. 2003. Bangladesh: Community-based integrated flood plain resource management for rural development. In: *Past Roots, Future of Food Ecological Farming Experiences and Innovations in Four Asian Countries,* PAN AP. (ii) SHISUK. Undated. FLS on Community Enterprise Approach for sustainable development.

4.2 Agroecological practices

Low cost local inputs: organic brews, including fish amino acid and fermented plant juice, to increase soil and plant health and control pests, Philippines *Achim Pohl*

Gliricidia and maize growing together, with the *Gliricida* providing nitrogen for the maize

Whilst many of the agroecological approaches described below and highlighted in the case studies are more easily adopted on small-scale farms than medium- or large industrial-scale farms where labour is in short supply, nevertheless the principles can be applied and many practices adopted on farms of any size. Additionally, HHPs can be replaced by less damaging external inputs such as biopesticides, biological controls, mating disruption and other such nonchemical approaches that will also be described below.

This is by no means an exhaustive list of practices, just an indication of some options available. Experiences in Europe and the US, described in Chapter 9, show that agroecological techniques are clearly not the preserve of low-income countries alone.

Agroforestry to improve soil fertility and health

Building healthy soil is perhaps the single most important element of agroecology. It cannot be done by adding synthetic chemical fertilizers, which may give a short-term boost (if there is sufficient water in the soil for plant roots to be able to take them up), but at the expense of longer-term health of important soil biota. Fertilizers are also expensive, much more so than the free nitrogen obtained by nitrogen-fixing legumes via their bacterial 'collaborators'.

More than a quarter of a million households in Malawi have adopted agroforestry with *Gliricidia* and other nitrogen fixing trees, after trials showed that interplanting these with maize brought record-breaking yields. Trials in Zambia and Malawi found that when *Gliricidia* is intercropped in this way, the maize yields doubled in comparison with use of commercial fertilizers, and increased seven times in comparison with maize grown without fertilizer.[207]

A study of 16 tree species found that food and fodder legumes can fix more than 176 kg nitrogen per hectare per year, that figure increasing to 650 kg in high density plantings.[208]

In crops where agroforestry is not possible, growing and incorporating into the soil short term

207 Jiggins J. 2014. Adaptation and mitigation potential and policies for climate change: the contribution of agroecology. Chpt 123 in: Freedman B (ed), *Global Environmental Change,* Springer, Dordrecht.

208 Leakey R. 2014. The Role of Trees in Agroecology and Sustainable Agriculture in the Tropics. *Annu Rev Phytopathol* 52:113-33.

"In Tanzania, 350,000 hectares of land have been rehabilitated in the Western provinces of Shinyanga and Tabora using agroforestry."

Olivier de Schutter, UN Special Rapporteur on the Right to food, 2011

Catching fish in a floating (deep water) rice field, Vietnam. Research Centre for Rural Develeopment, *An Giang University.*

Zai pits ready for planting, Sahel

'green manure' legume crops and incorporating them into the soil is the best option. These crops pull free nitrogen out of the air and fix it in the soil.

Water harvesting combined with soil improvement

The traditional practice of digging zai pits in rock-hard barren land helps with growing crops in times of drought. This age-old water harvesting method has been successfully revived in Burkina Faso and Mali. The pits are filled with organic matter and attract termites; the channels they dig improve soil structure and increase water-retention capacity.[209]

No-till farming / conservation tillage

No-till or zero-till farming, also referred to as conservation tillage, involves sowing seed, or planting out seedlings, directly into untilled soil in which a narrow slot or trench has been opened. No ploughing or other tillage is done. This practice decreases erosion, breakdown of soil structure, and water losses, and increases carbon sequestration in the soil. It also hugely benefits the beneficial soil biota, as long as herbicides are not used to burn down vegetation before sowing, as is commonly done in industrial farming. That practice is detrimental to soil health and unsustainable, especially when followed by chemical fertilizers.[210]

In an agroecological approach, no-till can be combined with natural control mechanisms for managing pests, pathogens and weeds, reducing the need for further interventions. In Santa Catarina in southern Brazil, many hillside family farmers have developed an innovative organic minimum tillage system that relies on the use of mixtures of summer and winter cover crops, which leave a thick residual mulch layer that suppresses weeds. After these cover crops are rolled flat using adapted

[209] Li Ching L, Edwards S, Scialabba NE. 2011. *Climate Change and Food Systems Resilience in Sub-Saharan Africa.* FAO, Rome. p192.

[210] Rodale Institute. 2014. *Regenerative Organic Agriculture and Climate Change. A Down-to-Earth Solution to Global Warming.* Rodale Institute, Kutztown PA.

Farmer leader and MASIPAG board member Marcelino dela Rosa explains rice breeding during a training with PAN AP at the MASIPAG back-up farm in Sta.Rosa, Nueva Ecija. *MASIPAG*

equipment, traditional crops (maize, beans, wheat, onions, tomatoes, etc) are directly sown or planted into the mulch layer. Repeated application of fresh biomass to the soils has resulted in improved biomass content, minimized erosion and weed growth. During the severe drought of 2008-09, these farmers experienced only a 20 percent loss of maize yield compared with the 50 percent loss suffered by conventional maize producers.[211]

Nevertheless, tillage can have positive effects on pest, weed, disease, water and nutrient management (see Chapter 6.1). It should not be abolished from a cropping system until these aspects are being addressed by other agroecological techniques. See also the case study in Chapter 7, where ox-powered tillage of dry hard-pan soil in Tanzania brought real benefits in water penetration of the soil, with subsequent increased productivity.

Locally adapted seeds

Farmer-led rice seed breeding by MASIPAG, a nationwide network of small-scale farmers, scientists and NGOs in the Philippines, has resulted in the development of more than 580 rice cultivars. The network maintains almost 3,000 traditional varieties, MASIPAG and farmer-bred cultivars These seeds are well adapted to local conditions, and give the farmers the potential to adapt them further to future climate challenges. As a result of their seed breeding and other crop variety developments, together with agroecological techniques, the farmers have achieved higher incomes, better food security and a more varied and nutritious diet (see Chapter 6.5).

Agroforestry to manage pests and diseases

The manipulation of tree canopy density and diversity in the growing of crops such as cocoa and coffee has proven highly successful in managing pests and diseases. In cocoa cultivation, tree shading can be manipulated to control the incidence of frosty pod rot caused by the fungus *Moniliophthora roreri*. In coffee plantations, shade trees can be managed to provide optimal light conditions to minimize diseases such as leaf splotch and berry blotch (*Cercospora coffeicola*) and coffee rust (*Hemileia vastatrix*). Agroforestry can also help farmers manage citrus mealy bug pests (*Planococcus citri*) and maximize conditions for beneficial fauna and microflora; predation of insect pests by birds is greatest when the canopy is not intensively managed. Shade trees also provide habitat for beneficial insects that pollinate cocoa. Shade trees can reduce phorid flies which negatively affect ant populations, reducing their ability to control coffee berry borer.[212]

Biological control of pests

Natural enemy is the term given to any living organism that helps keep pests under control by feeding on them, parasitizing or infecting them. Ladybird beetles that eat aphids (greenfly) are a

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211 Parmentier 2014, *op cit.*
212 Leakey 2014, *op cit.*

The economic value of natural pest control is estimated at US $13.6 billion per year in the US alone.

Losey & Vaughan 2006

The carabid beetle, ***Ophionea***, a predator of leaf roller in rice. *TV Vineeth Krishan*

familiar garden example of a useful predatory natural enemy. Many species of spiders, lacewings, beetles, wasps, birds and frogs are effective predators of insect pests. Different types of parasitic wasp lay their eggs in or on caterpillars, aphids and other soft-bodied insect pests; when the wasp larvae hatch they feed on the paralysed host, eventually killing it. Several groups of bacteria, viruses and fungi cause fatal disease in certain insects, without harming other types of animal. Other microorganisms can help control crop diseases by competing with the disease-causing organisms.

These natural enemies (sometimes called beneficial organisms) provide a hugely important ecological service of biological control of pests, free to farmers. The economic value of natural pest control is estimated at US $13.6 billion per year in the US alone, from savings in insecticide costs and the damage to crops avoided when natural enemies are at work.[213] However, natural enemies are easily harmed by pesticides and farmers who spray often may unwittingly kill off the 'good bugs' in their fields. This can lead to more pest problems in the end, especially if the pests develop resistance to the pesticides used, while the natural control service is undermined. Many of the cheaper, older pesticides widely used in low-income countries are 'broad-spectrum' compounds and kill beneficial insects as well as the target pests. Avoiding use of these products helps to conserve natural enemies.

Making best use of existing natural enemies is one of the most important principles of ecological pest management. For example, by encouraging flowering weeds around fields, farmers provide nectar sources for adult parasitic wasps. Agroecological farmers can also 'top up' the level of natural pest control by adding extra biological control agents. Application of microbial biocontrol agents as biopesticides is a common tactic: many vegetable farmers use products based on the bacterium *Bacillus thuringiensis kurstaki* (Btk), which is one of the most widely used biocontrol agents. This naturally occurring bacterium is an effective biological control against moth larvae, such as bollworms, diamond back moth, leaf miners, fruit and shoot borer, armyworm and a range of other caterpillars. A close relative, *Bacillus thuringiensis israeliensis* (Bti), is effective against mosquito larvae.[214]

The case study in Chapter 8, on managing coffee pests without the HHP endosulfan, details experiences in using the fungal-based biopesticide *Beauveria bassiana*. Use of biopesticides is fully accepted by organic standards and is often an important part of organic farmers' pest management strategies. Releasing extra parasitic or predatory insects into fields or greenhouses is another method, either using commercially bought insects or mass-rearing these on-farm or in the village.

213 Losey JE, Vaughan M. 2006. The economic value of ecological services provided by insects. *BioScience* 65(4):311-23.

214 UNEP. 2012. Evaluation of non-chemical alternatives to endosulfan. Persistent Organic Pollutants Review Committee. UNEP/POPS/POPRC.8/INF/14/Rev.1.

Sticky traps for vegetable leafminer and whitefly in an organic greenhouse, Zarcero, Costa Rica. *Fernando Ramirez*

Control of the coffee berry borer in Mexico's organic coffee production systems includes the use of the entomopathogenic fungus *Beauveria bassiana,* the parasitic wasps *Prorops nasuta, Phymastichus coffea,* and *Cephalonomia stephanoderis,* attractant traps, removing dried berries from the plants (sanitary harvesting) to interrupt the pest's life cycle and spraying the botanical pesticide neem (see section below for more on this).[215]

Botanical extracts

A number of plant extracts are used as alternatives to synthetic insecticides; neem is perhaps one of the most well-known. Both leaves and seeds of the neem tree, *Azadiracta indica*, have insecticidal properties. The tree is native to South Asia, but now grows in other tropical and subtropical regions as well. Neem leaves and seeds have been used for thousands of years for cosmetics, personal hygiene, medicines and pest control. For pest control, it is used as a leaf extract, seed extract, neem oil, neem oil soap and neem cake. The oil is pressed from the fruit and seeds, and the cake is the by-product of oil extraction. The main component of neem active against insects is azadirachtin; it has insect growth regulator, anti-feedant and oviposition-deterrent properties.[216]

Neem is said to be effective on over 200 pests including species of whiteflies, thrips, leaf miners, caterpillars, aphids, scales, beetles, true bugs and mealybugs, but its efficacy varies. It is best used on immature stages of pests, before pest levels are high, and with repeated applications. It is permitted in organic agriculture in some countries, but preventative, cultural, mechanical and physical methods need to be the first choice of pest control method, with neem used as a last resort.[217]

Pest attractants

There are a number of methods of attracting pests away from crop plants, thereby removing or reducing the need for insecticides. These include planting attractive plants at the borders of crops, and use of mechanical devices such as sticky traps, light traps and attractant traps, such as those used for coffee berry borer.

In China, the Jiaduo Frequoscillation Pest-killing Lamp traps use a combination of light, colour and wave length to attract pests, which are then electrocuted and fall into a pest-collecting bag. These devices are widely used in agriculture, forestry, vegetable and tobacco growing, gardens and orchards, urban amenity plantings, warehouse storage, and aquaculture. They were used on over 15 million hectares of rice alone between 2004 and 2011. A study of their use in rice found that they attracted, on average, 42 species of rice pests.[218]

215 Bejarano et al. 2009. *Alternatives to Endosulfan in Latin America.* International POPs Elimination Network (IPEN) and Pesticide Action Network in Latin America (Red de Acción sobre Plaguicidas y sus Alternativas en América Latina, RAP-AL). http://www.ipen.org/ipenweb/documents/ipen%20documents/summary%20endosulfan%20alternatives_english.pdf

216 UNEP 2012*, op cit.*

217 *ibid.*

218 Huang S, Wang L, Liu L. Fu Q. 2014. Nonchemical pest control in China rice: a review. *Agron Sustain Dev* 34:275-291.

Mating disruption

The female sex hormones of moth pests can be used to dramatically reduce pest populations. Generally, lures impregnated with a synthetic version of a pest's female sex hormone are deployed amongst crops such as cotton, fruit or nut trees, or in warehouses. The odour emitted masks the pheromone produced by the female pest and confuses males trying to find a female mate. Males follow false scent trails, and as a result successful mating is reduced, females lay fewer fertilized eggs and there are fewer larvae to cause crop/fruit damage. This technology works very successfully in medium to large (>2 hectare) orchards and crops, but may be too expensive and less effective on smaller holdings, unless farmers work together cooperatively. Mating disruption is widely deployed in both organic and non-organic orchards and crops in a number of countries.[219]

Rice paddy, India. *Jayakumar Chelaton*

Cultivational control of weeds

Cultivational control of weeds is a commonly used agroecological technique. One example is weed management on organic rice in Japan based on pre-planting soil management. The land is ploughed and irrigated a month before transplanting rice seedlings in order to bring weed seeds and bulbs to the surface to germinate. After the weeds have germinated the land is ploughed lightly to remove the weeds and bury remaining seeds in the mud. Transplanting takes place within three days of the second ploughing; at the same time organic fertilizers such as rice bran, soybean trash or oil cake are added. The paddy is irrigated just after transplanting and water kept at 7cm depth for 30 days.[220]

[219] (i) Hassan NM, Alzaidi S. 2009. Mating disruption – an alternative bio-rationale control for stored pests. International Pest Control. http://www.international-pest-control.com (ii) Mating Disruption for Management of Insect Pests. Ontario Ministry of Agriculture, Food, and Rural Affairs. http://www.omafra.gov.on.ca/english/crops/facts/03-079.htm

[220] Mitsukuni I. undated. Part 1 Thematic report 4. Rice Farming Technique Creating Environment for Biodiversity and Human Beings and Restoration of Environment in Japan.

5. A global case study: System of Rice Intensification (SRI)

"While in the normal cultivation 3,450 kg of rice could be produced per hectare, under the intensification scheme it is somewhere between 6,000 and 9,000 kg."

Veerapandi S. Arumugam Tamil Nadu State Agriculture Minister [221]

The System of Rice Intensification (SRI) - *le Système de Riziculture Intensive* in French and *el Sistema Intensivo de Cultivo Arrocero* (SICA) in Spanish - is described by Cornell University experts as *"a climate-smart and agroecological methodology to increase the productivity of irrigated rice (and, more recently, other crops) by changing the management of plants, soil, water and nutrients."*[222] It is an innovative systems approach to farming that relies on better use of natural resources, and on basic agronomic prin¬ciples and biological processes to increase agricultural produc¬tivity while maintaining environmental sustainability, especially soil fertility and bio-diversity.[223]

SRI enables farmers to achieve high output with low external inputs, whilst maintaining ownership of local seeds and enhancing soil fertility. External inputs are replaced by farmers' improved knowledge and skills in managing plants, water, soil and nutrients. SRI is a particularly valuable approach for farmers with small, rain-fed land-holdings.[224]

Originally developed in Madagascar in the 1980s, SRI is now practiced in at least 51 countries throughout Asia (22), Africa (22), Latin America and the Caribbean (9). Average yield increases of 20-50 percent are reported (although higher yield increases have also been reported – see Table 5.3). These yield increases are accompanied by

Woman farmer in Vietnam holding SRI rice plant on left and same variety grown with standard methods on right. Behind her, the standard field has lodged after a typhoon, but not the SRI field. *Elske van de Fliert, FAO*

[221] The Hindu, Dec 1, 2009.

[222] SRI International Network and Resource Centre, Cornell University College of Agriculture and Life Sciences. http://sri.ciifad.cornell.edu/aboutsri/methods/index.html

[223] Koma YS. 2011. Building experiences with SRI development and dissemination in Cambodia (2000-2010). In: *Agroecology and Advocacy: Innovations in Asia*. IATP and AFASRD.

[224] *Ibid.*

Countries with SRI

Africa

- Benin
- Burkina Faso
- Burundi
- Cameroon
- Egypt
- Ethiopia
- Gambia
- Ghana
- Guinea
- Kenya
- Liberia
- Madagascar
- Mali
- Morocco
- Mozambique
- Nigeria
- Rwanda
- Senegal
- Sierra Leone
- Tanzania
- Togo
- Zambia

Latin America

- Brazil
- Colombia
- Costa Rica
- Ecuador
- Guyana
- Panama
- Peru

Caribbean

- Cuba
- Haiti

reduced need for inputs: seed by up to 90 percent, irrigation water by 30-50 percent, chemical fertilizer by 20-100 percent, and usually reduced need for pesticides (many farmers practice SRI with no use of pesticides). The system has also now been adapted for other crops, including wheat, sugarcane, teff, finger millet, mustard and pulses, all of which show increased productivity.[225]

5.1 Main benefits of SRI

Increased yields and profits

SRI farmers in Cambodia report increases in profit of as much as 300 percent.[226] Increases in yields of 68 percent in Cambodia and 30-50 percent in Sri Lanka have been reported for the period 2010-13. In Cambodia, incomes increased by US $339 per hectare, and in Vietnam by US $200–300 per hectare. In Ethiopia, farmers applying SRI principles to the growing of the indigenous cereal *teff* have seen yields triple, while also making savings on seed of up to 90 percent.[227]

Indonesian farmer comparing SRI plant with one grown using standard methods. *Shuichi Sato, Nippon Koei DSIMP Advisory team*

225 SRI International Network and Resource Centre, *op cit*.
226 Curtis M. 2012. *Asia at the Crossroads: Prioritising Conventional Farming or Sustainable Agriculture?* Action Aid.
227 Castillo GE, Parmentier S, Chinotti E, Munoz E, Ninh L, Tumusiime E. Oxfam. 2014. *Building a New Agricultural Future: Supporting agro-ecology for people and the planet*. Oxfam, Oxford.

Table 5.1 Yield and net income effects from SRI methods in Asia[228]

Country	No of samples	Increase in yield	Increase in net income	Source of information
Bangladesh	1,073	24%	59%	On-farm comparison trials sponsored by IRRI/Bangladesh programme.
Cambodia	500	41%	74%	Evaluation for GTZ, based on random samples in 5 districts; SRI methods not necessarily being fully used.
	120	105%	89%	Evaluation of experience of users (>3 years).
China	104	29%	64%	Evaluation of village where SRI use went from 7 farms in 2003 to 398 in 2004.
	trials	55%	NA	Evaluation by Sichuan Academy of Agricultural Sciences.
India	108	32%	67%	IWMI evaluation where SRI use had gone from 4 in 2003 to 150 in 2004.
	1,525	38%	NA	Evaluation by Andhra Pradesh state agric. uni. and extension service.
	100	28%	112%	Evaluation by Tamil Nadu agric. univ. with on-farm comparison trials.
Indonesia	12,133	78%	>100%	Evaluation over 9 season by Nippon Koei technical assistance team.
Iran	trials	69%	NA	Trials conducted by national rice research centre.
Iraq	trials	2.3%	NA	13% yield increase if not including trials where soil salinity was a constraint.
Myanmar	30	212%	NA	Farmer field school plots, 3 years.
	612	104%	773%	FFS graduates on own fields, 3 years.
Nepal	412	82%	163%	Records of district agricultural extension office from farmers' fields.
Philippines		>100%	NA	Compilation of 24 evaluations throughout the country.
Sri Lanka	120	49%	90-117%	IWMI evaluation, based on random samples in 2 districts: SRI methods were not necessarily fully used.
Vietnam	trials	14%	$139/ha	Evaluations across 9 provinces by the National IPM Programme.

[228] Uphoff NT. 2007. The System of Rice Intensification (SRI): an efficient, economical, and ecologically-friendly way to increase production. PANAP Rice Sheets. Pesticide Action Network Asia & the Pacific, Penang.

Reduced pests and pesticides

Although exact figures on pesticide reduction in SRI are hard to find, a number of publications report that SRI is more resilient to pests and diseases and hence there is a decreased use of pesticides. This is in addition to the replacement of herbicides by mechanical weeders. Some SRI farmers have stopped all synthetic pesticide use and become fully organic.[229]

When the National IPM programme in Vietnam conducted on-farm trials across eight provinces in 2005-06, they found a 40-80 percent lower incidence of pests and diseases in SRI fields (Table 5.3). The reasons have not been fully elucidated, but one suggestion is that greater silicon uptake by the crop when soils are not kept saturated could be a factor. The silicon in the plant tissue produces stronger, tougher rice tillers and leaves, which are more resistant to attack from insects and disease-causing microbes.

A 2010 report from Africare, Oxfam and WWF noted that the frequency of pesticide applications under SRI in Vietnam has gone down 45 percent.[231]

Other benefits

A number of other benefits are also reported, including:[232]

- √ Improved farmer net income and profitability
- √ Improved access to food in farm households
- √ More fodder for animals
- √ Reduced seed use
- √ Conservation of water
- √ Reduced or eliminated use of chemical fertilizers
- √ Lowered dependence on external inputs
- √ Improved water quality

Table: 5.2 Reduction in incidence of rice pests and diseases under SRI[230]

	Spring	**Season**		**Summer**	**Season**	
	SRI	**Non SRI**	**Difference**	**SRI**	**NON SRI**	**Difference**
Sheath blight disease*	6.7	18.1	63%	5.2	19.8	73.7%
Leaf blight disease*	-	-	-	8.6	36.3	76.5%
Small leaf folder worm**	63.4	107.7	41.1%	61.8	122.3	49.5%
Brown plant hopper**	542	1,440	62.4%	545	3,214	83.0%
Average			**55.5%**			**70.7%**

* = % of plants infected ** = insects/m2

229 Randrianarivelo J, Randrianarivelo A, Abhukara R, Fitzgerald W, Pargee C, Vent O. 2013. Organic production of pink rice in Madagascar. In: Auerbach R, Rundgren G, Scialabba NE (eds). 2013. *Organic Agriculture: African Experiences in Resilience and Sustainability*. FAO, Rome. See also Parmentier S. 2014. *Scaling-up Agroecological Approaches: What, Why and How?* Oxfam-Solidarity, Belgium.

230 Uphoff 2007, *op cit*.

231 Africare, Oxfam America, WWF-ICRISAT Project. 2010. *More Rice for People, More Water for the Planet*. WWF-ICRISAT Project, Hyderabad, India.

232 (i) Koma 2011, *op cit*. (ii) SRI International Network and Resource Centre, op cit. (iii) Africare, Oxfam America, WWF-ICRISAT Project. 2010. *More Rice for People, More Water for the Planet*. WWF-ICRISAT Project, Hyderabad, India.

Farmer in SRI rice field looking for pests, Cambodia. *CEDAC*

- √ Increased carbon in the soil and reduction in methane emissions
- √ Greater resilience against droughts, winds and storms because plants have stronger root systems, hence better adapted to climate change
- √ Often SRI shortens the crop cycle by 1-2 weeks, freeing up land for other uses, and reducing crop exposure to pest, disease and climate risks
- √ Strengthened ownership of seeds through farmer breeding
- √ Greater returns on labour, land, and capital
- √ Increased farmer knowledge, skills and capacity
- √ Increased farmer ownership of resources and technologies
- √ Promotes cooperation and mutual help among farmers

In addition, SRI paddy rice usually produces about 10 percent higher out-turn of polished rice when milled, because of fewer unfilled grains and less chaff; fuller grains, reduced chalkiness and reduced breakage of grains during milling further improve grain quality, which translates often to a higher price and better return for the farmer.

5.2 Principles of SRI

SRI is based on four main principles:[233]

- Early, quick and healthy plant establishment to favour healthy and vigorous root and vegetative plant growth
- Reduced plant density to allow optimal development of each individual plant and to minimize competition between plants for nutrients, water and sunlight
- Improved soil conditions through enrichment with organic matter to improve nutrient and water holding capacity, increase microbial life in the soil, and to provide a good substrate for roots to grow and develop
- Reduced and controlled water application, providing only as much water as necessary for optimal plant development and to favour aerobic soil conditions

Using these principles, farmers adapt their practices to their own agroecological and socioeconomic conditions, to accommodate changing weather patterns, soil conditions, labour availability, water control, access to organic inputs and the decision whether to practice fully organic agriculture or not.[234]

5.3 SRI practices

The SRI approach aims to create the best conditions for root growth: as root growth increases, the number of tillers[235] and grain yield per plant increases. This is achieved by adopting a

233 SRI International Network and Resource Centre, *op cit*.
234 *ibid*.
235 Once the seedling has about five leaves, more stems develop from the main stem – each is a called a new tiller.

Countries with SRI

Asia

Afghanistan
Bangladesh
Bhutan
Cambodia
China
DPR Korea
India
Indonesia
Iran
Iraq
Japan
Laos
Malaysia
Myanmar
Nepal
Pakistan
Philippines
Rep of Korea
Sri Lanka
Taiwan
Thailand
Timor Leste
Vietnam

Pacific

Solomon Is

number of key practices, which are described below,[236] and illustrated with some additional detail from SRI organic pink rice growing in Madagascar. Pink, or Dista, rice is a long grain rice, discovered in a field in Madagascar by a producer in the 1990s, and now grown for export to the USA. It was found to have a good flavour, a longer growing cycle, lower water requirements, good response to organic fertilizer, resistance to diseases and heavy rain, reduced lodging[237], an average of 30-60 tillers, yields of 4-8 tonnes per hectare and

Reduced planting density and straw mulch, typical of SRI, Cambodia. *CEDAC*

a milling rate of 68-70 percent with less than 15 percent breakage if drying conditions are good.[238]

Nursery management

- Growing healthy, and vigorous seedlings for transplanting by using healthy, full-grained seeds sown in a raised, unflooded nursery bed with good soil structure, ensuring each plant has space to develop a strong root system without getting entangled with others. With Madagascar organic pink rice, the rice is sown into a bed of farmyard manure, at least 3 cm deep and level, and covered with a thin layer of manure and straw.

Transplanting

- Transplanting the strongest seedlings at the 2-leaf stage (ideally 8-15 days for short-term varieties, and 8-20 days for medium- and long-term varieties), a younger age than usual.
- Planting seedlings immediately after uprooting, minimizing trauma to the roots.
- Planting shallow (1–2 cm deep).

236 (i) Koma 2011, *op cit.* (ii) SRI International Network and Resource Centre, *op cit.*
237 Lodging, in the case of rice, means falling over.
238 Randrianarivelo et al 2013, *op cit.*

Poster describing SRI techniques in Cambodia. *CEDAC*

Reduced planting density

- Wider spacing between each rice plant, preferably with one seedling per hill and with wider and equal spacing between each hill in a square pattern (planting in a square pattern enables mechanical weeders to be used); generally at 25 cm x 25 cm, but reduced to 20 x 20 in less fertile soil and with lower tillering varieties, and increased to 30 x 30 in soil enriched with organic matter and for higher tillering varieties.

Reduced water application

- Improving soil aeration by avoiding continuous field saturation with flooded water and minimum water levels when transplanting and during the vegetative stage of growth. It is preferable to have alternate wetting and drying: only a shallow water layer of 1-2 cm during the vegetative period, the plot is left to dry until cracks become visible and then another thin layer of water is introduced. During flowering, a thin layer of water is maintained, followed by alternate wetting and drying during the grain filling period, before draining the paddy 2-3 weeks before harvest. Some farmers irrigate every evening, others leave the fields to dry over a 3-8 day period, depending on soil and climate conditions and control over irrigation water. The drying period creates aerobic conditions allowing roots to better develop.

Enhanced soil organic matter

- For example, through application of compost to improve soil structure, nutrient and water holding capacity, and soil biological

SRI in other crops

Wheat:
- China
- Ethiopia
- India
- Mali
- Nepal
- Poland
- USA

Sugar cane:
- Cuba
- India

Finger millet (ragi):
- Ethiopia
- India

Teff:
- Ethiopia

Maize:
- India
- Madagascar
- Pakistan

Pulses; eggplant; mustard/rapeseed; tumeric:
- India

Onions, potatoes, carrots:
- India
- Pakistan

activity. With Madagascar organic pink rice, Zebu manure is added at a rate of 2 tonnes per hectare when the land is prepared for planting. Another 500 kg of poultry manure is added to soil before transplanting seedlings.

Reduced planting density and straw mulch, typical of SRI, Cambodia. *CEDAC*

<u>*Weed management*</u>

- Frequent weeding to prevent weed competition and to improve soil aeration, preferably using a small, simple mechanical weeder up to 4 times starting at 10 days after transplanting and repeated every 7-10 days until the canopy is closing.

Mechanical weeders are favoured in SRI because they have a number of benefits over herbicides in rice cultivation, including:[239]

- Incorporation of weeds into the soil, where their nutrients are recycled and organic matter increased
- Superficial tillage improves soil aeration
- Root growth is stimulated through some root pruning and soil aeration
- Water, organic matter and soils are mixed anew and oxygenized through the weeding process, and nutrients become better available to the plants (a greening effect of the plants can be observed one to two days after weeding)
- Redistribution of water across the plot through the weeding process

[239] SRI International Network and Resource Centre, *op cit*.

Table 5.3 Key difference between conventional and SRI practices for irrigated rice[240]

Key practices	Conventional	SRI
Seed preparation	seeds not selected	seeds soaked for 24 hrs prior to sowing to eliminate non-viable ones
Nursery management	flooded, densely seeded	not flooded, raised beds, not densely seeded
Quality of seedling for transplanting	all kinds of seedlings	only thick, health seedlings transplanted
Age of seedlings at transplant	21-30 days, sometimes up to 60 days	8-20 days, the 2-leaf stage
Spacing	hills are 10-15cm apart, in rows or random spacing	hills in square pattern, spaced 25cm x 25cm
No. of plants/hill	3-5; 130-500 plants/m2	1 plant/hill (<16plants/m2)
Depth of planting	> 3cm	<3cm, preferably 1-2 cm
Water management	continuous flooding of fields during crop cycle	minimum water; alternate wetting and drying
Weed control	hand weeding or herbicides	mechanical weeding which aerates soil
Fertilization	reliance on chemical fertilizers	organic matter as base fertilization; complemented if needed with chemical fertilizer.

- Contribution to a continuous levelling of the plot and elimination of water patches in lower lying areas in the field that create anaerobic conditions for the plants.

5.4 SRI in Cambodia

The following brief summary of SRI in Cambodia illustrates how successful the technique has been in increasing countrywide rice yields. It also illustrates that when a government works with farmers' organizations, great advances can be made.

Weeder designed by H.M. Premaratna, Sri Lanka. *Gamini Batuwitage*

[240] (i) Koma 2011, op cit. (ii) SRI International Network and Resource Centre, *op cit.*

Using mechanical weeder, Cambodia. *CEDAC*

SRI was originally introduced to farmers in Cambodia by the Cambodian Center for Study and Development in Agriculture (CEDAC) in 2000. The success of the farmers' efforts and CEDAC trials over the next few years enabled the organization to gain the attention and support of government officials and ministers. Then, in 2005, the Cambodian government offi¬cially endorsed SRI and included it in the national strategy for agricultural development in 2006. The Ministry of Agriculture, Forestry and Fisheries then set up a secretariat to coordinate and promote SRI in Cambodia; and by 2010 more than 130,000 farmers were using SRI principles and methods. Prior to this, the government approach had been one of promotion of fertilizers, 'safe' use of pesticides, the use of improved seeds and the promotion of IPM.[241]

Table 5.4 National rice yield comparison with SRI [242]

Year	Average yield (tons/ha)	National total yield (tons)
2002	1.91	3.82 million
2009-10	2.90	7.97 million

Productivity and inputs

Rice productivity over the first 10 years increased by more than 100 percent, resulting in a surplus at the national level.

In June 2011, 107 SRI farmers, who on average had been implementing SRI for five years, were interviewed. The information they provided on yields and inputs is presented in Table 5.5, showing an average 61 percent increase in yields and 72 percent decrease in pesticide use.

Table 5.5 Yield and inputs for 107 farmers in Takeo and Kampong Speu provinces[243]

	Before SRI	With Sri (2010)	Remarks
Rice yield	1,921 kg/ha	3,100 kg/ha	61% increase; 1 farmer achieved yield of 7 tons/ha
Quantity seeds used	79 kg/ha	37 kg/ha	53% decrease; some farmers still used 2-3 seedlings per clump
Quantity organic fertilizers used	2,260 kg/ha	4,182 kg/ha	85% increase
Quantity chemical fertilizers	152 kg/ha	42 kg/ha	72 % decrease; 32 farmers stopped using chemical fertilizer

241 Koma 2011, *op cit.*
242 *ibid.*
243 *ibid.*

Application of natural fertilizer in SRI rice field, Cambodia. *CEDAC*

Additionally, certified organic fragrant rice, known as Phkar Malis, is being successfully grown using SRI by more than 2,500 small farmers, mainly from Kampong Chhnang, Kampong Speu and Takeo provinces. About 50 percent of the field is grown for export and the rest for family consumption. Yields of fragrant rice are generally about 25 percent less than non-fragrant varieties, but these farmers are getting yields of 2.5-3.5 tonnes per hectare of certified organic fragrant rice. The higher price for fragrant rice is an important incentive and organic farmers get a 10-20 percent premium and a 4.5 percent social development fund premium. The number of organic rice farmers using SRI is increasing every year.[244]

Overall, experience with SRI has shown that the system generally produces stronger plants that have better resistance to pests and diseases, as well as to varying climatic conditions, with reduced pesticide usage, reduced water usage, and reduced production of the greenhouse gas methane.

SRI systems increase the productivity of resources used in rice cultivation, and help households become more productive, secure and self-reliant. It also helps farmers adapt to climate change and provides higher yields with better quality grains. Very small scale farmers report that using this system has enabled them to have a stable and increased income, live in better conditions, educate their families and pay for health services.

SRI is a good example of how innovative thinking combined with farmer experimentation can result in dramatic improvements in agricultural practices, and other crop, cultivation, as demonstrated by the way the system has been taken up in so many countries. It is also illustrative of the potential of shared lessons and transnational cooperation.

As SRI is an ecosystem-based approach, the practices described here should not be taken as necessarily the best under all agro-climatic, topographic, soil or socioeconomic conditions. To be most effective, practices must be adapted to fit local circumstances.

244 CEDAC. May 2014. Cambodian Organic Fragrant Rice Produced with System of Rice Intensification. http://www.cedac.org.kh/?page=detail&ctype=article&id=498&lg=en#sthash.L6GexSv4.dpuf

6. Agroecology in Asia

Community Managed Sustainable Agriculture has significantly reduced the costs of cultivation without significantly reducing productivity, resulting in a net increase in farmers' income and significant health and ecological benefits.

World Bank Report, 2009

The following case studies are just a brief selection of some of the many excellent projects and programmes under way across Asia that illustrate how a change to agroecological practices is assisting farmers with improved yields in many cases, and increases incomes in all cases. The success of Community Managed Sustainable Management, and extent to which it has been taken up in India, demonstrate very clearly that with appropriate policy support and resources it is possible for agroecological approaches to rapidly replace pesticide-dependent agriculture on a wide-scale.

Rice paddy ecosystem. *Jayakumar Chelaton*

6.1 India: Community Managed Sustainable Agriculture[245]

Community Managed Sustainable Agriculture (CMSA) is a system of agricultural production developed in the mid-2000s in the state of Andhra Pradesh. Between 2004-2008, CMSA grew from a small experiment on 163 hectares in 12 villages to over 300,000 farmers cultivating over 552,000 ha. Since then, over a million farmers have adopted CMSA practices in more than 8,000 villages across Andhra Pradesh, with other Indian states and neighbouring countries eager to put similar programmes in place. Latest available estimates are that about 10 million farmers are practising this approach on about 10 million ha in Andhra Pradesh.[246]

A decade ago, many smallholders in the Indian state of Andhra Pradesh were facing crisis, caught in a downward spiral due to the high investment costs required by conventional farming reliant on agrochemicals, lack of credit and poor access to markets. Household income from farming was uncertain

245 Most of the material in this case study is drawn from Kumar TV, Killi J, Pillai M, Shah P, Kalavakonda V, Lakhey S. 2009. *Ecologically Sound, Economically Viable: Community Managed Sustainable Agriculture in Andhra Pradesh, India.* World Bank. Washington, DC.

246 Ramamjaneyulu GV, Raghunath TAVS. 2011. *Government of India Recommended Use of Endosulfan and Available Alternatives.* Centre for Sustainable Agriculture, Secunderabad. UNEP-POPS-NPOPS-SUBMSC5-4-ENDOSU-IPEN_5-110729.En.pdf

and often inadequate to cover the costs. Farmers were spending as much as 35 percent of their production costs on agrochemicals, yet crop yields were often poor, even after applying pesticides and using high-yielding seed varieties and commercial fertilizers. Unprofitable farming led to indebtedness and many smallholders were forced to mortgage their land to moneylenders. A spate of farmer suicides drew attention to their plight and the need for a radical change of direction.

Replacing expensive agrochemicals

In 2004, a pioneering group of NGOs led by the Centre for World Solidarity (CWS), began to address the root cause of the crisis by working with farmers to develop methods that would significantly reduce the cost of cultivation, avoid the need for large amounts of credit and reduce the debt burden.

The first step was introducing the practice of what was called Non-Pesticide Management (NPM) – replacing pesticides with ecologically-friendly farming techniques, based on a combination of physical and biological measures. These techniques combined scientifically proven methods with traditional knowledge and were deployed in a sequence that farmers learn during on-farm training. As with other good IPM programmes, helping farmers learn about the ecology of pests and understand the essential role of natural enemies in their fields was the starting point.

The second step was to introduce alternative pest control methods such as pheromone traps, sticky plate traps, botanical extracts such as neem, and locally available biopesticides.

In the third stage, NPM was complemented by measures to increase soil fertility. Farmers were encouraged to phase out expensive conventional fertilizers and use intensive composting techniques (e.g. worm compost and watertank silt), sow green manure crops and add beneficial, nitrogen-fixing bacteria (Azospirillum and Azotobacter species) to the soil. Farmers also moved away from relying on one or two main crops (rice and cotton) grown under monocultures to inter-cropping a more diverse set of crops (peas, beans, lentils, millets, spices and vegetables) to maintain soil fertility and reduce pest incidence.

"Over 300,000 farmers have adopted CMSA in Andhra Pradesh alone, covering half a million hectares of farmland – 5.1% of the net cropped area in the state – in just over four years."

World Bank Report, 2009

Guiding Principles of CMSA

1. **Observation and documentation of pest and predator behaviour, pest incidence.**
2. **Replace chemical pesticides with physical methods of pest management, complemented by botanical formulations and bio pesticides.**
3. **Aim to manage pest populations, not eliminate pests.**
4. **Focus on balancing predator and pest populations.**
5. **Enhance and maintain soil health through mulching, green manure and vermicompost (compost made using worms).**
6. **Reduce, then phase out synthetic fertilizers.**
7. **Increase diversity and intensity of crops.**
8. **Identify appropriate cropping systems: inter-cropping, multi-cropping, crop rotations.**
9. **Preserve local varieties and land races.**
10. **Maintain crop genetic diversity.**

World Bank Report, 2009

The first results were a great success. By the third year of operation, farmers had replaced all chemical fertilizers and pesticides with agroecological technologies, without experiencing any significant drop in yields, but drastically reducing the cash investments needed, therefore earning much higher net income than before.

The range of pest, weed, disease and soil management methods available evolved through the joint learning in demonstrations and trials in farmers' fields, and became standardized into NPM training and resource material.

Building the community base for sustainable farming

CMSA does require increased investment in labour as some of the pest and soil fertility management methods are more labour intensive than using agrochemicals. However, as many households were previously underemployed on their small plots, which were left uncultivated for part of the year, they had the capacity to adjust easily to the increased labour needs of more intensive cropping; and they also worked together in groups to share the load. Reduced pest infestation benefits all farms in a village, hence the importance of community-based actions.

While the NPM techniques developed were successful, changes were also required in how farmers organized themselves so as to empower them to negotiate a better deal both with those selling agricultural supplies and those buying farm produce. To make farming a more viable enterprise, the NGOs partnered with the Society for Elimination of Rural Poverty, which linked them up with hundreds of women's self-help groups across Andhra Pradesh, to promote what has come to be known as Community Managed Sustainable Agriculture (CMSA).

Village-level co-operatives form the centre of all local CMSA activities. Farmer Self-Help Groups are established, while appointed Village Activists identify groups of 20-25 farmers interested in trying out CMSA, each paying a small registration fee towards working capital. Together they develop a plan for crop production, capacity building and marketing.

"We have also noticed that a good number of [CMSA] farmers, especially women farmers, are young and they feel excited that they have control on the inputs and processes. These young women bring to the field traditional wisdom. So more and more people are getting attracted towards farming."

DV Raidu, Director, CMSA

Natural pest management: dragonfly consuming a rice pest. *Jayakumar Chelaton*

Although CMSA produce was not certified as 'organic' in the first few years, growing market demand for pesticide-free produce within India has convinced the movement to start converting to organic methods as a logical next step, with more attention to soil and water management. CMSA produce is recognised in the market with a price premium and was fetching 14-33 percent higher prices for vegetables, red gram, chilli, cotton and rice. In 2012, retail outlets were set up for organic farmers' produce grown in 626 villages at that stage. Some CMSA pesticide-free chillies had been exported to Europe, attracting a high price premium, and links with importers of organic and Fairtrade cotton and coffee were being established.

The Centre for Sustainable Agriculture has been set up to spearhead the CMSA movement

and is playing an important role in influencing government policy. The success of CMSA in improving smallholder livelihoods has helped convince more decision makers in the Ministry of Agriculture that the 'business as usual' promotion of agrochemical inputs should now be questioned.

> ***There is a potential of scaling up this [Community Managed Sustainable Agriculture] approach to the whole of India***
>
> *World Bank Report, 2009*

Ecologically sustainable agriculture makes sound economic sense

A 2008 World Bank survey of 400 farm households involved in CMSA has exposed the misconception that farming without pesticides and fertilizers will cause crop yields to fall and/or threaten the security of food production.[247] Yield in all crops had remained roughly the same after adopting CMSA practices with any minor fall in yield tending to be reversed over time as measures to improve soil fertility took effect. Overall, CMSA farmers reduced their pest management costs by 70-80 percent and their total cultivation costs by 33 percent. These reductions in the costs of cultivation have led to significant savings, at the State level estimated to be US $52 million for 2008-09, the largest single contribution coming from CMSA in rice cultivation (US $18.2 million).

Table 6.1: Comparison of average yield of principal crops

Crop	CMSA average yield (kg/ha)*	Conventional av. yield (kg/ha)
Chilli	4,323	4,323
Groundnut	2,718	2,718
Red gram	1,359	1,235
Cotton	2,224	2,224
Rice	5,436	4,942

These cash savings are very significant for poorer farmers and those unable to access credit, with a saving of US $250 a year on the cost of pesticides alone for households cultivating one hectare of cotton, equivalent to 56 percent of the farmer's annual income. These savings provide immediate relief to households under the pressure of high interest debt. Within two years of practicing CMSA, some farmers had been able to pay off the moneylenders and regain ownership of their land.

Where multi-cropping was introduced, bringing greater cropping intensity, significant gains in income were experienced, the most outstanding example being one farmer on 2.44 ha of land who increased her annual net income from US $100 to $875.

Table 6.2: Average saving on cost of cultivation through CMSA

Crop	Average saving on cost of cultivation (US $/ha)
Rice	82
Chilli	806
Cotton	297
Groundnut	59
Red gram	77
Other (fruits, vegetables, cereals, etc)	59

Social and environmental benefits

One of the most impressive economic benefits of CMSA was the improvement in food security. For example, household expenditure on buying grains reduced by 44 percent based on data collected

247 Kumar et al 2009, *op cit.*

Table 6.3 Benefits of Community Managed Sustainable Agriculture

Economic benefits	Social benefits	Environmental benefits
lower costs of production	fewer pesticide health problems	improved soil ecology
yield maintained or increased	improved food security	water conservation
increased crop intensity & diversity	social empowerment	pesticide-free groundwater
higher household income	new livelihood opportunities	agri-biodiversity conservation
lower debt	reduced suicides	return of birds
higher investment in agriculture increased area being farmed business innovation	lower risk perception, increased area being farmed relief from debt and mortgage	smaller carbon footprint from reduced inorganic fertilizer and pesticides

"…. compeling evidence that sustainable agriculture has significant positive impacts on food security at the household level"

World Bank Report, 2009

from 22,000 farmers practicing CMSA in the Khammam district who were able to grow more food grains for themselves.

As well as the economic benefits, a wide range of social and environmental benefits have resulted from CMSA, including new livelihood opportunities such as vermicomposting units, a drop in pesticide-related health impacts, and an increase in beneficial insects and birds (see Table 6.3)

CMSA farmers are now able to manage pests effectively without recourse to a long list of insecticides, many of which are HHPs. The Centre for Sustainable Agriculture has produced an extremely valuable report detailing the different biological controls and other non-pesticidal methods used by CMSA farmers in place of HHPs in 29 different crops for over 30 leaf-feeding, stem-boring, sap-sucking and other arthropod pests.[248] Table 6.5 gives the methods used for five different pests attacking pigeonpea. Overall, the experiences generated by the CMSA programme has proven that trained farmers can get effective pest management using various agroecological methods, without the need to use any of the following 22 active ingredients, of which 19 feature in the PAN HHP List (June 2015 edition):

acephate	endosulfan	monocrotophos
carbaryl	ethofenprox	phosalone
carbofuran	fenvalerate	propargite
chlorpyrifos	imidacloprid	quinalphos
cyhalothrin	indoxacarb	spinosad
dichlorvos	lambda cyhalothrin	triazophos
dicofol	malathion	
dimethoate	methyl oxydemeton	

248 Ramamjaneyulu and Raghunath 2011, *op cit*.

Table 6.4 Agroecological alternatives to HHPs in pigeonpea cultivation, Andhra Pradesh

Pest	Chemicals replaced	Biological controls	NPM methods
Pod borer	acephate endosulfan triazophos	*Helicoverpa armigera* nuclear polyhedrosis virus (NPV) *Bacillus thuringiensis (Bt)*	* spray 5% neem seed kernel extract (NSKE) * remove leaf folds using thorny twigs * spray Vitex solution
Pod bug	endosulfan chlorpyrifos oxydemeton-methyl imidacloprid		• spray 5% NSKE • spray 3% neem oil
Pod fly	endosulfan		• spray 5% NSKE • spray 3% neem oil
Defoliators	endosulfan acephate		• spray 5% NSKE • spray 3% neem oil

Source: Ramamjaneyulu and Raghunath 2011, op cit.

Enhanced natural pest management: perch provided for insect-eating birds. *Jayakumar Chelaton*

Key points:

- CMSA techniques provide immediate economic benefits from the savings in crop production costs.
- Targeting entire villages or a group of farmers, rather than individuals, for training and advice is more effective. This gives farmers an advantage to negotiate when they deal with traders in a collective manner. Sustainable agriculture technologies are also more effective when deployed on several, neighbouring parcels of land.
- Farmers are encouraged to look at cost effectiveness of various options and not focus just on yields. The process enables small holders to look at both productivity and profitability.

6.2 India: Cultivating paddy without pesticides

by Resmi Deepak, Agricultural Officer, State Department of Agriculture, Kerala, India

A group of farmers from the Kuruvai village in Palakkad district's Vadakkenchery panchayat (in Kerala) have withstood difficult times and emerged successful by turning to a method of paddy cultivation without using chemical pesticides.

Deep ploughing is used to control a number of insect pests. *Jayakumar Chelaton*

Farmers field school harvest and field day celebrations. *TV Vineeth Krishnan*

About a hundred farm families live in the village, eking a living out of their farm holdings which range between 0.2 and 0.6 hectares. The farmers grew paddy as their main crop for a long time, relying on traditional agricultural practices. Some farmers also cultivated tapioca, banana and ginger in their paddy fields. But the fluctuations in the prices of ginger and banana, and wild boar attacks on tapioca crops, forced the farmers to turn away. A lot of the paddy areas were converted to cash crops, such as rubber, resulting in the paddy area being drastically reduced from 33 to 18 hectares in eight years.

Then paddy cultivation became quite profitable again when the Kerala State Government increased the procurement price to Rs 19/kg. But the cost of cultivation increased gradually because of high labour costs, and because increasing amounts of fertilizer and chemical pesticides were used. The large-scale use, and misuse, of hazardous pesticides such as quinalphos, chlorpyrifos, lambda cyhalothrin, and cypermethrin, caused serious pest outbreaks and created environmental and health problems. These pest outbreaks were mainly due to pest resurgence, a condition in which minor pests become more important after broad-spectrum insecticides kill their natural enemies. More and more pesticides were used, but achieved less and less pest control. As a result, the requirement for investment in paddy cultivation increased many times.

Over a period of time, the farmers became entangled in a vicious cycle of more investments and more expenses and were forced to borrow money, not only for their seasonal crop operations, but also for their family expenses and daily needs.

Intervention: Replacing toxic pesticides with agroecological approaches

As a result, in 2013-14 the Department of Agriculture, Kerala, with support from the National Food Security Mission Scheme, worked with the farmers of Kuruvai padasekharam[249] to implement a package of improved practices, including mechanisation and reduced use of chemical fertilizers and pesticides. The programme was extended in the 2014-15 season with the aim of eliminating pesticides from paddy fields.

The ATMA Plus (Agricultural Technology Management Agency) scheme of the Department of Agriculture financially supported a Farmer Field School (FFS) in Kuruvai Padasekharam in the

[249] Padasekharam means a collection of field or other areas of lands suitable for the adoption of a common cultivation programme or common agriculture.

Using a sweep net to catch insects for anlaysis. *Resmi Deepak*

second crop season, starting October 1, 2014. The emphasis was mainly on pest surveillance and agroecology-based plant health management, which in turn leads to non-pesticide management of the paddy ecosystem.

Using agroecosystem analysis as the foundation for FFS learning

Agroecosystem analysis was employed to analyse field situations with regard to pests, natural enemies, soil conditions, plant health, the influence of climatic factors, and their interrelationship with the paddy. Critical analysis of the field situation every week helped the farmers take appropriate decisions on management practices. Farmers had first-hand experience of understanding the agroecosystem and observing natural enemies and their predating behaviour, as well as pest and disease surveillance, and taking appropriate timely actions.

On their weekly field visits, farmers recorded their observations on climate and soil conditions. They observed the types of weeds, their size and population density in relation to the paddy plants, together with diseases and their intensity, and insect damage in terms of percentage or population per plant. They captured flying insects (both pests and natural enemies, called 'defenders') and noted inhabited rodent burrows. They recorded crop health parameters like the number of leaves on plants, their branches and height; and made notes of the reproductive parts of the selected plants.

This weekly analysis of the agroecosystem is very important for the control of pests. It helped farmers take appropriate decisions on management practices. The key parameters analysed were stage of the crop, nature and status of pests, severity of attack and presence of beneficial organisms.

The important research finding, on which no-pesticide management was adopted, is that under optimum field conditions, with a moderate level of natural enemies and without insecticides, rice can tolerate a certain level of pest infestation without causing yield reductions.[250]

Cultivation practices

<u>*Mat nursery preparation*</u>

A very thin polythene sheet was spread on a levelled field for the mat nursery and puddled soil was spread over the sheet. The seeds were treated with the beneficial bacterium Pseudomonas fluorescens at 10g/kg seeds before planting, in a technique known as bio-priming which combines seed protection with hydration. This results in reduced disease, and increased germination and seedling vigour. P. fluorescens protects the seed against soil-borne bacterial pathogens. Sprouted seeds were uniformly spread over the mat area at a rate of 0.4 to 0.6 kg/m2. The mat was ready for transplanting when seedlings reached a height of 150 mm. It was drained 6-12 hours before it was transplanted.

250 Nalinakumari T, Hebsybai. 2002. Influence of pests and natural enemies on yield of rice. National symposium on priorities and strategies for rice research in high rainfall tropics, 10-11 October 2002. Regional Agricultural Research Station, Pattambi. Abstract: 58.

Labour Army transplating rice seedlings. Arun Sreedhar Malayala *Manorama Daily*

Agroecology ecosystem analysis chart on observations prepared during Farmers Field School showing more defenders than pests. *Resmi Deepak*

Mechanized Transplanting

The high cost and scarcity of agricultural labourers was a major challenge, so, a 'Labour Army' or 'Thozhil Sena' was formed to mechanize transplanting operations. Kubota 'four-row walk-behind' and 'six-row sit-and-drive' transplanters were used. The charges for preparation of mat nursery and transplanting were US $ 117/ha.

Nutrient Management Plan

A soil test is essential for efficient fertilizer application. Based on the results, a nutrient management plan was prepared to help farmers to make best use of fertilizers and organic manures to achieve a balanced supply of nutrients and improved crop performance, as well as savings in input costs, improvements in soil health and reduced environmental hazards from excess nutrient run-off. The fertilizers used were dolomite to correct acidity, farmyard manure, the biofertilizers Azospirillum (a bacterium that increases nitrogen) and vesicular-arbuscular mycorrhizae (VAM) to increase absorption of phosphorous, and vermicompost. Some nitrogen, phosphorous and potassium were applied, and borax to correct a deficiency in micronutrient boron.

Water and weed management

The farmers adopted continuous flooding water management practices: after transplanting, water levels are around 3 cm initially, gradually increasing to 5–10 cm (with increasing plant height) and remain there until the field is drained 7–10 days before harvest. Flooding prevents seed germination and growth, and this was the most acceptable means of weed control, together with some hand weeding after 15-20 days after transplanting (DAT).

Observation

Climatic factors, such as temperature, relative humidity and rainfall, have a direct influence on insect pest multiplication and disease severity, so close monitoring of weather parameters was carried out. Vulnerable stages of the crop with regard to pests and diseases were identified through the close monitoring. On the basis of

Flaming torches on paddy bunds to attract pests out of crop. *Resmi Deepak*

these observations, and farmers' past experience of climatic conditions and pest appearance and multiplication, pest management options were selected.

Not all defoliation results in yield loss: the plant is able to compensate for most leaf damage during most of the stages of rice growth. The flag leaf is the most sensitive leaf, especially during the panicle initiation and booting stages. During the vegetative stage, leaves are rapidly replaced and during the reproductive stage, the lower leaves are shaded and often use more energy than they produce. The farmers were encouraged to observe the plant compensation abilities. This information helped them to avoid chemical pesticides during the vegetative phase of crop, which they would otherwise have used on noticing pest damage that, although visible, does not necessarily translate into reduced yield.

Pest and natural enemy surveillance

The most important activity was the weekly systematic surveillance of the field for pests and defenders, using agroecosystem analysis. The insects present on upper parts of plants and inside the leaf canopy were collected with sweep nets. The symptoms of pest attack and live stages of pests and defenders at the base of the plants were also recorded throughout the entire season. Through this surveillance, farmers were able to observe the intricate relationship between pests and natural enemies in the paddy agro-ecosystem. Identification of defenders, their ability to control pests through predation and parasitoidism, and understanding the 'pest: defender' (P:D) ratios that ensure pest control, were crucial skills learned by the farmers. They learned how to calculate the P:D ratio and its relevance to the pest management strategy. They understood that when the defender population is adequate to control the pest population insecticide application is not required. They understood the importance of regular monitoring of pest and defender population dynamics for management decisions. On an average, one hectare of paddy field may have up to five to seven million parasitoids, predators and neutrals. The predator population develops very early in the growing season by feeding on neutrals (detritivores and filter feeders); and this makes the rice fields more stable and resilient to an influx of rice pests.[251]

- Neutrals (i.e. neither pest nor defender) were dominant in the initial stages of crop growth, and thereafter gradually reduced from the vegetative to reproductive stages of the crop.
- Thirteen major insect pests were found during the weekly surveillance.
- In the early vegetative stages at least 13 major predators were identified, and by 15 DAT, at least 11 egg, larval and pupal parasitoids.

Pest management practices

Every week the numbers of defenders were much more than pests, so pesticide application was avoided every week. But by 20 days after

251 Settle WH, Ariawan H, Astuti ET, Cahyana W, Hakim AL, Hindayana D, Lestari AS. 1996. Managing tropical rice pests through conservation of generalist natural enemies and alternate prey. *Ecology* 77(7):1975-88.

transplanting (DAT), the climatic conditions were very conducive for the attack of leaf folder and stem borer and the attacks were seen to be increasing. Pheromone monitoring traps were installed in the field for rice yellow stem borer. As the number of 'dead hearts' [252] and adult males increased, it was decided to adopt the biological control measure of mass release of egg parasitoids *Trichogramma japonicum* for yellow stem borer and *Trichogramma chilonis* for leaf folder, rather than using the highly hazardous pesticides used previously.

Trichocard in rice. *Resmi Deepak*

Placing pheromone trap in rice field. *Resmi Deepak*

- These egg parasitoids were released at 5cc, or 50,000-100,000 parasitoids, per hectare over the total area of 18 ha from 20 DAT, at weekly intervals. Since leaf folder and yellow stem borer were present in the paddy field throughout the season, the Trichogramma was released five times, up to 60 DAT. The total quantity of Trichocards used was 450 cc. [253]
- Pheromone traps for adult male yellow stem borer were placed at 20 traps/ha.

No other pests reached levels above the 'Economic Threshold Level'. The paddy crop recovered from leaf damage due to its in-built compensation abilities. Both the major pests were very effectively controlled by the use of Trichocards and pheromone traps.

Rice bug damage was noticed during flowering-to-dough stage. The farmers used to spray lambda cyhalothrin and fenvalerate or cypermethrin at the initial stages, but this resulted in increased 'chaffy' grains,[254] mainly because pollination was affected by the pesticides applied at the time of flower opening. Now the rice bugs were effectively controlled by the installation of flame torches on the bunds after dusk by the farmers, as a group approach. After two days, a fish amino acid spray made from sardines and jaggery (a type of sugar) was applied at 5ml/L of water, to distract rice bugs.

No pests exceeded the economic injury level and the pest:defender ratio was always low (at least two defenders per pest) so that no pesticides, even botanicals, needed to be sprayed. It is very evident that, through the agroecosystem analysis approach, pest and natural enemy populations can be detected early and conservation of the latter, by avoiding insecticide spray, is the very best approach for pest management in rice.

[252] Death of central tiller of rice plant during the vegetative stage of paddy growth, caused by larvae of stem borer.
[253] Parasitized pest eggs are pasted on cards, called Trichocards; the emerging adult then parasitizes pest eggs in the crop. 5 cubic centimetres (cc) of Trichocard contains about 50,000-100,000 parasitoids.
[254] Empty grains: the nymphs and adults of rice bugs suck the sap from developing grain at the milky stage.

Harvested rice. *Resmi Deepak*

Benefits

Yield

The adoption of agroecological practices and nutrient management lead to an average rice yield increase of 30 percent, from 4,250 kg/ha to 55,00 kg/ha. In addition, 3,000 kg per hectare of straw were collected for use as animal fodder, with the possibility of also using it as a medium for mushroom culture.

Costs

In adopting non-pesticide management during the second crop season, the farmers avoided four to five pesticide sprays which would have cost about Rs 4,000-5,000 (US $ 63-77) per hectare, spending instead only Rs 2,725 (US $43/ha) per hectare on biocontrol agents and pheromone traps.

Profit

Supplyco paid Rs 19/kg for the paddy; and additionally the Department of Agriculture Kerala provided a subsidy of Rs 11,500/ha to the farmers. This, together with the straw, resulted in a net profit per hectare of Rs 70,015 per hectare.

Table: 6.5 Yield, cost, profits per hectare

	Rice	Straw	Rice & Straw
Yield (kg)	5,500	3,000	8,500
Income (Rs)	104,500	18,000	106,300
Costs (Rs)			47,785
Profit (Rs)			58,515
Subsidy (Rs)			11,500
Total profit/ha (Rs)			70,015

Looking ahead

All the farmers of the padasekharam (collective farm) were convinced of the effectiveness of agroecosystem analysis and non-pesticide management in paddy and were quite satisfied with the way they were able to address their most important problem, that of rising costs of cultivation. They grasped the strength of group actions in addressing their pest problems, and the conscientious application of preventive actions paved the way for their success. With agroecological approaches to pest management they were able to save considerable amounts of money for themselves and for the whole village.

Now they are procuring paddy under the banner of Kuruvai Padasekhara Samithi[255] and planning for value addition as 'Safe-to-eat Rice'. The growing awareness about the ill-effects of chemical fertilizers and pesticides is leading to

255 A samathi is a group registered under the Charitable Societies Act for carrying out operations in paddy fields collectively.

a huge demand, and premium prices, for safe-to-eat food. The farmers of Kuruvai are now planning to organize themselves into a sellers' co-operative and seek better bargaining power for their produce. They are also planning to cultivate vegetables organically in their paddy field during the third season as a crop rotation. The organic vegetables also fetch a premium price. After the third crop they can move back to paddy cultivation in the next season.

6.3 India: Tamil Nadu Women's Forum

by Aasha Ramesh, for the Society for Rural Education and Development (SRED)

The following is the narrative of Komalavalli, who owns five acres of land at Thakkolam village, Arakkonam taluk, Vellore District, Tamil Nadu State, India:

The Government was giving chemical fertilizers, and chemically grown and genetically modified seeds. Government created the impression that the yield will be more if the farmers used the chemical products. So over a period of time the land became alkaline/salty in nature with the use of chemical pesticides and fertilizers. The rice turned yellow and the yield became less. The agricultural loan could not be repaid. We had spent 22 to 25 thousand rupees to grow one acre of paddy. After harvesting we got 15 bags of paddy for one acre. We sold one bag of paddy for Rs.800 to 1100 to the agents. We were losing Rs.3000 for every acre. There was no profit and we could not repay the loans taken for the agricultural expenditure.

There was also sand trafficking in their area, which affected the ground water table and for two years we could not do farming and struggled a lot. We started attending meetings and trainings organized by Tamil Nadu Women's Forum. We decided to adopt natural farming methods. We started growing 'manure plants' (Thakkapoondu) during rainy seasons. The plant acted as compost, started changing the alkaline nature of the land.

Applying a natural pest control agent. *TNWF*

Local food grown with out pesticides. *TNWF*

Following this, we started growing small grains. Even then we could not take the profit from the farming since there was no water. We started growing trees like teak, coconut, mango, jackfruit, lime, sapote, papaya, and sweet potato. The trees were grown in between the other crops.

We were now able to grow vegetables, pulses and groundnut. We used natural farming practices like vermicompost and natural pest control products. We also used fish oil (meenamilam) as a fertilizer. We do one crop in a year and we started getting 33 percent of profit from the produces.

Our farm is a model farm for natural farming in our community. We are very happy since we are part of the movement of producing natural food which is not poisonous.

Since its inception in the 1990s, Tamil Nadu Women's Forum (TNWF) forum has been actively working in Tamil Nadu and neighbouring state Andhra Pradesh to secure women their right to land, and to train them in natural farming. TNWF is clear that unless women have access to land, their empowerment is limited: "Ownership of land gives women the strength to counter the violence they are faced with. It gives woman security, not just in terms of food security, but also personal security as she can no longer be treated as a disposable entity – a threat that most women face when they are subjected to violence and more often than not, thrown out of their house." [256]

TNWF has established a training centre, *Bio-diversity Ecological Rural Women's Collective Farm and Training Centre*, at Palavoy, Arakkonam Taluk, Vellore District, Tamil Nadu State. There it undertakes a number of activities:

- Traditional seed collection
- Biodiversity preservation
- Promotion of natural and traditional farming
- Training on natural pest control
- Training on vermi culture
- Natural and animal compost making
- Fruit and fodder tree plantation
- Training on livestock
- Distribution of livestock to Dalit and tribal women
- Traditional millet production
- System of Rice Intensification process
- Training students in agriculture

6.4 China: The rice-duck and rice-fish-frog systems

A number of traditional and innovative agroecological practices have proven to be successful in China. These include the 'rice-duck' system of cultivation, described as the essence of traditional Chinese agriculture. It operates on multiple layers of ecological functioning: the ducks' treading, pecking and predation decrease rice diseases, pests, and weeds, boosting the growth of rice, improving soil properties and reducing the emissions of methane (up to 61 percent). The system also reduces the amount of feed needed for ducks (by about 30 percent), reduces pesticide use, increases biodiversity, reduces fertilizer requirements, spreads risk, increases the quality of the rice and the duck meat and increases profitability.[257]

Ducks have multiple benefits in rice paddy, including pest and weed control and fertility improvement.

One review of the system describes a 98.47 percent reduction in the incidence of rice planthoppers and 100 percent reduction in rice leafhoppers, providing better control than pesticides do. The ducks also assist in control of stem borers *Chilo suppressalis* and *Tryporyza incertulas*, rice leafrollers, and the semi-looper *Naranga aenescens*. They assist in control of the fungal diseases sheaf blight (60-100 percent control), rice blast (50 percent), rice stripe disease (>70 percent); and broadleaf weeds and grasses. A grazing density of 225-330 ducks per hectare

256 Personal communication, Tamil Nadu Women's Forum, January 29th, 2015.

257 Long P, Huang H, Liao X, Fu Z, Zheng H, Chen A, Chen C. 2013. Mechanism and capacities for reducing ecological cost through rice-duck cultivation. J Sci Food Agric 93(12):2871-3136.

Fish harvested from a rice-fish-frog system.

provides better weed control than do herbicides, with overall weed burden about 80 percent controlled. Ducks also provide good control of golden apple snails (a major invasive pest). Ducks help to improve paddy air and light conditions, reduce relative humidity and maintain the stability of temperature and humidity, thus helping to reduce conditions that favour bacterial and fungal growth. Soil content of nitrogen, phosphate and potassium improved, as did nutrient utilization. Beneficial insect function also increased, notably the ratio of spiders and *Trichogramma* to pests.[258]

Economic analyses showed that the rice-duck system provides greater income than rice alone. In Guangdong Province, in 2001, rice-duck farmers were making a net income of US $323.52 per hectare more than rice-only growers. If the rice is grown organically, i.e. without any chemical pesticides or fertilizers, then the rice-duck cultivators could produce US $6,478.2 net income per hectare more than the conventional fields, the difference being so great because the price of organic rice was eight times that of ordinary rice. Additionally, the value of ecological services for no-tillage rice-duck cultivation is estimated to be US $2,928.64 per hectare.[259]

Another study showed that the rice-duck system reduced plant hoppers by 63.9 percent, leafhopper by 77.3 percent, weeds by up to 94.2 percent, and sheath blight incidence by up to 67.2 percent. Fertilizer use was reduced by 30.6 percent and pesticide use by 59.4 percent, with quality of rice improved, and yield increased by 4.42 percent; duck sales add extra income.[260]

Similarly, adding fish and frogs to the rice paddy system has been found to reduce pest and disease incidence and pesticides use, and increase yields. A review of data found that plant hoppers were reduced by 86.9 percent, diseased plants by 70.5 percent. Rice yield increased by 10.1 percent with an additional yield of fish and frogs of 1,177.5 kg/h.[261]

6.5 Philippines: Farmer-led sustainable organic agriculture

MASIPAG is a nationwide network of small-scale farmers, farmers' organizations, scientists and non-government organizations (NGOs) in the Philippines, working since 1986 to improve the quality of life for resource-poor farmers through farmer-led sustainable agriculture. The name MASIPAG translates to Farmer-Scientist Partnership for Agricultural Development – and this identifies the key to the success of the organization. This is a farmer-centred and bottom-up approach, in which farming families are encouraged to learn and work together in groups; and which builds on farmers' knowledge in active ways, not only working with traditional knowledge but also incorporating farmers as fundamental to the farmer-scientist partnership.[262]

The network involves approximately 35,000

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258 *ibid.*

259 *ibid.*

260 Huang S, Wang L, Liu L. Fu Q. 2014. Nonchemical pest control in China rice: a review. *Agron Sustain Dev* 34:275-291.

261 *ibid.*

262 This section is based on: (i) Bachman L, Cruzada E, Wright S. 2009. *Food Security and Farmer Empowerment: A study of the impacts of farmer-led sustainable agriculture in the Philippines.* MASIPAG, Laguna. (ii) Personal communication with Dr Chito Medina, National Coordinator of MASIPAG.

"moving to organic farming ultimately can mean the difference between eating and not-eating for many of the farmers involved in the program"

Bachmann et al, 2009, MASIPAG

Farmer Jojo Paglumotan demonstrates rice breeding. A prolific MASIPAG breeder and farmer, his varieties have been adopted by other farmers in his province in Negros Occidental. *MASIPAG*

farmer members in the three main regional zones of the Philippines: Luzon, the Visayas, and Mindanao. MASIPAG has offices in each region and works in 62 of the country's 79 provinces. It has 40 regular staff and co-operates with 60 NGOs and 15 scientists from various universities. Research is focused on 107 food crops, cash crops, vegetables, fruits, agroforestry species and herbal plants, including banana, rice, coconut, taro, cassava, sweet potato, yam, corn, jackfruit, guava, mango, papaya, avocado, calamansi (small citrus), pomelo, malunggay (a green leafy vegetable), eggplant, chilli, string beans, okra, squash, bamboo and mahogany.

A central focus of MASIPAG's work is farmer-led rice seed breeding. In 2014, there were 70 farmer rice breeders who had developed a total of 508 rice cultivars. MASIPAG has a national backup farm which serves as the core of the rice genetic conservation and improvement programme, maintaining almost 3,000 traditional rice varieties, and MASIPAG and farmer-bred cultivars. MASIPAG also has 10 regional back-up farms cum community seed banks and 223 trial farms in 62 provinces. These seeds are well adapted to local conditions and the farmers have the potential to adapt them to future challenges. Seeds are respected by MASIPAG and its farmers as a common good and heritage, not as a commodity.

Another key element is the farmer-to-farmer diffusion model. The network has 142 farmer-trainers to assist new farmers. They are selected within their communities, based on their ability to practice sustainable agriculture successfully. This ensures that farmers have a sound understanding of what they teach and a high level of practical experience. They can use their own farm for demonstration purposes, and speak the language and know the culture of their fellow farmers. Farm exchange visits and demonstration and training days also take place. This process allows an organization with a very small staff to have a wide reach, providing extensive training which leads to good adoption rates.

The agroecological farming promoted by MASIPAG is also organic. MASIPAG has its own organic standard which is equivalent to the common objective requirements in the organic standards of IFOAM. MASIPAG has a participatory guarantee system for assurance that farmers are adhering to the standard, and this is also recognized by IFOAM. The organic approach results in increased on-farm diversity that helps farmers to reduce production risks. It reduces CO2 emissions since it avoids the use of fossil energy-intensive inputs and prioritizes local markets, is adaptive to the challenges of climate change, and facilitates farmer empowerment through their control over genetic resources, agricultural technology and associated knowledge.

Food security is emphasized by the network as the first priority of farming, and a comprehensive study, published in 2009, demonstrates the success of their approach. The study included data from 280 full organic farms, 280 in conversion to organic, and 280 conventional farms as a reference group, covering the three regional zones of the

Philippines. The average farm size was about 1.5 ha.

The study revealed that total net incomes per hectare, as well as total production per farm, is consistently higher for organic growers, and that the national Philippines economy is losing GDP by not converting fully to organics. This does not even include the savings on no-longer-imported chemical inputs, or all benefits accruing to the individual farmers listed below. MASIPAG farmers breed their own varieties of rice which compete well with the high yielding varieties of international research institutions, and at lower cost, lower risk and in a shorter time. The farmers, most of them belonging to the poorest sector of society, have improved food security and incomes, better health and a positive view of their future.

However, the study also noted *"the program's positive outcomes around food security and income simply could not be achieved in the absence of its social changes".* These are based on the bottom-up approach in which farmers decide what they need, and they take key roles throughout the organization. The flow-on effect is that the farmers are more positive, in greater control of their lives and involved in leadership roles in their communities.

"The family first, before money. We prioritise diversity, because that is our source of food for every day, instead of planting the whole farm to a single cash crop such as rice. Before MASIPAG, we used to prioritise cash, for paying debts. Now we prioritise food."

Bachmann et al, 2009, MASIPAG

Practicing rice breeding techniques at a Masipag's trial farm in the Philippines. *PANAP*

Benefits for organic farmers

- *Better food security:* 88% of organic farmers found their food security better than in 2000, compared to only 44% of conventional farmers. Of conventional farmers, 18% were worse off. Only 2% of full organic farmers were worse off.
- *More diverse and nutritious diet:* Organic farmers ate 68% more vegetables, 56% more fruit, 55% more protein-rich staples and 40% more meat than in 2000. The increase in consumption for organic farmers were double those for conventional farmers for vegetables, 2.7 times higher for fruit, 3.7 times higher for protein rich staples and 2.5 times higher for meat.
- *Higher diversity of crops:* Organic farmers were growing 50% more crop types. In the Visayas, the organic farmers grow on average 51 species, while Mindanao and Luzon farmers grow 42 species; figures for the conventional farmers are 36, 28 and 26 species. On average, nationwide, the organic farmers were growing three times more varieties of rice.
- *Chemical fertilizer and pesticide use:* Organic farmers had eliminated these chemical inputs altogether but they were still being used by 85% of conventional farmers. 97% of the organic farmers used alternative pest management techniques such as redesigning the agroecosystem, working with natural enemies, reducing pest-favourable conditions, hand-weeding, better land preparation, water management; and for fertility they used animal manure, agroforestry, green manure, rice straw recycling, and azolla (a small

MASIPAG farmer-breeder Pepito Babasa farms near Lake Bato, which floods the adjacent plains during monsoons. Ka Pepito has selected MASIPAG rice varieties that can withstand flooding. *MASIPAG*

"The most frequent benefits listed by MASIPAG farmers relate to food security: lower costs, safe food, improved food taste and improved health."

Bachmann et al, 2009, MASIPAG

nitrogen-fixing aquatic plant that produces huge amounts of biomass very quickly and is used as a biofertilizer).

- *Better health outcomes:* 85% of the organic farmers rated their health better than in 2000. In the reference group, only 32% rated it positively, while 56% saw no change and 13% reported worse health.
- *Lower costs:* Production costs for organic farmers were half those of conventional farmers. The biggest saving was in input costs; labour costs were slightly less for organic.
- *Higher net incomes:* Net incomes were higher for the organic farmers than the conventional ones, and had increased since 2000 in contrast to stagnant or falling incomes for the reference group. Over the previous 7 years, 74% of full organic farmers reported increasing income. Only 31% of conventional farmers claimed an increase while 68% reported stagnant or declining incomes. Organic farmers' net agricultural income per hectare was, on average, 23,599 pesos, that of the conversion group was 17,457 pesos, and the conventional farmers was 15,643 pesos.
- *Positive annual household cash balance:* Organic farmers had, on average, a positive annual cash balance of +4,749 pesos. Conventional farmers had an average negative cash balance of -4,992 pesos. Consequentially organic farmers were less indebted.
- *Greater overall farm productivity:* Rice yields for organic farmers were on a par with those of conventional farmers. But the organic yields were increasing over time in contrast to declining yields of the conventional farms; and yields were higher when total farm output is taken into account, not just one major crop.
- *Improved soil fertility:* 84% of organic farmers, but just 3% of conventional farmers, reported increases in soil fertility.
- *Less erosion:* 59% of organic farmers, but just 6% of conventional farmers, reported a reduction in soil erosion.
- *Increased tolerance of crops to pests and diseases:* 81% of organic farmers reported increased tolerance to pests and diseases; but 41% of conventional farmers saw tolerance to pests worsening.
- *Greater climate change adaption:* Crop diversification, agroforestry, windbreaks, salt-tolerant MASIPAG-bred rice varieties, more root crops, sloping agricultural land technology in upland areas to prevent erosion caused by continuous rainfall, staggered planting, intercropping, crop rotation,

"Nutritionists now increasingly insist on the need for more diverse agroecosystems, in order to ensure a more diversified nutrient output of the farming systems."

Olivier de Schutter, UN Special Rapporteur on the right to food, 2011

> ***"The diversified nature of MASIPAG farming systems, using good yielding farmer-bred varieties without chemical inputs, allows for lower production costs, higher net agricultural incomes, better livelihood security and stronger household balances. In short, farmers involved in sustainable agriculture use available resources better."***
>
> *Bachmann et al, 2009, MASIPAG*

community co-operation – all help farmers adapt to climate change.

- *Increased community:* The MASIPAG approach led to increases in communal labour, community activities and marketing co-operatives.
- *Greater empowerment and civic engagement:* Among the organic members, every 2nd was a leader of a people's organization, every 3rd was a farmer trainer or committee member, every 10th a rice breeder, every 25th a maize breeder and 1-in-100 a chicken gene pool caretaker.
- *Greater control and self-reliance:* Through using inputs from the farm itself (rather than purchased inputs), such as compost and green manures, as well as seed selection and breeding, and producing primarily for home consumption, farmers have gained greater control over their lives and are less dependent on the markets and its price fluctuations.

MASIPAG farmers are active in promoting organic farming. *MASIPAG*

Box 6. 1 The MASIPAG approach

The MASIPAG approach encompasses the following elements:

Bottom-up approach

Decision-making, planning and implementation within the organization come from the membership. This is coordinated through farmer groups and a decentralised organizational structure.

Farmer-scientist-NGO partnership

The organization is run as a process of mutual, ongoing learning between farmers, scientists and NGOs.

Farmer-led research

Research, including breeding of new rice varieties, is designed and conducted by farmer-members for farmer-members.

Farmer-to-farmer mode of diffusion

Training in the network is largely conducted by farmer-trainers, using a wide range of techniques including trial farms, exchange days and cultural activities.

Opposition to technological fixes

Change needs to be understood in a holistic way, including attention to farmer empowerment and farmer knowledge.

Advancing farmers' rights

MASIPAG works within a broader commitment to farmers' rights. These include rights relating to land, seeds and genetic resources, production, biodiversity, politics and decision-making, culture and knowledge, information and research, and socio-political factors.

7. Agroecology in Africa

"In Algeria, ancestral agricultural practices in oases provide multiple benefits and are perfectly adapted to local conditions. These agroecosystems have been balanced, sustainable and resilient over centuries."

H.E. Minister Nouri (Algeria), 2015 [263]

Case studies in this chapter beautifully illustrate the power of low cost innovative agroecological techniques to dramatically improve the lot of low income farmers – particularly the food attractant spray for beneficial insects in Benin's organic cotton, and the push-pull weed and pest control technology developed in Kenya. Classical biological control has been adapted to the needs of low income farmers in the West Sahel growing traditional subsistence millet crops, whilst a whole village approach in Tanzania has brought multiple benefits across multiple systems. Three of the case studies also illustrate the importance of empowering farmers through experiential leaning and farmer-to-farmer transmission of knowledge.

Pesticides authorised only for cotton but used on vegetable crops, Benin. *OBEPAB*

7.1 Benin: Productive and profitable organic cotton

By Dr Stephanie Williamson, Senior Scientist, PAN UK and Dr Davo Simplice Vodouhê, Director, Beninese Organisation for the Promotion of Organic Agriculture (OBEPAB), drawing on work by Robert Mensah and Simon Ferrigno

The rationale for 'going organic'

The Beninese Organisation for the Promotion of Organic Agriculture (OBEPAB) and the farmer groups it works with now form one of the oldest continuously producing organic cotton suppliers in the world.[264] BEPAB, a member of the PAN Africa network, was set up in 1995 by Professor Davo Simplice Vodouhê, professor of agronomy at the University of Abomey-Calavi in Benin, who had already spent several years investigating the shortcomings of conventional cotton farming, and innovations in agricultural practices.

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[263] FAO. 2015. Final Report for the International Symposium on Agroecology for Food Security and Nutrition. 18 -19 September 2014, Rome, Italy. http://www.fao.org/3/a-i4327e.pdf

[264] PAN UK. 2010. Growing organic cotton and food crops in Benin: the role of OBEPAB and farmer organisations. http://www.pan-uk.org/foodAfrica/PDFs/OBEPAB%20leaflet.pdf

These boys from a Beninese cotton-growing village are using empty insecticide containers to carry milk. *OBEPAB*

Cotton is hugely important to households and the national economy of Benin in West Africa, with over 2 million of its 8.5 million citizens relying on cotton as their main source of income. Most farming families cultivate cotton on just 0.5-2.0 ha land, relying only on rainfall as there is no irrigated cotton farming in Benin. Cotton production has been vigorously promoted by West African governments and donors as the economic 'engine' for rural development and national income generation. Prior to the introduction of organic cotton, however, pesticide-reliant cultivation had become a story of poverty and ill-health for many farming households. Numerous pesticides distributed for cotton were highly hazardous in nature and few farmers had any proper training in pesticide use, most tending therefore to use them in very risky practices and almost never with any form of personal protective equipment. Not surprisingly, these conditions of use led to serious effects on health, including deaths.[265] Furthermore, many pesticides supplied for cotton ended up being used to treat stored cereals, on kitchen gardens, or misused for fishing, due partly to a lack of adequate pesticide management policy.

In 2000, 67 fatalities from acute pesticide poisoning occurred in just two of the country's cotton-growing districts, as recorded by OBEPAB.[266] In 2002, 106 poisoning cases were documented, with the highest number of deaths and poisonings occurring in the 20-30 age group while 20 poisoning cases affected children under 10. The main products responsible were all cotton pesticides: endosulfan (68 percent of incidents); cypermethrin + dimethoate, the product Cotalm D (21 percent); chlorpyrifos (6 percent); and an unnamed herbicide (5 percent).

Episodes of sickness for a few days after each spraying round were common among farmers using insecticides, with symptoms consistent with moderate intoxication by OPs or endosulfan. Affected cotton farmers interviewed were spending on average 10 percent of their cotton income on medical or other treatment for health issues related to pesticides and much higher in some cases.[267] Cotton HHPs also found their way into food and drinking water, leading to acute health problems, not just for farmers and farm workers handling pesticides directly, but also their families.[268] Research by OBEPAB and PAN UK revealed that exposure via contaminated food, water and re-use of empty pesticide containers

265 EJF. 2007. *The Deadly Chemicals in Cotton,* Environmental Justice Foundation in collaboration with Pesticide Action Network UK, London. http://www.panuk.org/attachments/125_the_deadly_chemicals_in_cotton_part1.pdf

266 Ton P, Tovignan S, Vodouhê DS. 2000. Endosulfan deaths and poisonings in Benin. *Pesticides News* 47:12-14

267 PAN UK. 2008a. Hazardous pesticides and health impacts in Africa. Food & Fairness briefing, no. 6. http://www.pan-uk.org/attachments/101_Hazardous_pesticides_and_health_impacts_in_Africa.pdf.

268 PAN UK. 2008b. Pesticide Food and Drink Poisoning in Africa. Food & Fairness briefing, no. 4. http://www.pan-uk.org/attachments/101_food%20&%20drink%20exposure.pdf

formed a major exposure route for farm families and was responsible for numerous fatalities. OBEPAB's painstaking documentation of acute poisoning incidents in the country's cotton zones, and their identification of endosulfan as the most frequent culprit, were influential in persuading the government to announce a national endosulfan ban in 2008.[269]

Conventional cotton is simply not sustainable, not only in terms of health and environmental impacts and the economic burden these impose on farming communities and national health services, but also in terms of livelihoods. Use of agrochemical inputs has risen as farmers try to cope with increasing pest problems and declining soil fertility and can account for up to 60 percent of production costs in smallholder conventional cotton farming. The result is falling profitability of cotton, especially when global prices are low, and rising farmer indebtedness, calling the region's cotton-led strategy for poverty reduction into serious question.

Building viable organic cotton alternatives: the first decade

The seeds of the OBEPAB organic cotton project were sown in 1995, with the first trial of organic techniques with a group of 17 smallholder farmers. The following year two pilot projects were started in the central and northern regions of Benin, with twin goals:

- Reducing the human and environmental impacts of reliance on hazardous pesticides
- Improving the livelihoods and prospects for resource-poor farmers

However, organic cotton production is both labour and knowledge intensive, and the fact that conventional cotton farmers could achieve higher yields, initially put many farmers off adopting organic methods. Key to overcoming these obstacles has been OBEPAB's dual strategy of practical farmer training combined with field research to develop effective replacements for synthetic pesticides and fertilizers. Introducing a 'bottom-up' approach to education and knowledge-sharing through Farmer Field Schools (FFS), new organic converts learn from experienced farmers, under the technical and organizational guidance of OBEPAB through its field agents, providing farmers with the support and confidence they needed to go organic.

Maize inter-rows planted before cotton provides a refuge for natural enemies to build up numbers before the main pests arrive, Ethiopia. *PAN UK*

The early years of the project aimed primarily at demonstrating the feasibility of organic cotton production in Benin and evaluating how well this could meet the goals of improved welfare and livelihoods. This phase lasted between 1996 and 1999, with the focus then shifting to developing better market outlets for the cotton grown by organic farmers.

Farmer training on agroecological principles for soil, pest and crop management

OBEPAB has founded its training on the participatory, learning-centred Farmer Field School approach, adapting the methodology over the years to a version best suited to the local circumstances. The FFS approach works

269 Vodouhê DS, Watts M, Sanfilippo D. 2008. Endosulfan banned in Benin. *Pesticides News* 79 3-4.

well to enhance farmer ownership of the training process and sustain activities beyond the initial training. Growing organic cotton is not only about learning new techniques, but also requires change in attitudes and different ways of thinking and evaluating progress. The training process is flexible, adapting activities to farmer needs. Farmers help set research and training plans based on their local conditions and priorities.

- With respect to pest management and weed control, the basic 'discovery learning' in the FFS curriculum for new farmers covers:
- Decision making for selecting the best plots for cotton cultivation
- How to know whether your soil is healthy and how to carry out a soil test
- Recognising 'good' and 'bad' insects (predators and pests)
- Understanding the life cycle of pests
- Scouting and sampling methods for key pests and their natural enemies
- Analysis and decision making on pest management needs
- Preparation and use of botanical extracts for pest management
- Weed control through the crop cycle

To meet the needs of organic cotton growing in the Beninese context, OBEPAB expanded the FFS training modules and parallel research on demonstration plots to include:

- How to know whether your soil is healthy and how to carry out a soil test
- The role of leguminous plants in organic systems and suitable species in each region
- Crop rotations and how to manage them in organic cotton
- Measuring the quantity of organic matter in the soil
- Comparison of soil fauna from different farming systems

Thinning cotton seedlings in the IPM trial plots on a large cotton farm, Ethiopia. *PAN UK*

Rows of sunflowers planted among cotton as a trap crop for pests and refuge for natural enemies. *OBEPAB*

- Post-harvest hygiene, storage practices and quality criteria for seed cotton and lint
- Basic marketing skills for cotton farmers

Pigeon pea intercropped with organic cotton Benin. *OBEPAB*

'Training of trainers' sessions ensure that extension workers and lead farmers have the latest knowledge and skills. Representative farmers are trained in order to train and mentor their fellows in each village, both those new to organic farming and those with experience, with continuous follow-up by OBEPAB's locally recruited field agents. Farmers acquire a deeper understanding of organic agriculture through exchanges and taking active part in design, data collection, analysis and evaluation of research on demonstration plots.

New farmers take part in one season-long FFS training when they join the project. Farmers graduating from the FFS are then visited individually at least once a year by an OBEPAB field agent, often more; this both helps the farmers prepare for the certification inspection required for organic production and reinforces farmers' knowledge of organic techniques. To date, over 3,000 farmers and 300 lead farmers have been trained.

OBEPAB has innovated by adapting the rather rigid and 'top-down' Internal Control System (ICS) required for organic certification of groups of smallholders into a framework for genuine capacity-building and village-level decision making. In their version of the ICS, farmers are the main actors, and organize their self-regulation via elected committees which check individual farmers' compliance with the organic requirements in each village or co-operative, following training. OBEPAB field agents then cross check farmers' practices across the whole farming system. New farmers participate in one ICS workshop as part of their beginner training and are mentored by experienced farmers in their area. OBEPAB's ICS coordinators visit several farmer groups each year in each area to assess the effectiveness and reliability of the system. Further experience sharing opportunities are provided through farmer exchange visits between districts and several demonstration farms have been established to test and showcase new pest management and soil fertility methods.

Developing and testing effective organic methods with farmers

Instead of hazardous pesticides and expensive fertilizer, OBEPAB promotes use of simple organic preparations, based on locally available natural resources wherever possible and mainly produced on-farm. Most farmers in the northern project areas own, or have access to cattle, which provide valuable organic fertilizer and draught power, combining manure with other sources of organic fertilizer (compost, guano). In the south, farmers rely more on palm kernel cake (waste product from palm oil production) and tend to carry out tillage and weeding by hand, rather than with oxen. Under its philosophy of practical experimentation to adapt known agroecological techniques to the needs of Beninese organic cotton farmers, OBEPAB has tested several soil and pest management methods to work out which are effective, cheap and readily available to poorer farmers and make use of waste resources. Over several seasons of refinement, the most effective techniques, preparation methods and modes of application have been codified into a set of recommended good practices (Box 7.1). By collecting data from individual farmers' practices and yields achieved, OBEPAB has helped farmers to analyse the effectiveness of these methods on

BOX 7.1: Soil and pest management methods – making use of local resources

Soil fertility improvement options

- √ Crop rotations using leguminous plants
- √ Learning to value and make effective use of fallows
- √ Collaboration with cattle herders to take advantage of their animals' manure (by allowing animals to graze on-farm for short periods)
- √ Incorporating crop residues (except cotton stalks which can harbour pests)
- √ Use of green manures (e.g. moukounna beans where applicable, pigeonpea)
- √ Use of 'home-made fertilizer: per hectare of cotton apply 250-500kg of palm kernel cake + 250kg ash (available from household cooking with wood fuel) + 250-500kg cow manure (depending on soil status)

Pest management using botanical extracts

- √ Per hectare of cotton apply a preparation of: 5-6 kg crushed and ground neem seeds, fermented for at least 48 hours. Then add 20 pawpaw leaves + 5 garlic cloves + 20g soap + and dilute with 9 litres water
- √ Spray on cotton foliage from 21 days after sowing, at approx. 7-8 day intervals or according to insect pest counts from the field. Applications usually total 10 to 15 per season. These neem-based preparations tend to repel and stun pests rather than kill them. Some farmers release their chickens in the fields after spraying to eat the stunned insects.
- √ When extra control is needed, use commercial pheromone traps to reduce numbers of cotton bollworm moths or handpick bollworm caterpillars when the first cotton buds appear (feasible on smaller plots)

their farms, compare their own performance with others and understand how the best-yielding farmers achieve their results.

Lessons from the first decade of organic cotton

Economic benefits

The project found that farmers benefited from major savings in their production costs, as the costs for the farm-produced organic preparations and manure or waste-based fertilizers were considerably lower than buying synthetic agrochemical inputs. Even though average cotton yields were very often only half those from conventional cotton, organic farmers' net income was higher than many of their conventional counterparts as they no longer had to spend up to half of their income on agrochemical inputs. In some cases, organic farmers have equalled or exceeded conventional yields.

When sold into the certified organic market, organic cotton earns producers between 10-20 percent more than non-organic, although gaining this premium took some seasons for OBEPAB to achieve. Furthermore, the organic cotton trading relations that OBEPAB developed with external buyers, independent of the now privatized conventional supply chains that dominate the Beninese cotton sector, enabled the organization to pay farmers shortly after harvest, rather than

the weeks or months that the standard cotton companies took to sort out payments at village level. [270]

There were several reasons for the lower average yields in organic cotton. There is no doubt that yields drop in the first two to three seasons of not applying synthetic fertilizer, while it takes time to rebuild soil fertility through organic methods of manuring, compost and rotation with nitrogen-fixing legumes. Lack of experience for farmers in conversion was another factor: OBEPAB's monitoring through the village-based Internal Control Systems clearly showed that as farmers' skills and confidence increased, their yields increased too. The more experienced farmers and those who dedicate most effort to following the best practices obtained much higher yields (sometimes approaching those under conventional management) than the project average, which tended to be skewed towards the larger numbers of inexperienced entrants joining once the project expanded. For other farmers, once they reached a satisfactory income, they felt no need to invest more time and energy into raising yields. Feedback from farmers reflected that rather than aiming for yield as their priority, they are strongly motivated by improved health, timely payments, lower production costs, reduced debt burdens, equivalent or higher cash income and better food security/soil fertility in the organic system. Moreover, organic cotton farmers use more diverse crop rotations and produce more food crops than their conventional counterparts, so success is better judged on their whole farm output rather than the yield of just one of their crops.

<u>Food security benefits</u>

Another major benefit reported by project farmers was improved food provisioning, since the organic approach requires more diversified crop rotations than non-organic systems. This fits well with the traditional, diverse and often intercropped plots of African family farms. Resource-poor farmers were keen to grow more of their own food crops (cereals, legumes, kitchen garden staples of tomatoes and chilli pepper, as well as field border fruits) and the organic system enabled them to do this safely by intercropping and rotating with cotton, without risk of cotton insecticides contaminating food crops in the same field. In conventional systems, intercropping food crops with cotton sprayed up to eight times per season with a range of HHPs (including OPs, carbamates and endosulfan) risks very high levels of insecticide residues and there had been fatalities documented from eating food, such as maize cobs, grown in treated cotton fields. Under the organic alternative, families were able to devote more of their fields and effort to food for domestic consumption and generate extra income from the sale of any surplus.

<u>Empowering poorer farmers, especially women</u>

OBEPAB's experience is that it is most often the poorest farmers, including women, who are attracted to organic farming, as these are the farmers who struggle to afford the high production costs of conventional cotton. They face the highest risk of falling into crippling household debt if harvest income fails to cover the amount owed to the cotton companies, which provide inputs on credit at the start of the season in the conventional sector.

Until recently, cotton production was considered a male activity, even though women play an important role in sowing, weeding and picking. Women's own fields were given little priority and women had to go via their men folk to get hold of inputs and to sell their produce. In the conventional sector, inputs are supplied to farmers' co-operatives, in which women are hardly represented and therefore have no influence on decision making. Women are often discouraged from growing conventional cotton because the chemical-intensive nature of production presents too many health risks, especially for pregnant

[270] Williamson S. 2003. *The Dependency Syndrome: pesticide use by African smallholders.* PAN UK, London.

and nursing women. Thanks to OBEPAB's gender empowerment objectives, in the organic farmer groups women are encouraged to take control of their fields and the income they earn from them, giving them more financial independence. At least 30 percent of organic cotton farmers are women and now make their voices heard in the organic co-operatives, with several women gaining leadership roles at village level.

"I decided in 2000 to grow organic cotton because of the problems in getting paid properly in the conventional cotton system. It was also because of the huge amount of debts farmers accumulate and the large number of poisonings we frequently suffered. With organic farming, I get health security for me and my family and benefit from fair payment for my cotton".

Mrs Martine Okou, Djidja region, Benin

Enhancing the biological control foundation for agroecological cotton

<u>*Experimenting with the 'food spray' method*</u>

To help improve management of key insect pests, in 2006 OBEPAB partnered with Dr Robert Kofi Mensah, a Ghanaian entomologist at the Australian Cotton Research Institute. Over the previous ten years he had developed and refined a method using supplementary 'food sprays' to boost natural biological control in large-scale Australian production, in order to reduce farmers' reliance on harmful insecticides used at that time (endosulfan and organophosphates in particular). Australian IPM farmers already had several years of success in using the Envirofeast® product resulting from Dr Mensah's research – a yeast-based formulation sprayed onto cotton foliage which, by its odour, attracts natural enemies, particularly predatory insects, into the crop in order to encourage them to prey on pest species present.[271] Through the auspices of PAN UK and supervised closely by Dr Mensah, OBEPAB set up a preliminary 1 hectare food spray trial on one of the more experienced organic farmer's fields to see whether using Envirofeast® would work in the Beninese organic cotton context and if it could help farmers improve their yields.

Results from an ecological balance assessment showed that cotton treated with food sprays had

Organic farmers preparing the food supplement to attract natural enemies, Benin cotton zone. *OBEPAB*

significantly higher numbers of predatory insects (ladybirds, spiders, ants, bees, brown earwigs, glossy shield bugs) and lower numbers of the major pest species per metre compared with untreated plots.

To see whether this enhanced level of natural enemies could translate into reduced pest damage and better yield, plots under the food spray treatment were compared with the standard organic pest management, based on neem seed extract applications, and also with conventional insecticide treatment, and the cotton yield and gross margins assessed. Organic food spray

271 (i) Mensah RK. 2002. Development of an integrated pest management programme for cotton. Part 2: Integration of a lucerne/cotton interplant system, food supplement sprays with biological and synthetic insecticides. *Int J Pest Manag* 48(2):95-105. (ii) Mensah RK, Singleton, A. 2003. Optimum timing and placement of a supplementary food spray Envirofeast® for the establishment of predatory insects of *Helicoverpa spp.* in cotton systems in Australia. *Int J Pest Manag* 49(2):163-8.

treated plots did yield more (805 kg/ha cotton lint) compared with the neem seed extracts alone (562 kg/ha), although still much less than conventional insecticide treated plots (1,145 kg/ha). However, the gross margin for the farmer, in terms of cotton revenue minus pest control and fertilizer application costs, was highest in the organic cotton managed with food sprays (US $207/ha) followed by the conventional cotton (US $148/ha) and then the organic cotton with neem alone (US $132/ha).[272]

Having shown that the food spray method had great potential, the next challenge was to devise a local 'recipe' for the food spray, as the Envirofeast® product was not available in Benin and, in any case, would not be affordable for smallholders. Over the next two seasons, OBEPAB and Dr Mensah experimented with different recipes, including yeast, sugar, and maize meal, to come up with an effective and affordable version, now produced as 'Benin Food Product' using waste yeast material from Benin's breweries. Applying 'BFP' to cotton foliage attracts beneficial insects into the cotton from the refuge/companion crops, such as maize border rows or sorghum, established as part of the organic cotton system. It works best when the first application is made early in the season before plants reach the 6-8 leaf stage so that natural enemies are 'ready and waiting' when the first damaging pests arrive at the start of 'squaring' (formation of flower buds).

Subsequent applications are made based on regular scouting for numbers of pests and natural enemies and assessment of the balance between them, a concept with which all trained farmers are already familiar from the Agroecosystem Analysis learnt in the basic FFS curriculum. A more detailed and quantitative sampling protocol was developed for the food spray decision-making purpose to enable farmers to assess whether the desired

Organic cotton farmer sprays food spray to attract beneficial insects, instead of using pesticide. *OBEPAB*

'Predator to Prey' ratio of 0.5 (derived from early trials) is present or not. To make this simple for farmers with limited literacy, Dr Mensah designed a counting method in which the farmer places a small stone into his or her pocket or bag for each pest observed along a set distance of cotton row, and a maize kernel for each beneficial insect or spider. After sampling the appropriate number of cotton plants, it is easy for farmers to count the stones and kernels to see what 'balance' they currently have in their field. If they have more than twice the number of stones than maize kernels, they need to attract in more natural enemies by applying another food spray.

Training on how to produce and apply food supplements for natural enemies has now become part of the FFS curriculum, with farmers producing their own food spray using fermented maize or sorghum from local food processing. Fieldwork has shown that following food spray application, predators' consumption rate increases, leading to lower pest numbers, including bollworms and cotton stainer bugs – the two most important cotton pests in Benin. Field trials with experienced

272 (i) Vodouhê DS, Mensah RK, Sanfillippo D, Assogba, G. 2009. A new tool for improving organic cotton yields in Africa. *Pesticides News* 84:6-9. (ii) Mensah RK, Vodouhe DS, Sanfillippo D, Assogba G, Monday P. 2012. Increasing organic cotton production in Benin West Africa with a supplementary food spray product to manage pests and beneficial insects. *Int J Pest Manag* 58(1):53-64.

organic farmers in 2007-2009 showed that using 'BFP' alone results in yield increases of more than 40 percent over farmers' usual neem-based methods, thanks to the enhanced biological control. The food spray odour and deposits on foliage and buds may also contribute by deterring egg-laying by bollworm moths, as has been found in the Australian research.[273]

Refinement and dissemination of food sprays with other non-chemical methods

Further trials with farmers in following seasons showed that when they combine use of the food spray with either neem-based preparations or a locally manufactured virus-based biopesticide against bollworm, the pest control results can be superior to control by insecticides. Yields using the food spray as the foundation for enhanced biological control increased as farmers became more experienced in using the technique. OBEPAB staff think that the prolonged absence of endosulfan and other broad-spectrum pesticides may well have contributed to the yield improvement too, as beneficial soil fauna populations linked to nutrient cycling and good soil structure recovered. Yields in excess of 900 kg/ha are now possible using food spray plus other agroecological methods – not far off those that good conventional farmers achieve but leaving organic farmers with much more money in their pockets.

OBEPAB has prioritized promotion of the food spray method, with the aim of attracting more farmers to the organic approach now that much improved yields are possible. By 2011, 1,700 organic cotton farmers had been trained and data from this large number of farmers has confirmed what the earlier research trials indicated: the average yield from farmers in the best performing region was 910kg/ha, while smallholder organic cotton growers in West Africa typically achieve around 400-600 kg/ha. This also compares very well with Benin's average 726 kg/ha yield in conventional cotton (rising to over 1,000 kg/ha only on the best managed farms).

Refinement of the pest management component continues with trials of additional non-chemical methods which can be useful, including pheromone traps for different bollworm species and light trapping at peak moth flight periods, to reduce egg laying. In 2013, the OBEPAB team visited Ethiopia to train PAN Ethiopia's technical staff in using the food spray method so they can introduce it to farmers in their programme to promote cotton grown with reduced or zero pesticide use. Very encouraging results have been obtained with smallholders in two seasons of trials. Two large cotton farms are now testing whether applying food spray and using trap crops can help them change their pest management regimes, which currently rely on at least 6 applications of HHPs (mainly endosulfan, dimethoate, carbosulfan, dicofol and chlorpyrifos).

Addressing production and marketing constraints of organic cotton farmers

At the end of each season, the project in Benin evaluates successes and difficulties with organic

Trialing the effectiveness of food spray attractant for predatory insects on a smallholder farm, Ethiopia. *PAN UK*

[273] Mensah RK. 1996. Suppression of *Helicoverpa spp.* (Lepidoptera: Noctuidae) Oviposition by Use of the Natural Enemy Food Supplement Envirofeast®. *Aust J Entomol* 35 (4) 323-9.

Examining cotton foliage for pests and natural enemies, as part of IPM training, Benin cotton zone. *OBEPAB*

farmer groups in each of the seven regions in which it now operates. Women raised concerns that grinding of neem seed to make the botanical preparations is very time-consuming when using a traditional mortar and pestle. In 2009, OBEPAB therefore obtained four diesel-powered mills to be used by women's groups in organic villages. The women manage the mills to grind both neem seed, and food cereals for a small fee, which generates income to maintain the mills and help their families. The time saved by mechanized grinding also means women farmers can dedicate more time to other farm activities, including weeding. Increasing the volumes of neem powder available also promotes better-timed application against pests.[274]

Cotton remains the major cash crop in most of the dryland regions, grown in rotation with other crops such as maize, groundnut and sorghum. Farmers often supplement their income with sales of shea nut paste or fruit grown in their field borders. Under the certification requirements, the entire farm of organic cotton farmers must be managed under organic practices so farmers wanted to explore the commercial potential for crops grown as part of the organic rotation. In the southern regions, some success has been found with organic pineapple, dried for sale. OBEPAB organized training on quality improvement for cashew nut production and around 50 tonnes of organic cashews have been sold in the national market. In collaboration with organic cotton groups in Senegal, OBEPAB has looked for export options for certain rotation crops, selected by farmers as easy to grow, non-staple food crops which will not undermine their household food provisioning.[275]

One continuing frustration for the organic cotton sector is the need to improve seed access and multiplication to reduce the project's reliance on bought-in seed. Farmers also need a variety that will perform well under organic growing conditions and produce high quality cotton, rather than the conventional varieties bred to respond well to high inputs of fertilizer but often are very susceptible to pests. "Hairy" cotton varieties, for example, tend to be more resistant to pest and disease attack and an organic breeding programme would test these and other genetic material for suitability.

Success factors

From the perspective of OBEPAB and the several thousand farm family members now involved, twenty years after its introduction to Benin, organic cotton systems have delivered a major success story for agroecology in practice. Smallholder farmers have seen their incomes rise out of poverty levels and the extra income circulating in local economies has helped meet basic needs that were previously impossible. Organic farmers are finding new markets for other crops and are better able to access services and information. Farmer groups are building schools and consultation rooms for health care and paying for teachers, with many

274 Vodouhê, DS. 2010. Improving organic cotton farmers' access to neem in Benin. *Pesticides News* 88:16-17.

275 (i) PAN UK. 2011a. Organic cotton systems reduce poverty and food insecurity for African farm families. Fibre, Food & Beauty briefing. http://www.pan-uk.org/foodAfrica/PDFs/FFB%20stories%20and%20issues%20briefing.pdf (ii) PAN UK. 2011b. Can organic cotton feed Africa? A short guide to the issues. http://www.pan-uk.org/publications/can-organic-cotton-feed-africa

Cheap and readily available local ingredients used for pest management methods in pesticide-free cotton, Ethiopia. *PAN UK*

children from organic cotton farms now being sent to secondary school for the first time.

OBEPAB identifies the following factors in its success:

- √ A strong focus on improving productivity in the challenging savannah environment
- √ Diversifying crop rotations and exploring market options for selected crops
- √ Practical research and technology development based on ecological science
- √ Experimentation using participatory methods, in which farmers are the main actors
- √ Participatory training, employing local staff with local knowledge and languages and prioritizing processes of learning and evaluation by farmers
- √ Building on local knowledge and combining it with external knowledge
- √ Open and democratic structures at local level, via farmers' elected representatives and attention paid to participation of women and youth
- √ Building farmer capacity at family, village and district levels to reduce their reliance on external support and move from aid to self-help
- √ Developing a sustainable and profitable farming 'business model', based on agroecological principles for production

7.2 Kenya: Push-pull system of pest management[276]

Yields of cereal crops in sub-Saharan countries have been seriously undermined by both pests and weeds, with land degradation and poor soil fertility also contributing to the problem.

However, scientists at the International Centre of Insect Physiology and Ecology *(icipe)* in Kenya and Rothamsted Research in the United Kingdom, and farmers in Kenya, have developed an innovative approach to managing the pests and weeds – known as the 'push-pull system'. The principle is simple: essentially pests are pushed away by insect-repellent plants interplanted in the crop and pulled towards insect-attractive plants at the edge, in a system that also controls weeds.

The main cereals are maize, sorghum, millets and rice; the main pest problems are stem borers; and the main weed problem is the parasitic weed *Striga*. *Striga* is a root parasite of cereal crops that competes for nutrients, impairs photosynthesis in the crop, and within days of attachment to the crop plant causes a toxic effect. It even makes the plant more preferred by the stemborer insects, which alone can result in 80 percent reduction in yields. Parasitism by Striga can cause 100 percent losses.

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276 Khan ZR, Midega CA, Pittchar J, Murage AW, Birkett MA, Bruce TJ, Pickett JA. 2014. Achieving food security for one million sub-Saharan African poor through push–pull innovation by 2020. *Phil Trans R Soc B* 369 20120284. See also (i) Khan ZR, Midega CA, Pittchar J, Pickett JA, Bruce T. 2011. Push-Pull Technology. In: *Encyclopedia of Pest Management*. Taylor & Francis. (ii) Khan ZR, Midega CA, Pittchar J, Murage AW, Birkett MA, Bruce TJ, Pickett JA. 2014. Push—pull technology: a conservation agriculture approach for integrated management of insect pests, weeds and soil health in Africa. *Int J Agric Sustain* 9(1):162-70.

How it works

Maize, for example, is interplanted with *Desmodium*, a small flowering legume that exudes high amounts of chemicals, which repel pests but attract natural enemies (parasitic wasps). Because it is a legume, *Desmodium* also fixes nitrogen in the soil, which then feeds the maize and, although it first stimulates the germination of *Striga* seeds it then inhibits their growth, in this way depleting the *Striga* seed bank in the soil. It also improves soil organic matter and acts as a living mulch that keeps moisture in the soil, smothers weeds, and reduces soil erosion. So *Desmodium* confers a number of important benefits on the maize crop. An additional benefit to farmers is its use as fodder for livestock.

Napier grass *(Pennisetum purpureum)* planted around the field edges acts as a trap crop, as it is considerably more attractive to the stem borer female moths than is the maize. But the stemborer larvae do not actually survive on the grass and there is about 80 percent mortality within the first 25 days after larvae emerge and commence feeding on the grass. This is because the Napier grass exudates a gummy substance that immobilises the larvae as they try to bore the stem. The Napier grass can also be used as fodder.

Benefits of *Desmodium:*

- * Repels stemborer
- * Attracts natural enemies
- * Fixes nitrogen
- * Increases soil organic matter
- * Retains soil moisture
- * Smothers weeds
- * Inhibits Striga growth
- * Depletes Striga seed bank
- * Fodder for livestock

Mrs Alice Odima a farmer in Siaya, western Kenya in her sorghum and maize, 'push-pull' cropping system. *icipe*

Benefits

Yield and income

Typically, using the push-pulling system has resulted in dramatic yield increases:

√ Maize – from < 1 tonne/hectare to > 3.5 t/ha
√ Sorghum – from < 1 t/ha to > 2.5 t/ha
√ Finger millet – from < 0.5 t/ha to > 1 t/ha

A detailed economic analysis in Kenya found that in areas of higher productivity, yields increased from 3.9 to 6.3 tonnes per hectare (t/ha), whilst in areas of lower productivity the increase was from 0.9 to 1.9 t/ha. Positive total revenues ranged from US $351/ha in low productivity areas to US $957/ha in the high productivity areas and these generally increased in subsequent years. The analysis concluded that *"push–pull earned the highest revenue compared with other soil fertility management technologies, including green manure rotation."*

Intercropping rice with *Desmodium* has also resulted in dramatic increases in Striga control in rice, with associated increases in yields.

Additionally, farmers observe increases in fodder and milk production, with an overall improvement in incomes and livelihoods. Others have been able to add dairy and poultry to their farming enterprises. Some are incorporating bean production into the system. Farmers have been able to convert to organic production.

Although some productive land is seen as being lost to planting of the Napier grass trap crop, the benefits, through increased maize yield and additional income from sale or utilization of Napier grass and Desmodium as fodder, more than compensate and allow farmers to cover the initial costs (capital and labour), while making a substantial profit.

Social and environmental benefits

The improved yields from the push-pull system are such that they can *"support many rural households under existing socioeconomic and agro-ecological conditions. This will reduce pressure for human migration into environments needing and designated for protection".*[277] Food security, nutrition and health have all improved.

Agroecosystem benefits

These include significant improvements in soil fertility, particularly nitrogen fixation, increased soil organic matter, prevention of soil erosion, reversal of land degradation, reclamation of abandoned farmland and enhancement of agroecosystem integrity.

Farmer uptake of Push-Pull systems

Farmer-to-farmer transfer of the technology is regarded as being especially effective, with about 80 percent of those who attend farmer field days eventually adopting the technology. Push-pull technology is readily adopted and practiced by smallholder farmers in east Africa, by about 68,800 smallholder farmers to date, including:

- About 52,746 in western Kenya
- About 10,600 in Uganda and Tanzania
- 343 in Ethiopia

The system fits with traditional African mixed cropping, is a low-cost, effective technology that can be adapted to fit local plants and is widely accepted by farmers. The annual adoption rate at present is about 30 percent, but this is expected to rise to 50 percent with extensive efforts to transfer the technology to the entire cereal-livestock farming population in Sub-Saharan Africa.

Work is continuing to identify the best intercrop and trap crop species for different conditions, especially for climate extremes. Farmers are themselves contributing to identifying these plants.[278]

According to Janice Jiggins of the Dutch Wageningen University,[279] one of the missing elements in this story is *"is a social mechanism of sufficient power and reach to drive adoption forward".* One of the main private seed producers in East Africa, the Western Seed Company Ltd, is selling commercial quantities of *Desmodium* seed, produced through a network of contracts with individual farmers and farmer groups. But beyond this, there is little scope for market actors, especially international corporations, to progress the transfer of this technology and, in fact, good reason for them not to, because it undermines sales of their proprietary products. Hence the need for the delivery of advice and extension support through public services, to support the farmer-to-farmer transfer of knowledge.

277 Khan et al 2014, *op cit*.
278 Jiggins J. 2014. Adaptation and mitigation potential and policies for climate change: the contribution of agroecology. Chpt 123 in: Freedman B(ed), *Global Environmental Change,* Springer, Dordrecht.
279 Jiggins 2014, *op cit*.

7.3 Sahel region: Biological control in pearl millet[280]

Pearl millet is the staple cereal crop in the West African Sahel, which is characterised by drought, heat and poor soils. Between 1970 and 2000, as a result of attack by caterpillars of the pearl millet head miner caterpillar, *Heliocheilus albipunctella*, pearl millet yields in the region dropped by up to 40 percent.

This case study gives a good example of very effective biological control of a highly damaging pest in a subsistence food crop. Even though biological control solutions were already known in the Sahel at the time of the first outbreaks 40 years ago, only recently has an effective system been established to control this pest, involving national researchers working hand-in-hand with local communities and organized farmer groups.

The decline in yields has now been halted and reversed by the rearing and release of a tiny parasitic wasp – *Habrobracon hebetor* – into farmers' fields and grain stores. The wasp attacks the head miner by stinging the caterpillar, causing paralysis and preventing it developing into an adult. The wasp then lays its own eggs on the pest, and when the wasp larvae hatch they feed on their paralysed caterpillar 'host' and eventually pupate within the head miner cocoons.

Simplifying an existing technology

The same wasp had already been used in other parts of the world to control pests, including China, Bulgaria, the former Soviet Union, the Middle East and the United States. However, the challenge was to develop a simplified system for rearing the wasps by smallholders in this part of Africa.

The "Integrated Management Of Pearl Millet Head Minor" project (GIMEM in French) began work in Niger, Mali and Burkina Faso in 2006. Through a combination of laboratory and field tests undertaken with farmers themselves, a wasp mini-rearing kit was developed. It consists of a small jute bag containing a little pearl millet grain, impregnated female wasps ready to lay eggs and rice moth larvae as a host food source for the wasp offspring. Each bag produces around 200 adult wasps within a period of 2 weeks, which farmers can then release into their millet fields. Wasps released from 15 bags per village can spread up to 15km to find and attack the millet headborers, killing 60-75 percent of the pest within a month of release.

The parasitic wasp *Habrobracon hebetor*

Farmer Field Schools for rearing parasitic wasps

The project engaged major farmer co-operative organizations in Niger, Mali and Burkina Faso, not only for training, but also to take part in developing the wasp release methods and assessing the project impact. Interested villages not belonging to formal farmer co-operatives were also included. Through Farmer Field Schools (FFS) 709 farmers, of which 214 were women, and 142 technicians and local extension agents were trained in the rearing

280 Payne W, Hamado T, Baoua IB, Ba NB, N'Diaye M, Dabire-Binso C. 2011. On-farm biological control of the pearl millet head miner: realization of 35 years of unsteady progress in Mali, Burkina Faso and Niger. *Int J Agric Sustain* 9(1):186-93.

and release of the wasps. Learning activities helped farmers understand the concept of biological control and become familiar with the lifecycle of the headborer moth and its wasp natural enemy. The Integrated Pest and Production Management (IPPM) curriculum also covered other IPPM practices for combating millet pests and diseases, plus better crop husbandry and soil fertilization practices for pearl millet.

The first phase of the project, which ran from 2006 to 2008, saw the release of the wasps in 385 villages, with an effective coverage approaching more than 200,000 ha. As a result, yield increases of 40 percent were recorded, with around 72 percent of head miner larvae killed by the wasps.

Success breeds success

This success meant that a second four-year phase was initiated in 2009, which looked to extend the use of the wasps to 3,000 villages through the formation of an additional 50 FFS trainings of 100 extension agents and 3,000 village promoters. One third of these were women. Its target was to achieve a 20 percent pearl millet yield increase over an area of one million hectares by the end of 2013.

The second phase of the project has seen further experimentation, which has resulted in improved efficiency and effectiveness of the wasp rearing and release system. They now kill up to 88 percent of the headborer larvae in a period of 4 weeks, while also reducing the cost to farmers of the kit required to rear the wasps. New varieties of pearl millet, which are partly resistant to headborer, have also been bred and are being tested with farmers.

Combining natural enemy releases with farmer training in IPPM methods is delivering real impact on farmer productivity in this staple food crop. Data from two villages in Niger after FFS training shows that using biological control and employing the IPPM techniques can achieve pearl millet yields of up to three and a half times that of farmers using traditional techniques.

Success factors

- √ Cereal yields can be increased considerably with good training and a focus on ecological methods, without recourse to pesticides.
- √ Good research alone is not enough to deliver real impact. It requires developing effective implementation with (rather than 'for') resource-poor farmers. Involving farmer associations from the start as active participants in the project has been essential.
- √ Coordinating research within the framework of a Sahelian regional discussion of the technical, social and institutional change processes involved many perspectives and participants in achieving solutions.
- √ Empowering national scientists and community leaders for a long-term solution is very important.

7.4 Tanzania: Climate adaption[281]

The Chololo Ecovillage project was part of a programme funded by the EU to increase the capacity of the most vulnerable communities to adapt to climate change through sustainable use of their own natural resources. More than 80 percent of Tanzania's population relies on rain-fed agriculture for their livelihood, so making that agriculture more resilient to climate change is of the utmost importance. Annual rainfall has reduced by an average of 3.3 percent per decade since 1960.

281 (i) Farrelly M. 2014. Chololo Ecovillage: a model of good practice in climate adaptation and mitigation. Institute of Rural Development Planning, Dodoma. (ii) Chololo Ecovillage. Final evaluation – a 3 page summary. https://chololoecovillage.wordpress.com/2015/02/17/final-evaluation-a-summary/

Minza Chiwanga, Chololo farmer, with her intercopped maize. *Institute of Rural Development Planning*

The project took a whole village approach – an eco-village approach – in which holistic, innovative and integrated approaches were tested, adopted and shared, across a wide range of aspects of village life. Women's vulnerability to climate change, particularly in terms of collecting water and firewood was a central consideration.

Launched in September 2011 and completed in May 2014, the project worked with three villages in Dodoma, central Tanzania. It was led by the Institute of Rural Development Planning (IRDP), and the other project partners were the Dodoma Municipal Council, Dodoma Environment Network (DONET), Hombolo Agricultural Research Institute, Maji na Maendeleo Dodoma (MAMADO) and Tanzania Organic Agriculture Movement (TOAM).

A multidisciplinary team visited the villages initially, and together with the villagers, used secondary research, rainfall data and climate change vulnerability reports to jointly identify the following key issues:

- *Drought:* the rainy season starts later, finishes earlier, and is less predictable; resulting in crop losses, low agricultural productivity, lowered incomes, food shortage and famine risk
- *Deforestation:* leading to loss of vegetation, increased desertification, reduced animal forage and pasture, shortage of fuel wood and timber, increased women's workload in collecting fuel wood for the home, and increased land pressure due to poor natural resource management
- *Flooding and strong winds:* leading to soil erosion, crop losses, land degradation, and declining soil fertility
- *Human diseases:* skin diseases, cholera and diarrhoea
- *Livestock diseases and crop pests:* e.g. Rift Valley Fever, army worm, calidea bugs, stink bugs
- *Water shortages:* inadequate ground water recharge, lowering water table, increased salinity, leading to shortage of drinking water for domestic use and livestock, and for crop production

The project addressed a whole range of issues, including livestock husbandry and production, bee keeping, fish farming, tree planting (forestry and agroforestry), water collection and storage, solar power, biogas digesters, energy-saving cooking stoves, value added production (e.g. sandals from goat hide) – all bringing much needed improvements and income across the village. Only the crop management issues are reported here, but more information on the other benefits of the project can be found on the project's website.[282]

Crop management methods

Traditionally, the village farmers relied on slash and burn methods to grow their crops. When nutrients in the soil were depleted after several years of cropping, the farmers would move on to new areas, cutting down the trees and preparing the soil with hand hoes.

The project worked with farmers to identify, test, evaluate, and implement a range of agroecological improvements in crop management, making the most of the rainfall,

[282] https://chololoecovillage.wordpress.com/

and improving soil fertility and the quality of their seeds. These improvements have resulted in greatly improved crop yields and food security and reduced farmer workloads.

Delayed seed sowing

One of the most important issues addressed was the changing pattern of rainfall and its effect on productivity. Traditionally, the first rainfalls in November triggered the start of seed sowing. However, the changing pattern of rainfall has brought less predictability, a later start and earlier finish to the rains, and a month-long dry period in February. If seeds are just germinating during this dry period, or the plants are at the critical flowering stage of development when they need adequate water, they may die. If planting is delayed three to four weeks (until late December to early January), then the plants will not have reached the flowering stage in the February dry period, do not need as much water, and can survive a few weeks without rain. They then reach the flowering stage in March when the rains return. This few weeks' delay in seed sowing alone makes the difference between crop failure and successful harvest, between recurrent famine and having something to eat.

Ox-drawn tillage

The project trained eighty farmers in tillage techniques using oxen. The farmers also learned how to make ox yokes and how to train the oxen. The oxen-drawn 'Magoye ripper'[283] helps open up the dry hard-pan soils and improves rainwater penetration, as well as reducing farmers' workloads. On sloping land, using the ripper to create ridges in the soil helps prevent water from flowing down the hillside carrying the soil and seeds with it.

"By early March the sorghum plants were starting to flower, and the cowpeas were fully mature and I started to harvest leaves and beans for my family. I expect to get enough yields in both cowpea and sorghum. I advise other farmers to use intercropping."

Minza Chiwanga, Chololo farmer

Ox-drawn magoye ripper breaks up the hard pan to improve water penetration. *Institute of Rural Development Planning*

Soil water conservation

A number of measures to improve the conservation of water in the soil were introduced. These included contour ridging on sloping land, fanya juu[284] and fanya chini bunds,[285] grass strips, infiltration ditches, and gully healing where soil erosion through gullies which form after rains has caused massive problems, all helping to capture rain and reduce soil erosion. The preparation of seedbeds across the slopes helps to minimize soil erosion through gullies.

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283 http://www.gartzambia.org/files/Download/Magoye%20Ripper%20Operator%27s%20Manual%202004.pdf

284 Fanya juu, the Swahili name for bench terraces, constructed by throwing soil up the slope from a ditch to form a bund along a contour. Several of these terraces are made up the slope following the contour lines. The distance between bunds depends upon the slope and may be from 5 m apart on steeply sloping lands to 20 m apart on more gently sloping lands. http://www.unep.or.jp/ietc/Publications/TechPublications/TechPub-8a/fanya.asp

285 Similar to fanya juu except the soil is thrown downhill. The embankment is usually planted with fodder grasses, legumes, trees, bananas, etc to stabilize it. http://www.foodwewant.org/eng/GAP/Fanya-juus-and-fanya-chini.

Contour terracing for soil conservation. *accessagriculture.org*

Improved seeds and community seed production

New varieties of traditional crops were introduced – sorghum, pearl millet, cowpeas, groundnuts, and sunflower. Importantly, these seeds were not genetically modified nor were they hybrid seeds; they were all open pollinated seeds that the farmers could save for the next season, year after year. Community saving of seeds ensures a good supply for next year's planting. Some of these varieties were developed in Tanzania by local scientists, supported by the International Crop Research Institute for Semi-Arid Tropics (ICRISAT).

Intercropping and crop rotation

Planting sorghum one year and pearl millet the next has increased the yield of both crops and helped control weeds, pest and diseases. Intercropping millet or sorghum with cowpeas or groundnut improves nitrogen supply, reduces pest damage, and provides the family with a balanced diet of staple grains, protein, and green leaves for essential vitamins. It also helps buffer household food security against single crop failure.

> ***"Before the project I was farming traditionally. In pearl millet I was getting an average of 2 bags per acre but now I am getting 5-6 bags per acre. In sunflower I am getting 6-7 bags per acre as compared to the past where I was getting 2 bags per acre."***
>
> *Stefano Chifaguzi, Chololo farmer*

Combining livestock and cropping

Farmers had not been spreading their animal manure on the fields prior to the project but now they spread on the soil before planting, improving soil fertility, soil structure and water holding capacity. Crop residues are fed back to the livestock, closing the cycle of nutrients.

Benefits

Yields have increased, income has increased, food is more secure, environmental damage is reduced and reversed, workload is reduced and resilience to climate change is increased, all without the use of agrochemicals or GM seeds.

Results of the whole project include:[286]

- √ Average yields increased from 234kg/ha in 2012 to 351 kg/ha in 2014
- √ Maize yields more than tripled; and pearl millet yields more than doubled
- √ 50 % of women are in leadership positions (up from 40% in 2012)
- √ The number of households eating 3 meals per day has doubled from 29 percent to 62 percent
- √ Average household income has increased 18%
- √ Women's income has increased 64%
- √ The period of food shortage has reduced by 62% from 7.3 months to 2.8 months.

[286] Chololo Ecovillage. Final evaluation – a 3 page summary. https://chololoecovillage.wordpress.com/2015/02/17/final-evaluation-a-summary/

8. Agroecology in Latin America

"We're trying to make an alliance between the farmer and the ecosystem. The farmer commits to preserving biodiversity and keeping the ecosystem healthy and the ecosystem responds by providing space and balance so that pests don't end up doing a lot of damage".

Germán Riveros, agronomist in agroecological cropping systems, Colombia

Case studies in this chapter are predominantly on coffee growing because of the sheer size of the industry, its extensive use of HHPs on the one hand and on the other, the highly successful experiences with agroecological practices. There is a small piece on large-scale organic growing in Brazil. But the final case study differs from all others in that it describes the use of agroecological practices to reduce, but not eliminate, pesticides in very input-intensive vegetable production in Costa Rica.

Plantain intercropped with coffee on smallholder farms to increase income and ecosystem diversity, Nicaragua. *Stephanie Williamson*

8. 1 Central America and Colombia: Growing coffee without HHPs

by Dr Stephanie Williamson, PAN UK

In 2013, the **Growing Coffee without Endosulfan** project visited 21 farms in Colombia, El Salvador and Nicaragua. The aim was to compile successful farmer experiences in using alternative pest management methods for control of the Coffee Berry Borer (CBB) *Hypothenemus hampei*, the main pest for which endosulfan is used in coffee. Implemented by Pesticide Action Network (PAN) UK and the 4C Association, the project was funded by FAO, the Sustainable Coffee Program powered by IDH, and the ISEAL Alliance.

CBB is a very complicated pest, which spends much of its life hidden inside the coffee bean, out of reach of chemical or biological insecticides. It mainly causes problems by reducing the quality of coffee beans, damaged by the tiny beetle boring into the developing beans and reproducing inside. Many coffee traders insist that growers do not exceed a maximum percentage of bored beans, often around 5 percent, or pay a lower price for badly bored coffee, while more demanding buyers will reject batches exceeding two or three percent. The borer population levels, reproduction rate, the economic damage it causes and costs of controlling it vary widely from year to year, in different regions, and even within the same farm. Blanket recommendations are simply not applicable and IPM methods need fine-tuning to the particular farm situation.

Monitoring traps for Coffee Berry Borer hung in coffee pulping unit, Colombia. *Stephanie Williamson*

Understanding the pros and cons of different IPM methods

The small, medium and large scale farms visited are all certified under standards such as Fairtrade, Rainforest Alliance, Utz Certified and 4C which have prohibited use of endosulfan for several years now. In interviews, the farm owners and managers explained how they gained useful experience in managing their farms without this particular HHP and have valuable lessons to share about phasing in alternatives. Their experiences were assessed to produce practical guidance documents and a series of farm case studies (including Las Brisas farm in Colombia, detailed in the Chapter 8.2). A set of YouTube videos was produced (available in English, Spanish, Portuguese and French) in which farmers describe how they use different cultural, physical, biological control methods for CBB and their pest monitoring systems.[287]

Getting farmers motivated to take up alternatives requires more than one-off training events, advisory leaflets or occasional field demonstration days. To become confident users of ecological pest management strategies, farmers need practical guidance, user-friendly monitoring and decision making tools, group discussions about what works well, where and under what situations and why things may go wrong, backed up with mentoring from more experienced farmers. Farmers and their trading partners will benefit from a shared understanding of the pros and cons of different IPM methods, including how these compare with the chemical control methods with which they are more familiar. The project used coffee sector stakeholders' assessment criteria to compare the usefulness of different methods for CBB management in terms of effectiveness, cost, labour required, training needed and ease of implementation.

Technical support activities

Technical support organizations, such as farmer co-operatives, coffee exporter groups, governmental or private extension services and agricultural research centres, play an essential role in developing and promoting uptake and refinement of ecological pest management methods which are appropriate to different farm contexts and cost-effective.

<u>*Working with smallholders*</u>

SOPPEXCCA co-operative works with 650 small and medium scale family farmers in Jinotega department in northern Nicaragua. The co-op is Fairtrade certified and faced challenges with some of its members when Fairtrade prohibited all use of endosulfan in certified coffee farms. Since 2010, the co-op's agronomists have promoted use of traps as part of coffee berry borer IPM, using a mixture of methanol/ethanol as an attractant for the female beetles. The effectiveness of these traps in reducing borer numbers early in the season has been proven in regional IPM research programmes. Co-op member Henry Zelaya has used the traps for three seasons on his eight hectare coffee farm:

"Traps are better and more reliable than spraying endosulfan because you don't have the

287 Available at http://www.pan-uk.org/projects/growing-coffee-without-endosulfan

problem of trying to time the insecticide application and the risk of wasted effort if CBB is already inside the bean. As long as the traps are in place in the dry season, they will start catching borers before they attack the new berries".

Henry now speaks at local coffee sector meetings to inspire more farmers to try this cheap and effective method for themselves. SOPPEXCCA encourages its members in lower altitude districts with higher CBB pressure to also try out semi-commercial Beauveria products, purchased from local small-scale laboratories, for additional control mid- to late- season. The co-op has persuaded numerous members to add plantains into their coffee groves to diversify their farming systems and income generation.

<u>Working with large estates</u>

Export company Coex grows coffee on its own estates in El Salvador and buys coffee from over 2,000 large and medium scale growers. The company faced serious challenges to selling into the growing market for more sustainable coffee when both Rainforest Alliance and Utz Certified standards announced their prohibition on endosulfan use from 2011, due to the insecticide's addition to the Stockholm and Rotterdam Convention lists. Most of the country's large estates were reliant on at least two endosulfan applications per season as their main CBB control tactic at that time. In close collaboration with national coffee research centre PROCAFE, Coex agronomists pioneered large-scale implementation of trapping and use of Beauveria on the company's estates. They experimented with home-made traps using empty soft drinks bottles to hold dispensers of the methanol/ethanol attractant and conducted detailed cost/benefit analyses. Costs of trapping (including attractant and dispensers, trap construction and labour for placement and maintenance), averaged US $14-20 per hectare, compared to US $70-84 for the standard two applications of endosulfan. Coex now organize regular CBB IPM training activities for their grower suppliers, via estate walks, hands-on sessions with groups of farm managers and tailored advice. In 2014 Coex set up its own biopesticide laboratory to enable more growers to use *Beauveria.*

Since COEX agronomists introduced him to trapping in 2011, Don Abelino Escobar, manager of the 96 hectare Belmont estate near Santa Tecla, has stopped all endosulfan use and is delighted with the results. He has succeeded in gaining Rainforest certification for the estate's coffee and found that combining trapping with good cultural controls can maintain very low levels of CBB in beans, between 1-2 percent on average, including in plots which used to exceed 10 percent even when he was applying endosulfan.

Key lessons

The key lessons learnt from the "Growing Coffee without Endosulfan" project provide useful food for thought for policy makers in coffee growing countries, coffee sector stakeholders, donor agencies, the BRS Conventions and SAICM community and other chemicals management decision makers at national and international levels.[288]

<u>*Ecological pest management can be cheaper than reliance on chemicals*</u>

The farm interviews show clearly that it is perfectly possible to manage CBB well without endosulfan, on small and large farms, using safer, IPM methods. They counter misconceptions that alternatives to endosulfan are always more expensive and demonstrate that considerable reduction in other HHPs can be achieved too.

The potential POP chlorpyrifos is being promoted in countries such as Colombia as the best chemical substitute for endosulfan for CBB

[288] FAO. 2015. Phasing out Highly Hazardous Pesticides is possible! Farmer experiences in growing coffee without endosulfan. FAO, Rome. http://www.pan-uk.org/files/Endosulfan_leaflet_ENGLISH

Home-made trap for baiting with alcohol attractant to trap Coffee Berry Borer, Nicaragua. *Stephanie Williamson*

control. Chlorpyrifos was responsible for the most frequent occupational and accidental poisonings in a joint pesticide vigilance project in the late 1990s by the health ministers of six countries in Central America. It continues to feature in clinical records of agricultural poisoning incidents compiled by departmental Health Secretariats in coffee-growing regions of Colombia.[289]

Yet phasing out chlorpyrifos for borer control is entirely feasible: experiences from several certified estates in Colombia show how dedicated farm owners have phased out first endosulfan and then chlorpyrifos and other HHPs, replacing them with comprehensive IPM strategies which prioritize ecological methods. Mrs Marlen Sánchez, from the management team of Agrovarsovia Farms in Risaralda Dept, recounts how combining rigorous cultural practices with very careful monitoring, and adding biological controls, they have managed to get CBB levels below 2 percent. Since 2010, the team has reduced chlorpyrifos use each year, replacing it with Beauveria applications, and achieved zero chlorpyrifos use in 2013. Investing in this IPM programme, with a full time borer control supervisor for Agrovarsovia's five estates, has delivered higher quality coffee with a 3-4 percent increase in price.[290]

Government actions to prohibit HHPs can trigger positive change

Prohibitions provide stimulus to take up ecological alternatives and remove the barriers to wider IPM uptake by farmers when cheap HHPs remain readily available in the market.

Progressive supply chain standards play a hugely important role

Supply chain standards (e.g. Fairtrade, Rainforest Alliance, Utz Certified), via their prohibited and restricted pesticide lists, help farmers shift away from HHPs and towards agroecological practices. Certification standards, farmer organizations and allied research institutes working together can achieve rapid changes to more sustainable practices in crops from coffee, cocoa, tea and cotton to fruit and vegetables.

Learning from successful farmers IPM experiences

Successful experiences, including analysis of costs and benefits, gives national decision makers the confidence that banning HHPs will not cause economic harm to farmers or coffee exports.

Promoting experiences to national stakeholders

Promoting experiences builds practical and political support for phase out. Implementing the BRS Conventions works best when governments collaborate with producer organizations, the private sector and civil society.

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289 Luz-Marina Garzon, pesticide hazard education team leader, Risaralda Health Secretariat, pers. comm.

290 Agrovarsovia. 2013. Integrated Management of Coffee Berry Borer. Agrovarsovia Farms, Colombia. Presentation by Marlen Sánchez and Arlides Aricapa at Growing Coffee without Endosulfan project workshop, Bogota, October 2013. Available in English and Spanish at http://www.4c-coffeeassociation.org/resources/final-conference-workshop-on-growing-coffee-without-endosulfan

Effective CBB management depends on the economic reward for farmers

The coffee quality requirements of different markets strongly influence farmers' practices. When traders pay the same price for poor quality, bored beans as for clean beans, there is little incentive for farmers to farm sustainably. Governments can help farmers to access the growing local and export markets which do reward higher quality food and safer pest management.

Using home-made compost on organic farm for propagating new coffee plants, Nicaragua. *Stephanie Williamson*

8.2 Colombia: Agroecological coffee production

by Dr Stephanie Williamson, PAN UK, with Juan Guillermo Londoño, coffee grower, and Germán Rivero, agronomist

Well-mulched coffee plot with non-competitive vegetation for soil cover on Las Brisas farm, Colombia. *Stephanie Williamson*

Box 8.1: Las Brisas farm, Pereira municipality, Risaralda Dept. COLOMBIA

***Owner:* Don Juan Guillermo Londoño**

Farm size: 25 ha *Altitude:* 1450m

Pest pressure in zone: Medium-High

Crop system: Coffee, part-shaded, with plantain borders and intercrop rows

Certifications: Fairtrade +Rainforest Alliance +Utz Certified +4C, since 2010

For over 15 years, Don Juan Guillermo Londoño has successfully replaced all insecticide use in his medium sized farm in Colombia's Risaralda Department. For managing the key pest, the Coffee Berry Borer beetle (CBB) *Hypothenemus hampei,* he employs a variety of IPM methods on his medium-sized farm in Colombia's Risaralda Department.

There are no 'magic bullet' solutions for CBB, especially in equatorial regions like Colombia where there are always some coffee berries developing on the trees at most times of year and hence a continuous cycle of borer attack on berries as they start to ripen, followed by egg-laying and reproduction inside the beans and new adults emerging. Effective management of this pest without using HHPs relies on careful field monitoring and combining at least two IPM methods, of which the starting point is good cultural controls – coffee grove management practices which help reduce the borer population levels and disrupt its breeding cycle.

Background

In this part of Colombia's coffee growing region, the warmer climate encourages rapid borer multiplication and levels may easily reach 6-8 percent bored beans, even when farmers carry out standard recommended cultural controls and field hygiene. Don Guillermo took an active decision not to rely on insecticides when he bought Las Brisas farm over 20 years ago, even though CBB levels were up to 18 percent in some of the plots and the extension service agents were advising him strongly to spray. Instead, he developed what he calls his own 'cultural-ecological coffee system', based on intensified cultural controls, biological and physical control methods, enhanced by changes in cropping and soil management practices across the farm.

Managing Coffee Berry Borer without insecticides

The six-point strategy Don Guillermo uses for managing the borer comprises:

- Very careful and frequent CBB monitoring in all the plots
- Frequent and timely picking of mature coffee berries
- Rigorous sanitary removal of bored berries around borer 'hotspot' trees
- *Beauveria* biopesticide applied to the ground at borer 'hotspots'
- Additional physical controls during picking and pulping operations
- Mulching to encourage higher background levels of *Beauveria* fungus

<u>*Monitoring and Decision-making*</u>

Las Brisas farm manager and a specially trained pair of young women workers carry out regular grove monitoring to assess pest incidence levels, identify borer 'hotspot' trees in each plot and later to assess whether control actions have worked.

Marking coffee berry borer 'hotspot' trees for intensive sanitation, Las Brisas farm, Colombia. *Stephanie Williamson*

They sample developing, green coffee berries on 60 trees per ha in plots of 4-5 year old trees (where CBB attack is most likely). They follow the simple CBB sampling protocol developed and promoted by the Colombian Coffee Growers Federation (FNC) research and extension service for farmers to assess: (a) average percentage borer incidence in berries in each plot and (b) position of beetles inside bored berries, to assess whether they can be reached by spraying insecticides or biopesticides.

'Hotspot' trees with significantly high numbers of borer are flagged with a yellow plastic strip and a white strip at the row end so the borer control team can easily find the relevant trees. Staff then dissect a sample of bored berries to assess whether the majority of beetles are still inside the berry outer flesh and can be reached by biopesticide action, or whether most have already started to penetrate the developing bean and are therefore out of reach.

The farm manager involves all workers in reporting any flowering episodes seen in the groves and uses the FNC's popular flowering calendar chart to forecast critical control periods (green berries become attractive to the borer at 90 days after each flowering episode). Don Guillermo maintains detailed computerized records of all CBB control tasks, timings and inputs so he can track effectiveness and costs.

Cultural Controls

Las Brisas farm workers make regular harvest pickings of mature berries as soon as they ripen, usually every 21 days but increased to every 15 days in plots with higher CBB levels. Although there are two main harvest peaks per year in this part of the country, Don Guillermo earns some income from the small volumes of coffee collected in these regular 'sanitary' picking rounds throughout the year, so this cultural control to remove potential CBB attack and breeding sites (ripening and mature berries) pays for itself in labour terms.

His system of intensified, post-harvest sanitary controls takes place every 3-4 weeks after the major and minor peak harvest periods. These controls consist of rigorous collections from identified borer 'hotspots' (trees with more than 5 bored berries from sampling) plus their 6-8 neighbouring trees, removing all berries from the ground and any overripe or dry berries on the branches. This helps to remove from the groves very large numbers of high risk CBB breeding sites – several generations of borer can reproduce inside each fallen or dried berry left on the tree.

Physical controls

Berries collected from hotspots and from second harvest passes are collected in greased lidded containers (to capture any adult borers emerging) and put into hermetically sealed barrels for 24 hours. As berry fermentation starts, carbon dioxide gases released kill any borers inside or emerging. Many of these berries can then be processed and sold as second grade beans. Don Guillermo employs simple barrier controls (mesh filters, greased plastic covers) at pulping and processing stations to collect any live borers emerging from berry pulp or collection containers. He has smooth-lined funnels for delivering the washed berries into the pulping machine, rather than the traditional wooden ones, so that there are no cracks where escaped borers can survive. While none of these physical methods are major controls, they all help to reduce the risk of borers re-infesting clean plots.

"Biological products need to get established and they work more slowly. It's a question of understanding, being sure about what a biological product will do… You've got to be patient because you won't see the results the next day, nor one or two weeks later, but you'll keep applying and gradually see the fungus getting established and then start seeing the effects".
Don Guillermo Londoño

'Worm juice' from vermiculture composting units produced by La Palmera coffee estate, Colombia, for sale as an organic fertiliser. *Stephanie Williamson*

Biological controls

CBB adults and larvae can be infected and killed by the naturally occurring insect pathogenic fungus *Beauveria bassiana*. This fungus is often present

Coffee pulp ready for composting, Las Brisas farm, Colombia. *Stephanie Williamson*

Home-made evaporation channels to convert sugary waste water from coffee pulping into solid fertiliser. *Stephanie Williamson*

at low levels in coffee groves, especially in shaded coffee, but rarely at levels sufficient to, by itself, keep CBB from causing economic damage. Several commercial *Beauveria* biopesticides for CBB are available, based on selected strains of *B. bassiana* known to be most virulent to this particular pest. When grove monitoring shows high CBB levels (over 2 percent infestation) in berries, Don Guillermo applies *Beauveria* to the ground 'plate' around the trunk under borer 'hotspot' trees and their immediate neighbours, to kill borers emerging from any fallen berries left on the ground, before they can fly up and attack the new season berries. The fungus is usually applied every two to three months but increased to monthly during periods of high temperature when borer breeding rate speeds up.

He has found that the Brocaril® product (Laverlam, USA), formulated and registered for the Colombian coffee sector, works best to prevent re-infestation from borers breeding in fallen berries, even though more expensive than nationally manufactured *Beauveria* products. *Beauveria* application is limited to the ground under hotspot trees on a maximum 40 percent of his groves which have taller, 4-5 year old trees (in the remaining 60 percent of groves with younger trees he use only cultural controls). On average, *Beauveria* applications cost the farm around US $200 per hectare over the year, but Don Guillermo does not consider the costs too high because he derives numerous benefits from using biopesticides, compared with insecticide use: no harm to the environment, workers are not put at risk and beneficial organisms are conserved. He has observed that *Beauveria* also reduces CBB reproduction rate, with only 2-4 larvae found on average inside fungal-infected berries, compared with the usual 30-40. However, he cautions that farmers need to understand that biological products will not give immediate results, because they need to get established first and they work more slowly than chemicals, but can deliver better control in the longer term.

Don Guillermo maintains a moisture-conserving mulch of plantain leaves, along with non-competitive weedy plants between his coffee trees. This mulch and ground cover provides a moist, shady micro-climate that helps *Beauveria* biopesticide applications work well, protected from midday sun and UV light which can kill the living spores in the formulation. He feels that this mulching also helps increase background levels of *Beauveria*, as well as benefitting coffee tree nutrition via a healthy and biologically active soil root zone.

Achievements and success factors

The farm team has achieved zero insecticide use for CBB management for almost 20 years, in a high pest pressure zone and after inheriting the farm with very serious borer levels. Don Guillermo's cultural-ecological system achieves an impressively low 1.5 percent bored beans even in seasons with unusually hot summers, which trigger high attack rates. Furthermore, Las Brisas has achieved better quality coffee, higher price and new markets via gaining Rainforest Alliance and Utz label certifications and becoming a member of *Entre Verdes* speciality coffee producers' association in Pereira, selling to companies keen to source top quality and environmentally friendly coffee for their customers.

In Don Guillermo's view, an important success factor is having specially trained staff working on CBB management. He gives incentives for good picking practices, rewarding the best work teams who avoid leaving any dried or overripe berries in the plots. He motivates his workers with good day rates, rather than piece rates, for time-consuming tasks; and prizes for the picking team which collects the least green berries during harvest and the most dried berries after harvest rounds, to deliver excellent grove management. His CBB programme is certainly labour-intensive in monitoring time and thorough sanitation but he benefits from better berry-bean yield ratios and selling quality coffee at a higher price. His pickers also benefit in their wages, paid by weight, because clean beans weigh more than bored ones.

Gaining confidence with biological control

Don Guillermo and his farm manager both highlight the need for farmers to understand how biological control works – applying *Beauveria* fungus will not have an immediate effect like a chemical; instead, it works more slowly. Don Guillermo's experience is that encouraging several farmers in neighbouring farms to all apply *Beauveria* at the same time can help a lot to increase natural levels and reduce CBB pressure on everyone's farms. He draws attention to the recent increase in *Beauveria* use by many more farmers in this area since 2011, even on large estates, thanks to availability of new products of better quality than before, containing more effective *Beauveria* strains for CBB.

Local agricultural supply stores and the departmental Coffee Growers Federation extension service now prioritize biological and cultural controls, with insecticides only recommended as a last resort. Companies selling biological products in Risaralda Department have contracted agronomists to run demonstration trials and train farmers in biopesticide use. With effective promotion and seeing *Beauveria* in action on others' farms, farmers are getting more used to the concept of fungal biopesticides. Risaralda Coffee Co-operative, of which Don Guillermo is a member, actively promotes their use, selling *Beauveria* products in its 16 supply stores and no longer sells any insecticide products prohibited by any of the certification standards, even if authorized for coffee at national level. Fear of worker poisonings from insecticides (a considerable problem in Risaralda Dept. in the recent past, especially with endosulfan) has also been a major factor for change in attitudes, as has awareness-raising about pesticide risks by the departmental Health Secretariat and promotion of safer alternatives with small family farms.

Other aspects of Las Brisas farm management

Don Guillermo moved away from coffee monoculture long ago and interplants his coffee with plantains, papaya and shade trees. The mulching and natural ground cover methods help to protect the soil, conserve moisture and encourage beneficial ecosystem services from good numbers of natural enemies of insect pests, including frogs, spiders, parasitic wasps and predatory insects, along with plentiful pollinators and active microbes in the soil. The farm is now

Don Guillermo holding a fertiliser wafer. *Stephanie Williamson*

insecticide-free in its plantain production too.

Certain non-competitive broad-leaved plants (known as 'noble weeds' in Spanish) are allowed to grow in the coffee groves as living 'cover crops' to help protect the soil and discourage the weedier species. Additional weed control is achieved where needed using a strimmer, plus occasional spot treatment using very small volumes of herbicide via a selective applicator to touch only those weeds hard to control by other means.

Don Guillermo likes to recycle farm wastes as much as possible. Not only does he follow FNC recommendations to compost pulped coffee berry waste and avoid polluting watercourses with the sugary liquid that collects in the pulping pits, he has devised a system of channelling this liquid into shallow evaporation tanks. As the liquid evaporates, the residues form thin wafers which he uses as organic fertilizer, in addition to his composted pulp. Pruning material from shade and other trees are placed in the coffee inter-rows to rot down as a slow-release fertilizer and all farm waste is recycled or composted where possible, although volumes are not sufficient to meet all crop nutrient demands at Las Brisas. Selected synthetic fertilizers are therefore used in minimal quantities when soil analysis indicates need for certain mineral supplementation.

Don Guillermo employs several tactics to prevent or reduce damaging levels of disease in the coffee groves. Only varieties resistant to coffee rust disease are grown, while careful plant nutrition, using farm-produced compost and selected fertilizers, helps to reduce susceptibility to other common diseases. Biofungicides based on *Trichoderma, Beauveria, Metarhizium* and *Paecilomyces* species of fungal antagonists are used in the coffee nursery and for applying to cut branches during pruning and grove renewal to reduce the risk of wound infection.

Pest management on the plantain crop requires no insecticides as the plantain rows are rotated around the coffee plots, breaking the pest life cycles and keeping incidence low. Sigatoka fungal disease is controlled manually via continual removal of infected leaves, with no need for fungicide spraying.

The plantain is grown in border rows as a protective shade for young coffee trees. As the local climate is often cloudy, too much shade may reduce coffee productivity. Along with other growers in the speciality coffee association, Don Guillermo is planting low densities of multi-purpose species of shade trees and has reserved 1.5ha of his land as protected woodland. Leucaena and other species of nitrogen-fixing trees are planted in and around grazing meadows to improve soil nutrient levels and provide an important protein-rich fodder supplement for his small cattle herd.

8.3 Nicaragua: Beneficial forest micro-organisms in coffee production

by Heather R. Putnam (Associate Director, Community Agroecology Network) and Stephen R. Gliessman (Professor Emeritus of Agroecology, University of California, Santa Cruz, and Board President, Community Agroecology Network)

Background: benefits of mycorrhizae on plant fertility and pest resistance

Endo- and ecto- mycorrhizal fungi (hereafter referred to as mycorrhizal fungi) are species of fungi that form a mutually beneficial (symbiotic) association with the roots of many plants, especially perennial shrubs and trees, either living in the soil or within the plant roots. They occur naturally in the leaf litter and root biomass on the floor of coffee groves (especially under shaded coffee systems, given the increased leaf litter). Mycorrhizal fungi help roots break down cellulose and increase their absorption of nutrients from the soil. In particular, they help improve roots' ability to assimilate phosphate, an element typically lacking in tropical soils. Mycorrhizal symbiosis in coffee plants is well established scientifically, as is its importance during the seedling formation stage.[291] It is also established that the symbiotic association of coffee plants with mycorrhizal fungi positively impacts coffee plants' resistance to pathogens.[292]

Case study context: smallholder coffee farmer co-operatives in San Ramon, Nicaragua

The Community Agroecology Network (CAN) has collaborated on a community food security project and an alternative coffee-purchasing model since 2010 with a second-level coffee co-operative organization, the Union of Agricultural Co-operatives Augusto Cesar Sandino (referred to as the UCA San Ramon) in San Ramon municipality in the northern Nicaraguan department of Matagalpa. The UCA San Ramon is made up of 21 first-level coffee co-operatives bringing together over 1,080 smallholder coffee farmers in the municipality, 36 percent of whom are women. CAN has engaged directly with one of the UCA San Ramon's members, the Denis Gutierrez Co-operative, to promote agroecological coffee production through its AgroEco® Coffee Program, which invests 10 cents per pound of coffee purchased in improving agroecological production practices.

CAN is an international non-governmental organization whose mission is to sustain rural livelihoods and environments in the global south through the integration of collaborative research, agroecological education, and locally informed development strategies. We operate as a network partnering with community-based organizations, farmers' cooperatives, nonprofits, and universities. Together, we promote food security and sovereignty in rural communities through agroecological farming practices; local control over food production, distribution and consumption; alternative trade models; and the empowerment of local and indigenous youth and women in the leadership of these initiatives. Our work is both regional and global, with projects and activities in Mexico, Central America, and the United States, and our international agroecology short course, which has trained hundreds of farmers, researchers, and community leaders from around the world since 1999.

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291 Habte M, Bittenbender HC. 1999. Reactions of coffee to soil solution P concentration and arbuscular mycorrhizal colonization. *J South Pacific Agric* 6:29-34.

292 Andrade SA, Mazzafera P, Schiavinato MA, Silveira AP. 2009. Arbuscular mycorrhizal association in coffee. *J Agric Sci* 147:105-115.

CAN had been working with the 15 members of the Denis Gutierrez Co-operative since 2011 to reduce and eventually eliminate their usage of chemical fertilizers and insecticides, as well as increase their use of agroecological methods to improve soil fertility. In 2011, only 2 of the 15 farmers were implementing ecological practices to increase soil fertility, including composting or applying fermented coffee pulp left over from coffee wet milling processes to their coffee plants. All 15 farmers stated that they utilized chemical inputs despite being aware of their negative effects, citing ease of use and, especially, a lack of confidence in the effectiveness of 'organic' fertilizers and pesticides.

Experimenting with native forest microorganisms

In 2012, Nicaraguan coffee was devastated by the coffee leaf rust disease Hemileia vastatrix. The rust is present in all coffee growing regions of the world, and is the most economically significant coffee pathogen.[293] A major infestation in Central America began in 2011 and worked its way north. In San Ramon, farmers reported losing on average 40-100 percent of their coffee plants to the disease. In the Denis Gutierrez Co-operative where farmers work an average of 1.4 hectares of coffee each, farmers experienced an 80 percent reduction in yields in 2012 due to the rust and an accompanying anthracnose pathogen, which kills coffee plants already weakened by rust infection.

The crisis led, in 2013, to a small group of seven farmers within the C-ooperative taking a perceived "risk": experimenting with different combinations of native forest microorganism applications (mycorrhizal fungi), compost and mineral foliar fertilizers. They applied these materials to newly planted seedlings and recuperating established plants on about 5 hectares of land set aside for the experiments. The expectation was that increased availability of nutrients in the soil, plus increased root capacity to absorb these, would also result in more robust plants with increased resistance to fungal diseases like leaf rust and anthracnose. Increased yields, once the plants were fully recuperated or had reached maturity for fruiting, were also expected. The soil amendment preparations were applied for about 1.5 years while the coffee leaf rust attack subsided and surviving plants regained foliage.

Coffee plant with the disease leaf rust, La Roya. *Heather Putnam*

The specific practices implemented included a combination of solid native forest microorganism inoculum with compost applied to soil, plus application of natural mineral foliar fertilizers. The native forest microorganisms are prepared by collecting decomposed leaf litter, which is mixed well with semolina and molasses to accelerate fermentation. Water is then added to achieve a thick, wet mixture and is compacted into barrels and left to ferment. The resulting solid mixture is then applied to the soil around the coffee plant.

293 Arneson PA. 2000. Coffee rust. *The Plant Health Instructor.* http://www.apsnet.org/edcenter/Pages/phi.aspx

Cooperative peparation of the beneficial mycorrhizal fungi. *Heather Putnam*

Mycorrhorizal fungi fermenting. *Heather Putnam*

Results and benefits

In 2014, farmers observed that coffee plants in the experimental plots were bigger, visibly healthier, and more resilient to the leaf rust (it was present at normal levels but not affecting foliage) as well as other fungi, than other plants renovated at the same time or recuperating from the fungus attack in other fields. Trees in the experimental plot were also more resistant to attack by borer insects. It was noted at the onset of the 2014-15 harvest that the plants treated with the preparations had heavier fruit loads than those in plots that did not receive the treatments.

The other eight farmers in the co-operative, as well as other neighbouring co-operatives, have seen the results and are enthusiastic about learning and applying these agroecological technologies in their own fields, confident that they will also see increased yields as well as higher plant resilience to future infestations of insects or fungal pathogens.

The major benefits of the application of native forest microorganism inoculum, in combination with compost and natural mineral foliar fertilizers, is not only increased plant vigour and resistance to leaf rust, but also resistance to other fungal diseases and borer insects. This holds true both for plants recovering from the rust infection, and for seedlings recently planted. The plants that had been severely affected by rust two years prior had recovered foliage as well as fruit, and incidence of rust on foliage appeared normal. An additional benefit to this application is that it is cheap, costing a total of about US $0.08 per coffee plant to apply, as opposed to an estimated US $0.80 per coffee plant for conventional fungicidal applications. Furthermore, the application is easy for community members to prepare and accessible to farmers because it utilizes locally available natural materials.

CAN plans to accompany the expansion of this agroecological practice within the co-operatives of the UCA San Ramon with research processes that will identify the specific strand of mycorrhizal fungi and expand on the science and mechanisms of its beneficial impacts.

8.4 Brazil: Large-scale organics combined with agroforestry

A family-owned organic farm in Brazil's São Paulo state shows that agroecological production can occur on a large scale. Founded in 2009 by supermarket chain heir and former Formula 1 race-car driver, Pedro Paulo Diniz, Fazenda da Toca has become one of Brazil's leading producers of organic eggs, dairy and fruit. The farm fosters ecological awareness and provides eco-education to younger generations, to its engaged consumer

Agroforestry on organic farm Fazenda da Toca. *FoodTank*

base and to the public in general. Their approach highlights the interactions between the soil, plants, animals, and people at the farm, developing sound soil and water usage methods and new agroforestry methods to enable the regeneration of surrounding nature – all while making good organic products. The farm provides livelihoods for 140 fulltime workers and their families, and they now have 2,200 hectares under organic cultivation.

Fazenda da Toca uses agroforestry methods to make use of a variety of trees, which play a distinct role in maintaining the balance between required biomass production and the nutritional needs of crops and animals. Integral to their success has been discovering the most beneficial combinations and planting successions of tree-based components, grasses, and crops, developing the right machinery and equipment to handle them on a large scale, while achieving all this economically. Located in the heart of Fazenda da Toca is the Instituto Toca, a non-profit school and research initiative, with a mission to "educate to transform". It provides direct instruction to students in the municipality of Itirapina, and currently hosts a primary education school, an after-school program of extracurricular activities, a continuing education training facility, events and study groups open to the community, and eco-teaching experiences for private schools and groups.[294]

8.5 Costa Rica: Reducing pesticide use in vegetables

by Ryan E. Galt, Associate Professor, Department of Human Ecology, Provost Fellow, Agricultural Sustainability Institute, University of California, Davis. regalt@ucdavis.edu

Introduction

Costa Rica has the highest use of synthetic pesticides per cultivated hectare in the world, in direct contrast with its image as an environmentally friendly nation.[295] With a focus on Northern Cartago and the Ujarrás Valley, the main vegetable producing area of Costa Rica, this case study using data collected in 2003-04 provides an example of how farmers growing high-value and input-intensive vegetable crops for market reduced their pesticide use by adopting some agroecological practices, largely in response to pesticide regulations. Examples in which farmers of very input-intensive crops are able to slow down or step off the pesticide treadmill using agroecological practices are important because they can teach us about the causes and conditions that allow this to occur.

Methods and data

A face-to-face survey of 145 farmers in 2003-2004 yielded data on about 430 field-specific spraying schedules for 33 different vegetable crops (based on three spraying schedules per farmer, on average). The data also include organic inputs used on these specific crops. The majority of the data

294 Reed M. 2014. Scaling Up Ecological Cultivation: An Interview with Richard Charity of Fazenda da Toca. FoodTank. Nov 3rd. http://foodtank.com/news/2014/11/scaling-up-ecological-cultivation-an-interview-with-richard-charity-of-faze

295 Galt RE. 2014. Food Systems in an Unequal World: Pesticides, Vegetables, and Agrarian Capitalism in Costa Rica. Tucson: University of Arizona Press, Tucson.

used is for the three crops grown for export and the national market: chayote (a trellised squash shaped like a pear), green beans and squash (including patty pan and zucchini).

Crops, markets and production practices in the region

More than 30 types of vegetables are grown in the region of Northern Cartago and the Ujarrás Valley. Farmers in the area grow three vegetable crops at a time, on average, and rotate their crops in quick succession year round. Almost all farmers in the area practice agriculture that depends on agrochemicals. They do so because they face extremely high pressure from insect and disease pests.

At the time of the study, pesticide use in the region was much higher than the Costa Rican average. Table 8.1 shows that a hectare of the very common annual rotation of potatoes, carrots, and cabbage was receiving, in 2004, 153.9 kg of active ingredient of synthetic pesticides per hectare per year (kg ai/ha/year), which was ten times the amount of pesticide used on the average cultivated cropland in Costa Rica, 15.9 kg ai/ha/year.[296] Even the least-heavily sprayed vegetable crop – chayote for export – was sprayed more than twice the national average. Subsistence crops of corn and beans had been almost entirely replaced with market vegetables by the 1970s, and when these were grown in 2003-04 they were little sprayed.

Most farmers in the area regularly used acutely toxic insecticides. Organophosphates (OPs), almost all of which are WHO Class Ia or Ib, constituted 35 percent of insecticide doses used on vegetable crops in the area, and on average, vegetable crops were sprayed with 5.2 doses of OPs per crop cycle. On average, crops in the region were sprayed weekly with 2 kg ai/ha.

The majority of the vegetable crops in the region were sold in the national market, which faced very little pesticide regulation. A handful of vegetable crops were also produced for export. These main export crops were chayote, green beans and squash. For these three crops, a substantial number of farmers grew them for national market, and another substantial group grew them for export, allowing for direct comparisons of input use.

Spraying green beans, Costa Rica. *Ryan Galt*

In the mid-1980s vegetable exporters in the region had shipments rejected from the United States. This was due to the United States Food and Drug Administration finding illegal residues of the OP methamidophos (WHO Class Ib) on imported vegetables. In response, these exporters created rules governing pesticide use for their contract farmers.[297] The rules included prohibitions on the use of OPs (mostly WHO Classes Ia, Ib, and II) and all other WHO Class Ia and Ib insecticides, especially near harvest time, and organochlorines (due to their residue persistence). In turn, exporters typically paid their farmers a higher price for their vegetables so that farmers could afford the more expensive, and less acutely toxic, synthetic insecticides that exporters recommend, like the pyrethroids. Additionally, some exporters provided training in Integrated Pest Management (IPM) or advised farmers learn more about organic agriculture and agroecology at the nearby training school (see below).

296 Chaveri F. 1999. Importación y uso de plaguicidas en Costa Rica: Análisis del período 1994-1996. Heredia, Costa Rica: Instituto Regional de Estudios en Sustancias Tóxicas, Universidad Nacional de Costa Rica.

297 Galt 2014, *op cit.*

Table 8.1 Average annual pesticide application intensity for common vegetable rotations by market, in 2003-04

Region	Market	Rotation	Pesticide used (kg ai/ha/yr)
N. Cartago	*Open national market*	potato, carrot, cabbage	153.9
		potato, cabbage squash	112.7
		potato, cabbage, broccoli	110.3
		potato, cabbage	89.5
		potato, carrot	121.7
		potato, potato	114.5
		potato, onion, lettuce	128.5
		potato, fallow	57.3
		corn (criollo variety) & bean (cubá)	1.4
	Export market	squash, green bean, squash, green bean	43.0
		squash, green bean, squash, corn	50.1
		squash, green bean, carrot, corn	55.7
Ujarrás Valley	*Open national market*	tomato, green bean, squash	111.1
		sweet pepper	65.9
		green bean, chayote	85.9
		chayote	71.5
	Export market	green bean,[1] chayote	47.9
		chayote	33.4
		squash, green bean, corn, squash	50.1
	Regional Average	**(not weighted)**	**79.2**
	National Average[2]		**15.9**

[1] Sold to open national market
[2] from Chaverri 1999
Source: surveys of farmers by author, 2003-04

Agroecological practices

Interest in organic agriculture was high among farmers in the region, but all were sceptical about the possibility of producing their crops economically based solely on organic inputs. For this reason, farmers used agroecological inputs to reduce their agrochemical dependence, but not to replace agrochemicals entirely. Since farmers' main production focus in the region was choosing which inputs to use in their very input-intensive crops, the main form that agroecological practices take in the region was different kinds of purchased and homemade organic inputs for the soil or to spray on crops.

The Instituto Nacional de Aprendizaje (National Institute of Learning, or INA) has an organic agriculture school, Organic Agriculture

Technological Unit, located in La Chinchilla, NW Cartago. This practical training school teaches farmers a number of organic agriculture skills. The classes offered in 2003-04 were: production of organic fertilizer including compost and 'bokashi';[298] vermiculture with California earthworms; plant protection with the use of bacteria and fungi to combat insects and plant diseases; growing and using medicinal plants; soil and water conservation; irrigation; making of nurseries and greenhouses; agricultural mechanization applicable to organic agriculture; and a general class in organic agriculture. Courses run throughout the year, and are taught one day per week for two to three months, and are free for farmers to attend.

In 2003-04, a small percentage of farmers in the area had adopted some of these agroecological practices, typically after taking classes at the INA. Table 8.2 shows that about 18 percent of farmers created their own organic foliar fertilizer sprays, 16 percent used 'worm compost tea' (many purchased it), and 12 percent used compost and organic insect repellents. About 9 percent of farmers used IPM. The rest of the chapter investigates how these agroecological practices relate to pesticide use intensity and organophosphate use in 2003-04. It also examines the effects of exporters' regulations on farmers' use of agroecological practices.

The vegetable chayote, Costa Rica. *Ryan Galt*

Table 8.2 Agroecological practices used by farmers*

Practice	average use
Compost	12%
Worm compost (vermicompost)	7%
Bokashi	5%
Organic repellants (pepper, garlic)	12%
Worm tea (vermiliquid)	16%
Homemade organic foliar fertilizer sprays	18%
Homemade organic fungicides	4%
Number of types of organic sprays**	0.5
Total number of agroecological practices	1
IPM techniques***	9%

* Data refers to 430 field-specific crop spraying schedules from 145 surveyed farmers (see Galt 2014).
** This includes all types of organic sprays, i.e. organic repellents, worm tea, homemade organic foliar nutrient sprays, and homemade organic fungicides.
*** Farmers' use of IPM is based on self-reporting. In the region, most IPM use focuses on insect identification and counts, with some knowledge and use of economic thresholds.

[298] Bokashi, also spelled bocashi, is a fermented organic soil amendment first created in Japan, made from waste materials such as food scraps, rice hulls, molasses, manure, ash, and yeast.

A farmer's homemade and purchased organic sprays. Agroecologically-oriented farmers in the region tend to focus on agroecological inputs due to the input-intensive nature of their vegetable crops. *Ryan Galt*

Farmers' pesticide use and use of agroecological practices

Almost all agroecological inputs are strongly, negatively related to pesticide intensity, with the exception of worm tea. This suggests that these agroecological inputs have an effect on the agroecosystem that allows farmers to reduce pesticide intensity. The exception of worm tea is curious, since agroecologically-oriented farmers in the area note that it provides plant nutrients in a concentrated form to grow healthier plants resistant to disease. Yet worm tea has also been adopted as a fertilizer by many farmers in the region, including those without much interest in reducing synthetic pesticide use.

Considering chayote specifically, two inputs reduced pesticide intensity considerably: organic repellents and organic foliar fertilizer sprays. Export farmers made organic repellents of hot peppers and garlic as a substitute for synthetic insecticides, against the insect pests "chino del chayote" (*Empoasca solana*), white fly (*Bemisia tabaci*, which spreads yield-reducing viruses) and leaf miners (*Liriomyza spp.*). Foliar fertilizer sprays sometimes included molasses, calcium carbonate, and other ingredients meant to make the plants stronger and better able to fight off infection. Both of these methods allowed chayote farmers to considerably reduce their dependence on synthetic pesticides. Chayote farmers who used organic repellents reduced their insecticide use to 2.8 kg ai/ha, compared to 7.7 kg for farmers not using organic repellents. Similarly, farmers who used organic repellents used an average of three doses of OPs compared to 10.6 doses used by farmers who did not use organic repellents.

In squash crops, the agroecological inputs that most reduced pesticide use were worm compost, bokashi and organic foliar fertilizer sprays. Reducing pest susceptibility through improved soil health has long been recognized and appears to have worked well for squash in the region. As for foliar fertilizer sprays, it is possible that the foliar nutrients helped strengthen the outer cells of the leaves, perhaps slowing the cellular invasion by pest organisms, especially fungal hyphae.[299]

Comparing national market farmers and export farmers

In addition to examining the effects of agroecological inputs by crop, it is important to desegregate the data more to look at specific groups of farmers. Export farmers faced an important pressure from the buyers of their produce to reduce their pesticide use. Exporters prohibited the use of OPs and all other WHO Class Ia and Ib insecticides. In contrast, national market farmers selling to unregulated markets faced little pressure to change their pesticide use, and organophosphates offered very strong and cost-effective pest control. Table 8.3 compares the use of pesticides and agroecological inputs on the crops of these different groups of farmers.

For all crops, export farmers used at least half the OPs with the less residual and less acutely toxic

[299] Galt RE. 2008. Pesticides in export and domestic agriculture: reconsidering market orientation and pesticide use in Costa Rica. *Geoforum* 39 (3):1378-92.

insecticides like the synthetic pyrethroids. Since the synthetic pyrethroids are less effective and cost more, export farmers would not do this without exporters' prohibitions on the OP insecticides.[300]

Other, more common, techniques for reducing pesticide use that were used by exporter farmers, were organic repellents (often made of hot peppers and garlic) and homemade organic foliar fertilizer sprays, as discussed above. In general, export farmers were much more likely to use these agroecological inputs than farmers selling in the open national market. The exception was squash. This exception exists for two main reasons. First, open national market farmers who are more oriented toward organic agriculture tended to grow squash due to its lower need for agrochemical inputs compared to many vegetables in the area, especially potato, carrot, onion and tomato. Thus, it is grown disproportionately by the more agroecologically-oriented farmers who sell to the open national market. Second, about half of export growers were more likely to use the IPM technique of counting insects and not spraying until they reach rough threshold values, rather than to use agroecological inputs, as discussed below.

Worm compost from California earthworms. Farmers use the worm compost (vermicompost) and the worm "tea" (vermiliquid) as crop inputs. *Ryan Galt*

Table 8.3 Pesticide and agroecological input use by market orientation

Chayote		
	Open National Market Mean (N=15)	**Export Market** Mean (N =29)
Pesticide use		
pesticide intensity (active ingredient per week)	1.1	0.5
doses of OPs	13.6	6.33
OPs as percentage of insecticide doses	31%	15%
Alternative practices		
compost	13%	7%
worm compost	0%	3%
bokashi	0%	3%
organic repellent(s)	0%	41%
worm tea	0%	3%
homemade organic foliar fertilizer sprays	7%	41%
homemade organic fungicides	0%	10%
number of types of organic sprays	0.07	1.0

300 (i) Galt RE. 2009. "It just goes to kill Ticos": national market regulation and the political ecology of farmers' pesticide use in Costa Rica. J Polit Ecol 16:1-33. (ii) Galt RE. 2014. *Food systems in an unequal world: pesticides, vegetables, and agrarian capitalism in Costa Rica.* Tucson: University of Arizona Press.

total number of organic practices	0.5	1.7
IPM techniques of insect counts and thresholds	0%	0%

Green Beans

	Open National Market Mean	Export Market Mean
Pesticide use	**(N = 22)**	**(N = 13)**
pesticide intensity (active ingredient per week)	1.25	0.92
doses of OPs	2.1	1.0
OPs as percentage of insecticide doses	32%	18%
Alternative practices	**(N = 22)**	**(N = 14)**
compost	9%	50%
worm compost	9%	0%
bokashi	14%	29%
organic repellent(s)	18%	36%
worm tea	23%	0%
homemade organic foliar fertilizer sprays	32%	43%
homemade organic fungicides	9%	0%
number of types of organic sprays	0.8	0.8
total number of organic practices	1.2	1.6
IPM techniques of insect counts and thresholds	9%	36%

Squash

	Open National Market **Mean**	Export Market **Mean**
Pesticide use	**(N = 32)**	**(N = 34)**
pesticide intensity (active ingredient per week)	0.93	0.86
doses of OPs	5.4	1.6
OPs as percentage of insecticide doses	35%	16%
Alternative practices		
compost	16%	18%
worm compost	16%	6%
bokashi	13%	18%
organic repellent(s)	19%	6%
worm tea	34%	0%
homemade organic foliar fertilizer sprays	19%	29%
homemade organic fungicides	9%	0%
number of types of organic sprays	0.8	0.4
total number of organic practices	1.5	0.9
IPM techniques of insect counts and thresholds	0%	18%

Export farmers' different strategies to reduce pesticide use

Farmers for the two main exporters (here referred to as A and B) of green beans and squash had different strategies for reducing their pesticide use to meet their exporters' demands. Those associated with Exporter A tended to emphasize the IPM threshold technique, whereas Export B's farmers tended to use agroecological inputs. While it is tempting to compare the two groups to determine which practice — IPM versus agroecological inputs — works better to reduce pesticide use, there are important socio-economic inequalities between the groups that strongly affected overall pesticide use.

Farmers for Exporter A tended to be wealthier, and used a strategy of moving their production outside of the regions where pest pressure is highest.[301] Additionally, Exporter A paid for IPM training for its farmers. As a group, these farmers have the highest use of IPM in green beans and squash. Exporter A's farmers succeed in reducing their pesticide use compared to open national market farmers, and used fewer OP doses, although it is unclear how much the IPM and how much moving their production contributed to these decreases.

On the other hand, farmers selling to Exporter B tended to be poorer, and could not afford to commute long distances to access better land. As a group, they faced higher pest and disease pressure than the farmers for Exporter A. They also did not receive IPM training. However, Exporter B strongly recommended they take short courses at the INA's organic agriculture school. In the face of their resource constraints and with this training, they turned to agroecological practices. As a group, these farmers have the highest use of a number of agroecological inputs on green beans and squash, especially compost, bokashi, and organic foliar fertilizer sprays. With these agroecological methods, Exporter B's farmers were able to reduce

A potent homemade pest repellent of hot chili peppers and garlic for use in chayote production. *Ryan Galt*

Harvesting potatoes, Costa Rica. *Ryan Galt*

their OP use to less than half of what open national market farmers used on green beans, and to a third of what open national market farmers used on squash.

Conclusion

Farmers in the primary Costa Rican vegetable production region of Northern Cartago and the Ujarrás Valley face substantial insect and disease pest pressure. During data collection in 2003-04, all farmers in the area relied upon agrochemicals for pest control, but a substantial minority of farmers

[301] Galt 2014, *op cit*.

Zucchini field, Costa Rica. *Ryan Galt*

had adopted agroecological inputs taught by the local organic agriculture school of the INA. These methods helped farmers to reduce their pesticide intensity and rely less on HHPs.

The different markets farmers sold to faced very different regulatory systems, with export markets having a prohibition on OP insecticides, especially near harvest time. Farmers selling to these export markets were able to reduce their use of OPs and other WHO Class Ia and Ib insecticides through a variety of methods, including IPM techniques and agroecological inputs. Agroecological inputs were most adopted by the resource-poor export farmers in the region, with beneficial results; they were able to reduce their acutely toxic pesticide use even in the face of very strong pest pressures.

Currently, farmers in the area continue to use pesticides intensively, but there are a handful of farmers converting fully to organic agriculture. The number of certified organic farms that are part of the Asociación de Productores Orgánicos de la Zona Norte de Cartago (Association of Organic Producers of Northern Cartago, APROZONOC) has increased in recent years to seven, farming on 12.5 certified hectares. While small, this is a considerable increase over virtually no certified organic land in the area in 2003-04.

Overall, this case points to the necessity of regulatory systems in pushing farmers of input-intensive crops to try agroecological methods to reduce pesticide use. It also highlights the importance of providing local and resource-appropriate training programs available to farmers who most need them. Major investments in and support for farmer- and expert-created agroecological knowledge are needed for the region. Farmers in the area grow more than 30 different vegetable crops, so the knowledge needs of farmers and educators in the area are enormous since each crop has its own assemblage of insect pests and diseases. Agroecological research on on-farm habitat management and further diversification of rotations and cropping systems could discover additional ways of reducing pesticide use. Lastly, larger-scale interventions should be explored, including stabilizing commodity markets (to make them more predictable and make it easier for farmers to make a living), supporting and subsidizing farmers who adopt agroecological methods and organic certification, and coordinating production of specific crops regionally to correspond with more conducive weather and to help break the lifecycles of pests in the area.

9. Agroecology in the industrialized world

"Its real value is in insisting on support for forms of agroecology around the notion of a group of farmers, acting as a pivotal force for change through economic and environmental interest groups."

Samuel Féret of the Groupe de Bruges, 2015

This chapter is a little different: it starts with a case study at the national policy level, illustrating how one high income country is attempting to make progress in replacing HHPs with agroecology. The remaining cases are all on-farm examples, illustrating a co-operative approach grouping family farmers to work together, alley cropping with cereal and legume crops, and medium-scale mixed organic livestock and cropping family farms.

French farm minister, Stéphane Le Foll

9.1 France: New law to promote agro-ecology

By Peter Crosskey, freelance journalist and publisher of the Urban Food Chains subscription website.

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As the heaviest user of crop protection chemicals in 21st century Europe,[302, 303, 304] France's attempts to get to grips with both reducing the use of pesticides and promoting alternative farming methods that sidestep any requirement to spray have lessons for us all. The results are mixed, but instructive. This case study is an edited version of a longer essay. The full version is available as a paid download from the Urban Food Chains website.

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302 2008 sales of active ingredients in France: 76,800 tonnes, world's fourth largest user behind USA, Brazil and Japan. http://www.assemblee-nationale.fr/13/pdf/rap-off/i2463.pdf

303 A 2009 French Parliamentary report [http://www.assemblee-nationale.fr/13/pdf/rap-info/i1702.pdf] suggests that 80% of pesticide applications are made on less than 40% of France's farmland, but since this represents application rates of 8.6 kg/ha these figure look unreliable.

304 The French national observatory for biodiversity website monitors pesticide usage with a two-year time lag. The most recent data, issued in May 2015, announced that in 2013, 88.4 million dosage units were applied, totalling over 60,000 tonnes of active ingredient. http://indicateurs-biodiversite.naturefrance.fr/indicateurs/evolution-de-la-consommation-de-produits-phytosanitaires

The current French farm minister, Stéphane Le Foll, is at present working to revive a national pesticide reduction plan which he inherited from a predecessor. Le Foll also steered a landmark agricultural reform act through the French parliament in 2014, with substantial cross-party support. *The Law for the Future of Agriculture, Food and the Forest* promotes agroecological approaches and has a headline target of implementing these on 200,000 French farms by 2025. It also adds agroecology to the curriculum of agricultural colleges across the country. About 40 percent of France's working farming population is either within five years of retirement, or well into an active old age. With a farming family background and as a former agricultural college lecturer, Le Foll understands the power of change that a new generation can bring to the rural economy.

2007: France starts to question its reliance on agrochemicals

When Nicolas Sarkozy became President in 2007, he lost no time in announcing a watershed conference and consultation process on the environment and economy that would involve government and sector professionals, as well as NGOs. After holding an open and extensive exchange of views, there would be time to draft appropriate legislation to tackle the issues raised. This major stakeholder consultation became known as the 'Grenelle' process, as it was held at the Work Ministry in the rue de Grenelle in Paris, in which a much earlier government had thrashed out agreements with protestors during France's May 1968 riots. Almost 40 years later, President Sarkozy's environmental 'Grenelle' national policy discussions ranged across climate change, biodiversity, health and the environment, as well as sustainable forms of production and consumption. In September 2007, the first set of policy recommendations was published. Those with a direct impact on pesticide use and farm management included:

- Establishing a way of taxing environmental impact of agrochemicals
- Trebling the proportion of organic farmland from 1.8% to 6%
- More public research to evaluate the environmental impacts, economic value and agronomic effectiveness of genetically modified crops, via an independent high level authority

Three major themes were identified for action: climate change, protecting biodiversity and cutting pollution. The farm minister, Michel Barnier, set up committees to draft policy actions to be implemented and relevant targets:

- Twin targets to promote organic farming: 20% of food served in public sector canteens by 2012 would be organic and organic production would occupy 20% of French farmland by 2020
- A target of 50% reduction in pesticide use by 2018
- To improve environmental practices, a target of 50% farmland to achieve the national High Environmental Value standard by 2012
- Agricultural energy use to be benchmarked on 100,000 farms by 2012

The set of measures aimed at pesticide reduction over the next ten years became known as the *Ecophyto 2018* plan.[305] To reach the ambitious target of halving pesticide use first required a means of measuring the intensity of pesticide application, using the Number of Dose Units indicator (NODU in its French acronym), specific to each active ingredient (Box 9.1). The scope of *Ecophyto 2018* extends beyond agriculture into the management of parks and gardens too.

305 Ecophyto 2018: pour le bénéfice des agriculteurs, au profit des consommateurs. Press pack, Ministry of Agriculture, 2011 (in French). http://agriculture.gouv.fr/telecharger/42544

BOX 9.1: NODU

NODU (NOmbre de Doses Unités/number of dosage units)[306] is a figure based on annual sales data supplied by pesticide distributors to the French National Office for Water & Aquatic Spaces (ONEMA). By correlating the dosage units and, in the case of an agricultural NODU calculation, the usable agricultural area, it is possible to estimate an average number of treatments per hectare. There are different NODU segments, reflecting the land use for which the products concerned were sold.

The data is collected by ONEMA as the basis for calculating a tax on low-level water pollution, instituted to implement a 2006 French law on water pollution. Based on the principle that *"the polluter pays"*, this tax funds part of the *Ecophyto 2018* programme and water quality work.

When the first government measure to implement the 'Grenelle' policies was passed in 2009, it contained detailed commitments to schedule future legislation. Those most relevant to agrochemical use included:

- *Water:* a commitment to define action plans to protect the 500 most-threatened water sources, incorporating solutions for crop treatment residues and agricultural runoff; preferential water priority for organic agriculture and other low-input systems.
- *Organic agriculture:* a commitment to treble organic farmland to 6% of national farmed area by 2012 and to reach a target of 20% by 2020 and to promote sustainable farming techniques.
- *Pesticides:* to withdraw 40 of the *"most worrying"* products by 2010; a ban on crop-spraying aircraft except under derogation; to base an emergency plan for bees on an independent toxicological evaluation; to ease market access for harmless natural preparations, such as nettle extract.
- *Environmental research:* a commitment to give priority to national research into biodiversity and ecosystems, as well as the integration of ecotoxicology into existing research frameworks.
- *Risk, health and environment:* a commitment to integrate an environmental axis into future health policymaking.

Farm minister Michael Barnier announced the first tranche of 30 active ingredient withdrawals under the Ecophyto pesticide reduction plan in January 2008, with a further 23 to follow.

France's pesticide reduction plan in practice: achievements and challenges, 2008-2011

Reducing pesticide use was not a new topic on the research agenda in France. The national agronomy institute INRA had been running successful trials with a group of farmers in Picardy, northern France, since 2004. In 2010, the financial newspaper *Les Echos*[307] ran a feature entitled "Cultivate better while earning as much", telling the stories of eight farmers' progress with reduced pesticide use. After six growing seasons, all but two of the farmers in the original group had converted to IPM, encouraged by being members of a group with the same objectives and covered by crop insurance in case of crop failure. The eight farms had successfully reduced pesticide use by 30

306 A note on the methodology used to calculate NODU (in French) can be found at http://agriculture.gouv.fr/Notes-methodologiques-Le-NODU with links to worked examples. Further detail on the sales data collection procedure can be downloaded (in French) from http://agriculture.gouv.fr/IMG/pdf/La_BNV-d_cle8978db.pdf

307 Les Echos, March 3, 2010, page 12 ISSN 0153-4831.

percent during the years under observation and had noticed other benefits as a result. These were as simple as reduced energy costs from cutting down the number of spraying trips, as well as freeing up more time in the farming calendar.

By October 2010, there were nearly 200 demonstration farms in 14 regions running pilot pesticide reduction schemes, referred to as DEPHY[308]. The reduction plan included a medium-term aim to reach 2,000 DEPHYs by the end of 2011. More than 17,000 professional users had undergone training in compliance and best practice, and gained a working knowledge of IPM. In terms of results, between 2008 and 2010 there had been *"...a marked decline in the sales of problematic substances for the environment or human health: a drop of 87% for carcinogens and substances that cause mutations and others toxic to the reproductive system."*[309] No fewer than 1,500 products were taken off the French market. Yet the results also showed that the NODU index value rose by 2.6 percent over the two years.

One of the serious challenges to reducing the intensity of pesticide use has been the idiosyncratic products approvals system in France for formulated products. French legislation is more demanding than elsewhere in Europe, insisting on proprietary products rather than allowing the use of cheaper generic equivalents. In parts of France this has led to very significant cross-border trading of generic products. The situation is further complicated by the taxation of pesticides. Since the French Ministry of Finance taxes manufacturers on the basis of domestic sales, both the use and taxation of imported generic products are beyond the administrative reach of the French government. While selling non-approved, trafficked products from across national borders is tantamount to aggravated tax fraud under French law, state resources for monitoring and enforcement have

French farming

not been available to bring enough successful prosecutions to deter illegal trading of products unauthorized for French users.

Spraying is a sensitive subject among French farmers, particularly in relation to taxation and the level of national restrictions, compared to farmers elsewhere in Europe. Despite the occupational hazards of applying pesticides, many rank and file farmers do not oppose pesticides on principle. For the conventional farming union Co-ordination Rurale, the problem in 2010 was that French farmers were paying more than their European neighbours. Co-ordination Rurale argued that *"The state should simplify and reduce the cost of authorisations to put generic crop treatments and pharmaceutical products on the market so as to maintain healthy competition and allow farmers to benefit from cheaper crop protection (2% generic products in France against 30-50% for our neighbours)."*[310]

2014: A new focus and a law for agroecology as the future for farming

In recent years, the financial collapse of some high profile French agribusiness companies, along with academic and policy critiques of the high input

308 This acronym sounds like the French word *"défi"* or 'challenge', while suggesting the reduction in what the French call 'phytosanitary' products.

309 Ecophyto 2018 press pack, download link: http://agriculture.gouv.fr/IMG/pdf/DP-Ecophyto_251011-4.pdf

310 CR infos no. 187, February 2010. ISSN 1168-7711.

production model and increasing citizen concerns about pesticide exposure and the industrialization of farming, have provided a compelling argument for changing an outdated and dysfunctional set of agricultural policy objectives. In particular, people and politicians are now questioning the received wisdom that large, specialist agribusiness enterprises are better and stronger than smaller, diversified land-holdings. Under a new government since 2012, France's 2014 *Law for the Future of Agriculture, Food and the Forest* is a bold strategy in challenging times. With the catchline *"produisons autrement"* (let us produce in other ways), the law looks to agroecology for solutions to current problems.[311] In 2014, the French state employed over 200 new researchers and tutors to teach agroecology across the country as a core part of the national agricultural educational programme. There is a pressing need to train a new generation of farmers who can take on the nation's farms and to create more jobs in the sector.

The new law includes promoting crop diversity and biodiversity as guiding principles. Being careful not to define agroecology too closely, it is being promoted through education and research. In addition, it encourages economic and environmental stakeholders to join forces and manage resources at a landscape level in cross-sector groups (GIEES by their French acronym). The law also makes a fundamental change in land policy, protecting farmland from competing land uses and making it easier for young farmers to get started.

To explain to the farming and wider community what agroecological practices are all about the French Ministry of Agriculture has published a booklet entitled '10 keys to understanding agroecology: let's start producing in a different way'.[312]

These are:

- *Education:* train the farmers of today and tomorrow
- *Stakeholder involvement:* encourage collective dynamics and develop GIEEs
- *Crops*: reduce the use of pesticides
- *Biological control:* preferring natural methods to protect crops
- *Livestock farming:* reduce the use of veterinary antibiotics
- *Bees:* engage in developing sustainable beekeeping
- *Methanization:* putting livestock farm effluent to good use
- *Organic:* promote organic farming
- *Seeds:* choose and select locally-adapted seed stock
- *Agroforestry:* use trees to improve production

Unlike some agricultural policies, the 'agroecology' law takes public expectations of agriculture into account, for example, requiring a degree of public accountability for spraying. It aims to protect vulnerable members of the population from pesticide exposure, notably the young, the old and the sick. It will require hedges around fields to catch spray drift and users will be required to post warnings of imminent applications in public buildings, such as schools, nurseries, retirement homes and clinics. Providing such warnings are logged – and there is no reason why they should not be kept on record – there will be the opportunity to establish a publicly accessible audit trail to help epidemiologists in the event of public health incidents. Whether this will be well received by farmers remains to be seen.

311 Ministry of Agriculture, Food & Forests, 2014. Website in English about agroecology and the new law: http://agriculture.gouv.fr/changing-production-models-to-combine-economic-and-environmental-performance

312 Ten keys to understanding agroecology. Ministry of Agriculture, Food & Forests, 2014. English guide to the 'Loi d'Avenir" at http://formulaires.agriculture.gouv.fr/IMG/pdf/plaqPA-anglais_vf_cle01abac.pdf

Evaluating the strengths and weaknesses of the pesticide reduction plan

In 2014, the Ministry of Agriculture also commissioned an independent assessment of the strengths and failings of the national pesticide reduction plan, Ecophyto, in its six years of operation, headed by a member of the French parliament, Dominique Potier. Quizzed about the positive and negative aspects of the Ecophyto programme, stakeholders consulted commended the solid policymaking toolbox, such as the DEPHY farms network; the Certiphyto user training, crop health bulletins and the EcophytoPIC internet portal for integrated crop protection. A regional plant epidemiological surveillance network now has 4,000 observers monitoring crops to produce regular plant health bulletins, freely available to download, helping farmers to fine-tune pesticide dosage.

For all these achievements, however, Ecophyto is perceived as a heavy framework generated by the 'Grenelle' process, which has managed to keep the French rate of growth in agricultural pesticide use below that of its European neighbours. The NODU index rose by 2.7 percent between 2009 and 2011, with policy makers looking for a reversal in the trend with the 2012 dataset when it is published. When the revised NODU index was published in May 2015,[313] the index stood at 5 percent, with a correspondingly steeper gradient on the graph.

Stakeholders agreed that publicly-supported pilot projects should be rolled out to reach a larger number of farms and other pesticide users and were unanimous that it was time to engage with people outside the inner circle of converts. There was also support for three policy suggestions made by the minister in 2012: the first was to promote the idea that a win for the environment was also a win for economic performance and business efficiency; the second was a tightening of post-

French vineyards are big users of pesticides

approval monitoring of pesticide products; and the third was agreement to crack down on fraud and trafficked pesticides.

In his conclusions from the evaluation,[314] Potier observes that leading exponents of sustainable agriculture have maintained their bottom line through better management of inputs and precision agriculture, as well as cutting their use of crop treatments by the 25 percent envisaged in the first stage of the Ecophyto plan. The next stage, the move from a 25 percent reduction to a 50 percent reduction is based on a more enlightened view of the nature of agricultural competitiveness.

"To be authentic, this should take into account a whole set of expectations: protection of common goods, generating new jobs, remuneration and quality of life for those at work, the costs and gains generated for society today and tomorrow. This approach justifies a balanced share of public funding, the rejection of an undue influence over the means of production being held by a minority and fairness in trade. Without these elements, even the notion of competitiveness itself could be a mistake."

He cites an example of alfalfa in Lorraine, which disappeared from mixed holdings in 1992 when CAP funding was decoupled from production and gave way to oilseed rape, mainly for biofuels.

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313 http://indicateurs-biodiversite.naturefrance.fr/indicateurs/evolution-de-la-consommation-de-produits-phytosanitaires

314 Pesticides et agro-écologie. Les Champs du Possible. http://agriculture.gouv.fr/rapport-pesticides-Potier

Rolling farmland, France

"It is impossible to determine the competitiveness of either crop without deciding on the nature of the indicators: the risk to water supplies, vegetable protein self-sufficiency or the carbon footprint."

Potier is adamant that true competitiveness is also realistic:

"It is not forgetful of environmental externalities and the social aspects of enterprise nor the human ambition that goes with it."

The parliamentarian and organic farmer stresses that there can be no "local" solution to pesticide use without a wider, global agroecological framework to support this. The vision that Potier shares is part of a series of wider, agroecological approaches that are generated by farmers of all descriptions.

The Ecophyto plan continues to evolve. The latest version, announced in June 2015, promotes a transition to alternative forms of pest control for amateur gardeners, aiming to move away from herbicide use in particular.[315] From January 2018, consumers will only be able to buy pesticides from certified sellers, who will be expected to offer advice on integrated pest control alternatives. Work on this will start with the retailers concerned in 2016, who must now explain to consumers which products are due to be withdrawn from the market. In 2013, the ministry re-evaluated the risks to amateur gardeners of authorized glyphosate products, after which a number of products were withdrawn. Ecophyto might have started out with an agricultural focus, but is now finding a wider application with householders. As with any pesticide policy, Ecophyto demonstrates that everyone is concerned, but that more people need to be involved.

Pioneers of agroecology in France

In 2013, the agriculture minister sent out a call for farmers to bid for funds for projects involving 'collective mobilization for agroecology'. From 469 applications received, 103 projects were chosen in 2014 to share project support over 6 million Euros, enabling 3,300 farms and land-holdings across France to spend two to three years trying out new processes that promote agroecology and to ensure greater awareness of agroecological principles. The farmers behind these projects are supported by local chambers of agriculture, co-operatives, centres for value-added initiatives in rural areas, groups of organic farmers, rural employment and development agencies and others assisting collectives of farmers.

So who and where are these ground-breaking

315 http://agriculture.gouv.fr/IMG/pdf/150611_CP_protection-phytos_cle09ac2d.pdf

pioneer farmers? The agricultural ministry has a map on its website[316] which shows all the regions of metropolitan France and its overseas territories.

For example, a group of 21 cereal farmers in the Centre region are making a decisive move to diversify their holdings by planting organic walnut trees on buffer strips bordering water courses or near habitation. This three-year, landscape level project is being assisted by a regional fresh fruit and vegetable producer organization and the Loir-et-Cher chamber of agriculture and local government. Also in the Centre region, a 20-strong group of mixed cereal and livestock farmers are working to restore an alfalfa crop into their rotations, which would provide local forage for their herds of goats. As well as the economic arguments for home-grown forage, this strategic change secures the farmers' position with regard to the technical manual when supplying creameries making the protected appellation Chavignol AOP goat cheese. In the Bourgogne region, 15 cereal farmers working land in the catchment area for Auxerre are researching the impact of sowing directly into grass cover in a bid to cut nitrate run-off into the water table.

In the Languedoc et Roussillon region, in the deep south of France, an 18-month project is supporting an association of 15 Minervois wine producers, planning to diversify their production with traditional varieties of fresh produce for local consumption and improve their soils in the process. *"The aim for our group is to develop agroecology from a coherent and autonomous point of view,"* explains project leader Nathalie Ramos. *"For us, agroecology is not just about being organic or withdrawing pesticides, but having more sustainable and diversified practices, built around a system of self-help."*

Agroecological experimentation with farmers is underway in the French overseas island territories too. For example, the volcanic island of La Réunion in the Indian Ocean is home to a fruit and vegetable growers' co-operative, la Vivéa. Comprising 120 growers whose crops are grown under glass, they are investigating the use of insect predators to target pest species.

Conclusions

The 'agroecology' law and its policies have both supporters and opponents. Some environmental NGOs and farmer groups representing small family farms have been supportive of agroecology for many years. They fear the measures may be too little and too late to meet the challenges of detoxifying the French countryside and saving the nation's remaining family farms from being pushed aside by industrial-sized intensive farms. Sceptics wonder if the new policies will undermine French agricultural competitiveness or food security, but often overlook more fundamental structural flaws in existing systems.

Samuel Féret of the Groupe de Bruges agroecology think-tank co-ordinates the Agricultural and Rural Convention (ARC2020), an EU-level platform for NGOs that want to see more food that is local, organic and fair across Europe. In February 2015, he told the 'Nourish Scotland' conference in Edinburgh that the 'agroecology' law was anything but a revolutionary concept.

"Rather, it is a consensual but necessary approach to mobilise and bring together farmers' networks, agricultural colleges and research institutes with shared agroecological approaches. This will mean working together to build better farming systems. In France, we might think that the law doesn't go far enough, that it should be more prescriptive in what it means by agroecology and that it should be more innovative in proposing territorial frameworks for negotiating reductions in pesticide use. But when you stand back and look at the law in a European landscape, it is rare to find other countries which define agroecology as the French

316 http://agriculture.gouv.fr/la-carte-de-france-des-projets-retenus-pour-lappel-projets-casdar-mobilisation-collective-pour-lagro

law does… Its real value is in insisting on support for forms of agroecology around the notion of a group of farmers, acting as a pivotal force for change through economic and environmental interest groups."

9.2 France: Agroecology in a joint farming enterprise

extracted from: Le Foll S.[317] 2014. France: support for family farming – quality rooted in territory. In: FAO. 2014. Deep Roots

With 270 hectares of land in the Chantonnay commune of Vendée, the agricultural group for joint farming, GAEC Ursula[318] is a model of agroecology, the fruit of an ecological process initiated in the 1980s.

"The GAEC was founded in 1983 by my parents, Jacques and Pierrette Morineau, and two other partners," recalled Marie Schwab. Today, Jacques Morineau is still part of the venture, while three younger farmers have replaced the original members. *"Sylvain was installed in 2009 and Sébastien, my husband, installed in 2011, and I replaced my mother in 2013,"* said Marie.

"In the 1980s we had an ecological approach," said Jacques Morineau: "In 1988/89, the weather was very bad and we found that the inputs did not help. What makes the performance is the sun and rain. We were then tempted by organic farming and we started with poultry." The hen house was a success, with 400 square metres devoted to housing hundreds of organic chickens. The entire farm went organic in the 2000s, and it is now considered a model of French agroecology.

All plots are cultivated with varieties of cereals and grassland. "We have 100 hectares of cereals (bread wheat, peas, faba beans, lupins, barley) which is sold directly to farmers," said Marie. "Everything is grown in mixtures, so whatever the weather, there is always a species that is doing well."

To preserve biodiversity, the plots are no bigger than 6 hectares and are all surrounded by hedges. "My father balances areas of cultivation to support wildlife such as ladybirds and beetles," said Marie. "We reproduce what happens in nature, but on the scale of agricultural production."

The GAEC Ursula also raises 100 dairy cows fed on grass, and manufactures organic rapeseed and sunflower – a well-oiled and efficient system on an economic as well as a social ecological level.

9.3 Europe: Cereal and legume intercropping

By Prof., DSc. Erik Steen Jensen, Swedish University of Agricultural Sciences, with Dr Stephanie Williamson, PAN UK

Introduction

Intercropping, including the use of leguminous plants, is a centuries-old practice and still widespread in much of the tropics. The traditional combination of maize grown with beans in Latin America is a well known example (see Traditional farming in Chapter 2.2), with soil fertility benefits from the nitrogen-fixing legumes and the increased and more diverse crop foliage architectures contributing to a more favourable microclimate, reduced levels of pests, weeds and diseases and higher overall productivity per area cultivated than under pure stand crops. Intercropping used to be common in temperate zone Europe until the post-war period, when farmers started to replace

317 Minster of Agriculture, France.

318 GAEC, which stands for Le Groupement Agricole d'Expoitation en Commun, is a civil society organization grouping family farmers together to work jointly and, in some cases, to sell jointly their produce. They were set up by an Act of Parliament in 1962, and by 2009 there were 38,000 GAECs in France. For more information see: http://agriculture.gouv.fr/les-groupements-agricoles-dexploitation-en-commun-gaec

Intercropped organic lentils and oats. *Erik Jensen*

legume rotations with synthetic fertilizers as their main source of nitrogen for crop nutrition. More recently, attention is returning to the practice of intercropping cereals with grain legumes (peas or beans), particularly in the context of organic farming. Researchers have been exploring how combinations of selected cereals and legumes can help organic systems to generate the crop yield and nutrition and protection functions that conventional farmers derive from use of agrochemical inputs.[319]

This case study summarizes the key findings from more than a decade of research in arable systems across different Western European countries and how this understanding could be applied not only in organic farms but in other systems aiming to reduce external inputs. It serves as a good example of two important agroecological principles:

- Increasing cropping diversity to help reduce unwanted effects (levels of weeds, pests and diseases) often found in pure stand crops or monocultures
- Enhancing positive interactions between species to achieve desired effects, such as better uptake of water and soil nutrients or optimizing use of sunlight

The research covered a range of both winter and spring-sown crops and combinations, including spring barley with spring pea; spring barley with spring faba bean; soft wheat (for bread-making) with winter pea; soft wheat with spring faba bean; durum wheat (for pasta) with winter pea; and durum wheat with winter faba bean. Season long or multi-year collaborative trials were conducted by several universities and research institutes in Denmark, France, UK, Germany and Italy across a range of growing conditions and farming practices.

The ecological principles behind cereal/legume intercropping and its benefits

The mechanisms behind the generally enhanced yield are based on the fact that competition for

319 Sources used to compile this case: (i) Bedoussac L, Journet E-P, Hauggaard-Nielsen H, Naudin C, Corre-Hellou G, Prieur L, Jensen ES, Justes E. 2014. Eco-functional intensification by cereal-grain legume intercropping in organic farming systems for increased yields, reduced weeds and improved grain protein concentration. In: Bellon S, Penvern S (eds). 2014. *Organic Farming, Prototype for Sustainable Agricultures.* Springer Science, Chap. 3, pp.47-63. (ii) Corre-Hellou G, Dibet A, Hauggaard-Nielsen H, Crozat Y, Gooding M, Ambus P, Dahlmann C, voan Fragstein P, Pristieri A, Monti M, Jensen ES. 2011. The competitive ability of pea-barley intercrops against weeds and the interactions with crop productivity and soil N availability. *Field Crops Res* 122:264-72. (iii) Hauggaard-Nielsen H, Jørnsgaard B, Kinane J, Jensen ES. 2008. Grain legume-cereal intercropping: the practical application of diversity, competition and facilitation in arable and organic cropping systems. *Renew Agric Food Sys* 23(1):3-12. (iv) Jensen ES, Bedoussac L, Carlsson C, Journet E-P, Justes E, Hauggaard-Nielsen H. 2015. Enhancing yields in organic crop production by eco-functional intensification. *Sustain Agric Res* (4):38-46. (v) http://www.ccsenet.org/journal/index.php/sar/article/view/50099/26955 (vi) LEGATO LEGumes for the Agriculture of TOmorrow project. http://www.legato-fp7.eu/

plant resources is often less between species, as compared to within species, resulting in increased or more effective use of available resources than the equivalent single crops alone. Crop health of intercrops is related to within-crop diversity.

Enhanced crop nutrition for increased yields and cereal protein quality

Since organic farmers aim to increase recycling and enhance the use of ecosystem services, synthetic fertilizers are not used. Consequently, organic farms need to find other ways to provide adequate nitrogen to nutrient-hungry cereal crops, especially if they have limited access to sources of animal manure. Although many organic farms in Europe make use of legumes in their crop rotations to boost nitrogen availability, arable crops still tend to be grown as single (i.e. monoculture) crops within any one year on an individual field. Intercropping cereals with legumes involves growing two or more plant species at the same time in the same field for a significant part of the season (although not necessarily sowing or harvesting the crops at the same time). This practice of diversification increases ecosystem services from the cropping system, reduces the needs for inputs, and can enhance yields in organic systems.

Cereals have a high demand for nitrogen inputs, if they are to yield profitably and produce good quality grain. Achieving these levels of nitrogen demand can be difficult in organic systems. A wide range of studies show that intercropping delivers increased total yields (cereal grain + legume grain) compared with the totals of the crops grown singly on the same area of land. In Danish and French studies, the total grain yield averaged 3.3 t/ha, compared with 2.7 t/ha of the pure stand crops. In most trials (64 percent) total yields of the intercrop components were higher than yields of the cereal crop alone; and in 83 percent of trials, they were considerably higher than the pure stand crop legume yield. Generally, the cereal is the higher yielding of the two crops when grown together, as it competes better for nutrients, water and light.

A further benefit is the increased protein concentration in the cereal grains under intercropping systems, especially in situations where the cereal protein content is low when grown in organic pure stand crops. Achieving adequate levels of protein concentration in cereals is important for farmers to meet the requirements of the flour and food processing sectors and obtain good prices for high quality grain.

One of the factors behind the increased yields under intercropping is that the combined crops not only make a better use of resources available than if grown alone, but they also use these resources in complementary ways. Cereals are generally deeper-rooting than legumes and grow more quickly in the early season, making them more competitive for existing nitrogen sources in the soil. When grown together, the legume crop is therefore forced to rely more on nitrogen fixation from the air via its root nodules – by around 10-15 percent compared with when grown as a pure stand crop. This may enable the combined system to access more nitrogen and in different forms than in monoculture, helping increase the legume yields and possibly better fitting nitrogen availability to the cereal crop's requirements to deliver high protein content in the grain.

Reduced competition from weeds

Intercrops, in theory, can help reduce weed levels, if the combined crops can out-compete the weeds for essential resources, mainly nutrients and light. By making better use of resources, both above ground (light) and below (soil nutrients, water) the intercrops can leave less opportunity for weeds to establish and grow. This benefit is particularly important for legumes grown, which tend to be poor competitors with weeds when grown organically and as pure stand crops. It seems that intercrops evaluated can make better and complementary use of soil nitrogen and atmospheric nitrogen via the legume fixation and capture more of the light energy with their differing canopies and growth habits, leading to weed suppression. In Danish studies, the weed biomass within the intercrop

Intercropped organic faba bean and wheat. *Erik Jensen*

was significantly lower (at around 0.4 t/ha) than the legume pure stand crops (1.38 t/ha). This weed suppression effect was observed even with low proportions of cereal (20 percent) in the intercrop mixture. Experiments across a range of countries found that, on average, 90 percent of the soil nitrogen available was taken up by the intercrops, and only 10 percent used by weeds, while in pea single crops, at least 30 percent of the nitrogen was available for the weeds. The intercropping strategy has been demonstrated to be very relevant for organic systems, in which farmers often struggle to achieve good yields because of weed competition, which they cannot combat with herbicides.

Danish studies on pea-barley intercrops showed also that peas grown on their own are more likely to suffer high weed levels late in the season, compared with the intercrop. Greater weed growth at the end of the season can translate into increased weed problems for the following crop, thus intercropping may also generate benefits for more than one season by reducing weed levels longer term.

In general, intercrops suffered lower levels of weeds than pure stand crops, indicating more resilient crops better able to respond to growing conditions. This can be a useful management tool in situations with a high quantity and diversity of weeds, as is typical in organic farms. The positive effect can also be useful for weed management in non-organic systems aiming to reduce reliance on herbicides.

Reduced disease incidence

In three-year trials in Denmark, of intercropping barley with peas, faba beans or lupins, less disease was observed in all the intercrops, compared with pure stand cropping, averaging a reduction of around 20-40 percent. For brown spot disease in lupin, disease reduction was almost 80 percent in the intercropped fields. Disease reduction may be related to the enhanced plant health from better nitrogen provision in the intercrops, and reduced dispersal of disease spores within the crop due to the within crop diversity.

More robust legume crops

Peas grown as pure stand crops are often prone to lodging (falling to the ground), with subsequent risk of damage and/or difficulties in harvesting mechanically. Growing them with a cereal reduces this risk, as the cereal stalks act as physical supports for the legumes, enhancing their resilience to wind and rain.

Stability over time

Danish studies suggested that intercropping legumes with barley may not always yield better than either of the pure stand crops in a given year but the strategy can act as insurance against the complex biological and weather stresses on crop performance. The beneficial interactions between the crop components can compensate to some extent for soil nutrient limitations, or pest and disease attack, and reduce the annual variability in yields. Peas and beans have a reputation for low yield and low yield-stability in organic rotations so intercropping with cereals, while delivering intermediate net income in some years, may provide a better income safeguard overall than solely growing legumes.

Harvesting, processing and marketing issues

For farmers to take advantage of the benefits from intercropping requires thinking beyond the farm-gate. Some farmers who have planted intercrops have been left with no viable market option other than selling the mixture for animal feed. While it is relatively easy to harvest mixed cereal-legume crops with a combine harvester, if they ripen at similar times, the challenge lies in persuading grain traders to buy mixed grains. Correct sorting of the different grains for use as human food is essential and traders will need to be able to do this efficiently, quickly and cheaply, and to handle large volumes.

A few Danish traders in the organic sector are now buying mixed grains, especially where these have less pest or disease damage and are therefore very suitable for the organic seed market. They may charge a separation and cleaning fee to the farmer but the premium paid for seed makes this worthwhile for the grower. Work in France shows that it is possible to achieve good grain separation if the two crops differ sufficiently in size and/or shape and the mixture does not contain many broken grains. Choice of machinery and correct adjustment of settings at harvesting, sorting and storage stages and in careful selection of appropriate crops and varieties are all factors to be considered when designing effective intercropping strategies. Most current varieties are probably not the best suited for intercropping and selecting better varieties would help.

Intercropping futures

Intercropping strategies are ways to manipulate plant interactions in time and space to maximize growth of the desired crops. By increasing nitrogen inputs by fixing atmospheric nitrogen, intercrops with legumes can help reduce the need for and levels of synthetic fertilizer and associated problems of nitrate run-off and release of greenhouse gases. The weed suppression function would be valuable in systems aiming to reduce use of herbicide HHPs,

Intercropped organic wheat and faba bean. *Erik Jensen*

while some reduction in fungicides and possibly insecticides might be feasible, depending on the farm context, pest and disease pressure and intercrop composition. Furthermore, legume crops in flower are generally highly attractive to bees and other pollinators, whereas cereals are not, being mainly wind-pollinated. With reduced reliance on synthetic fertilizers, cereal-legume intercropping can also help reduce use of fossil fuels needed in the energy-intensive manufacture of fertilizers.

An important finding from the last decade is that the yield advantage of the intercrop tends to be greater in situations where both single crops yield poorly and when soil mineral nitrogen is limited, suggesting that the intercropping can deliver the highest benefits under conditions of poor soils or other environmental stresses. This may be a very useful feature to exploit for farmers dealing with the impacts of climate change.

To encourage more farmers to make use of cereal-legume intercropping, further research is needed to develop more detailed guidance for farmers on which intercropping combinations in time and space are likely to deliver most benefits in their particular situations. It is hard to produce generic crop protocols to cover the huge variation in crop species, fertilization and weeding regimes, soil conditions and agronomic practices. Involving all the grain supply chain actors is essential, especially traders and processors and final buyers, as the technical requirements for the different

grains and the price differentials between crops will all influence the economic returns to farmers.

Swedish researchers are now working to understand better the current barriers to uptake of faba bean and lentil intercropping with cereals in organic systems, and conducting participatory research with farmers to develop organic intercropping system for these crops. In Sweden the approach is to involve grain traders and other stakeholders in a dialogue about steps needed in supply chains to promote more intercropping. There is plenty of machinery available for sorting if required but innovation processes are slow and the 'lock-in' effect to existing systems and processes can be hard to overcome.

At European level, new collaboration has started under the EU's LEGATO project – "LEGumes for the Agriculture of TOmorrow" – running from 2014 to 2017, with the aim of contributing to the increased sustainable reintroduction of grain legumes in European cropping systems. LEGATO aims to answer two key questions on the future of the European legume sector: what potential do European-produced legumes for food have to supply our protein needs? And how can their consumption be promoted? The project has 29 partners from eleven countries, including research centres, producer associations and small and medium enterprises handling legume and cereal crops. Partners are identifying priority issues currently limiting grain legume cultivation and devising solutions in terms of new variety development, cultivational practices, and food uses. Working on the major European grain legumes – pea, faba bean, and also white lupin and grass pea – LEGATO will identify and test new legume breeding lines possessing valuable characters such as disease and pest resistance and quality for human consumption. The selection of these lines will also be optimized for low-input agriculture and in innovative cropping systems that make the best use of the ecosystem services afforded by grain legumes. Researchers are working with stakeholders to undertake multi-criteria sustainability analysis of legume-cereal intercropping systems and to link with consumer organizations interested in the nutritional benefits of eating more legumes.

In conclusion, legume intercropping with cereals could provide a set of useful ecosystem services that help address several of the undesirable environmental and energy trade-offs in current conventional cereal pure stand and monocultures, which rely on high inputs of agrochemicals. The enhanced implementation of intercropping in organic and conventional agriculture will be stimulated by stronger investment in participatory research, involving farmers, advisors and more actors in the food system.

9.4 USA: M&M Heath Farms, South Idaho

Mike and Marie Heath grow 182 hectares of certified organic produce for a variety of markets. After initially growing eight hectares of organic potatoes and then finding they had no market for them, the Heaths expanded their organic production slowly, beginning with alfalfa and potatoes, and adding a variety of organic vegetables and grains and livestock.[320]

They own 7.3 hectares west of Buhl, Idaho, and lease the rest. The Heaths have farmed most of the land for 15-20 years, on a share-crop basis, dividing the income and the costs of production and labour with the owners of the land. The landlord pays 100 percent of the taxes and water, Mike Heath takes care of the irrigation and tractor labour, and they divide the packing supplies, harvest labour, mechanical costs and profits. At the end of the

320 This section is extracted from: DePhelps C, Williams C, Filtz J, Potter J, Faunce K. 2005. Mid-Size Producer: Capturing Local Value: M&M Health Farms. Farmer Case Study No. 04. Rural Roots and University of Idaho. http://www.extension.org/pages/18364/organic-vegetable-production:-farm-case-studies-systems-descriptions-and-farmer-interviews#outsideus

year, the farmers square up with each other – all on each other's word and a handshake.

They sell their produce through a variety of outlets because they believe that diversification of markets is an important business strategy, including to local processors, retail stores, farmers markets and Community Supported Agriculture subscription services.[321] They get premium prices for selling direct and locally, and are helping to develop and maintain a local food supply. Mike Heath says "I think it's silly to be putting 1500 miles on food. When I was overseas, (I saw) how vulnerable this nation is when it comes to food security. We are so totally dependent on diesel to feed 98 percent of the population. … I would like to at least let people around here (eat locally.)"

Crops

M&M Heath Farms grow three major crops: potatoes, beans and squash. They also grow alfalfa, grains such as wheat and barley, and fresh market crops including lettuces, tomatoes, summer squash, green beans, peas, and sunflowers. A number of vegetable crops, especially tomatoes, are grown in a 'hoop house', from seedlings raised by a local greenhouse. But it is the organic potato crop that M&M Heath Farms are particularly known for: in 2002, they raised over 20 hectares of at least six different varieties of potatoes.

A lot of labour goes into the potato production. They hand weed the fields once a year. Half of the potatoes go straight to processing facilities, which only require that the rocks and dirt are sorted out, and the potatoes are washed and graded at the facility. The remaining half are cleaned and put in bags or boxes and stored in the farm's storage sheds. A number of employees are required to pick, wash, sort and bag or box the potatoes. To fill a truck with 10 tonnes of potatoes requires ten people to work for four hours. Potatoes dug for the processing facility are dug with a mechanical harvester, which reduces the number of labourers needed. Potatoes that are not immediately shipped, as well as other crops, such as wheat and winter squash, are kept in a storage unit.

Organic potatoes

Dry and seed beans account for the majority of overall sales by product type, at 40 percent; potatoes are the second largest sales crop, totalling 24 percent; squash account for 14 percent of total sales.

Crop Rotation

They use a seven year crop rotation: three years of the legume alfalfa (lucerne), one year of row crop, one year of grain, one year of row crop, one year of grain, then back to three years of alfalfa. The alfalfa, which is sold to local dairy farms, has the added benefits of weed control and building up soil fertility through its nitrogen-fixing ability.

[321] Community Supported Agriculture (CSA) is a locally-based food production and distribution system that directly connects farmers and consumers. Generally, people subscribe, or buy 'shares' of a farm's harvest in advance and then receive a portion of the crops as they're harvested, although there are other approaches which also involve consumers undertaking some of the farm work. This system originated in the USA, but derived for European ideas and the Japanese teiki model that began in the 1970s. It has spread far beyond the USA, to Africa, Asia, Australia, Canada, Europe, Latin America and New Zealand.

Soils

Soil amendment is an important part of their land management. They add three tons of compost in autumn to all fields, except the potato fields, which get five tons. They buy in compost, despite access to manure, because they find that the process of managing manure, and the weed growth that results from its use, makes compost the more attractive proposition. They use a liquid fish or compost tea application as a foliar feed during the growing season.

Livestock

In 2002, M&M Heath Farms kept 20 brood cows and calves as a shared enterprise with one of their partners. They also kept between 500 and 600 broiler hens and 60 laying hens. The cattle were pasture fed and given organic alfalfa hay. Some grass-fed cattle were sold directly to customers, who had them custom butchered. The rest, though they were certified organic, were sold as 'feeders' to a non-certified market for conventional raising and slaughter.

The farm provided 90 percent of the feed for the chickens, all of it organic. The other 10 percent is a non-organic protein mix from a local mill. In 2002, the broilers were pre-ordered and then sent to a state-inspected facility in Hazelton for slaughter. At the time, there was no US Department of Agriculture inspected facility available locally for processing. Small beef and poultry growers in the area are frustrated by the lack of inspected facilities.

Costs

Production costs were 46 percent of the overall expenses in 2002; payroll was the highest expense in this category, comprising 34 percent of production costs. Packaging accounted for 18 percent, and seed and shipping costs each comprised 11 percent. Operational expenses were 17 percent of the total budget. Payroll was also the biggest cost associated with operations, comprising 55 percent of costs in this category.

Careful financial record-keeping allows Mike Heath to plan for the seasonal fluctuations in farm liabilities. By diversifying their markets, they ensure a steady income year-round, avoiding the 'feast or famine' dynamic which often results from a seasonal occupation. Seventy-five percent of the food they eat comes from their own farm, which according to the US Department of Labor 2003 Consumer Expenditure Survey, equals approximately $2,300 worth of groceries for a two person household. This savings contributes to the farm's financial sustainability, and contributes to family health in many ways.

The strength of M&M Heath Farms resides in diversity of production, marketing avenues, and biological activity. It is one of the oldest organic farms in the state giving them a strong advantage and opportunities in the marketplace. The production methods have maintained the health and value of his land.

When asked what he perceives as the greatest opportunity for his farm, Mike Heath says, *"I'm a firm believer in local food systems.... People are starting to ask questions about conventional agriculture (and) I think that the organic market is here to stay."*

9.5 USA: Alvarez Farms, Washington

Don Hilario Alvarez, originally from the coastal region of the Mexican state of Michoacán, immigrated in the early 1970s, first to southern California, and then to eastern Washington, where he worked for seven years on a farm in Wapato.[322]

[322] This section is exteraced from: DePhelps C, Williams C, Foltz J, Potter J, Selde C, Faunce K. 2005. Sowing the Seeds for a Better Future: Alvarez Farms. Farm case Study No 12. Rural Roots and University of Idaho. http://www.extension.org/pages/18364/organic-vegetable-production:-farm-case-studies-systems-descriptions-and-farmer-interviews#outsideus

Box 9.2: Types and Varieties of Crops

Asparagus	Garlic	Potatoes (15)
Basil	Green beans	Radishes
Beans	Lettuce	Spinach
Beets	Melons	Squash
Cabbage	Okra	Sweet corn
Cucumbers	Onions	Tomatillos
Eggplant (20)	Peanuts	Tomatoes (50)
Faba beans	Peas	Zucchini (13)
Garbanzos	Peppers (100)	

In all, Alvarez Farms produces 200 varieties of vegetables and fruits, and constantly experiments with new varieties.

Now he and his family own 49 hectares and one of the largest organic vegetable farms in eastern Washington, in the upper Yakima valley, an area described as *"some of the most intensively managed agricultural ground in the nation"* with rich volcanic soil, relatively moderate climate and abundant irrigation. Don Hilario decided to farm without chemicals after seeing a program on television about the effects of pesticides on farm workers.

In 2005, the Alvarez Farm was producing over 200 varieties of organic vegetables and fruits, including 100 varieties of peppers, 50 varieties of tomatoes, 20 types of eggplant, 15 varieties of potatoes, and 13 types of zucchini.

They get an early start to many of their crops in four greenhouses, and can harvest some crops (peas, garlic, potatoes, onions, green beans, cucumber, and sweet corn) twice per season. The greenhouses also enable the growing of okra and peanuts, not usually grown in the area because of their need for a longer growing season.

Keys to success

This wide diversity of crops has been one of the keys to success of the Alvarez Farm. Influenced by other farmers in the area, at first Don Hilario took only tomatoes and a few other vegetables to market, but was not able to sell enough to cover

Growing seedlings

the cost of transportation. On advice from a friend who suggested he sell many different kinds of vegetables, he started taking tomatoes, onions, garlic, peas, green beans, peppers, zucchini and potatoes to the market and selling the whole lot. Each year he tries out new varieties, and if they suit him and his customers, he adds them to his list of regulars.

The second key to success has been the decision to sell to farmers' markets rather than wholesale. Don Hilario's wife, Doña Soledad, and their older children take produce and manage stands at a number of farmers' markets. They also sell through Community Supported Agriculture programmes. Although this involves a lot of work,

Some tomato varieties

if they sold the produce wholesale, they would not cover the costs of production.

Their income is also increased by some value-added products: principally chili pepper wreaths and garlic braids. This has resulted in the chillies being by far the most profitable crop, providing two thirds of the farm's gross income.

But the most important factor in their success, according to Don Hilario, has been the whole family working together to attain their dream – from his father's and father-in-law's financial help, to his wife and children working season after season to plant, tend and harvest crops, and to take produce to markets.

Costs

Inability to access credit from banks when he was starting out and then, until recently, only being able to access it at high interest rates has not helped. Access to low-interest financing to get the crops in the ground each year, to get modern equipment and increase the acreage has made all the difference in the world.

Yet he still can give back to the community: produce that does not sell at the farmers' markets is given to food banks for those people who cannot afford to buy food. Then, just before the weather starts to freeze, the local community is invited in to pick what is left in the fields for themselves.

Hired labour costs accounts for over half of total operating costs; and fuel and machinery for another 26 percent. Because they eat fruit and vegetables produced on the farm, they save about US $2,871 per year on food expenses. No money is spent on pesticides, and manure is obtained free from local farms.

Benefits

In terms of the intangible benefits of their farming, Don Hilario said that he is grateful that he and his family have been able to work together on the land, and together they've been able to ensure the health, education and future well-being of their children and grandchildren. He knows families that see each other for only a few minutes each day, since the adults work long hours away from home. It also gives him great pleasure to be able to provide his customers with fresh, delicious vegetables that are organically grown, with no chemicals that can harm their health.

SECTION C: The Way Forward

Practicing rice-breeding techniques at the Masipag's trial farm in the Philippines. *PANAP*

10. National policy – next steps

"Most agricultural sustainability improvements seen in the 1990s and early 2000s have arisen despite existing national and institutional policies, rather than because of them."

Jules Pretty, University of Exeter, 2006, report for the World Bank, "Agroecological Approaches to Agricultural Development"

There is now global recognition that highly hazardous pesticides need to be phased out. Concern about them has been mounting for many years. The level of human health impacts, environmental contamination and impacts on non-target organisms, plus their associated social and economic costs are of such a magnitude that there is general agreement that something must be done. The FAO Council, in 2006, recommended a progressive ban on HHPs; and FAO and NGOs such as PAN have been working since then with some countries to assist this process. Numerous countries and organizations have recognised the problem and the widespread concern and, through the SAICM process, begun to formulate proposals for assisting the phase-out.

Hand weeding in rice grown by by the Sustainable Rice Intensification method, Cambodia. *CEDAC*

This book has argued that it is in the interests of farmers, communities, and countries as a whole to replace HHPs with ecosystem approaches to pest management, based on agroecological science. There is no point in replacing HHPs with other pesticides that are also going to harm people, kill pollinators vital to food production, or otherwise undermine the ecosystem services on which global food security depends. There is high-level support for turning away from so-called 'green revolution' technologies of intensive input farming, and turning towards agroecology as the direction that global agriculture needs now to take. Two UN Special Rapporteurs on the right to food, along with UNEP, UNCTAD, IAASTD, FAO and the Stockholm Convention have all indicated that priority should be given to ecosystem approaches to pest management, with most of those identifying agroecology specifically as the most sustainable form of agriculture that is resilient to climate change and at the same time capable of providing food security for all (see Chapter 2).

Evidence has been presented in this book that agroecology can:

- √ Yield the same or better than conventional high input-based agriculture
- √ Cost less
- √ Return greater profits to farmers and communities
- √ Empower women and communities

√ Improve farmers' health
√ Improve food security and nutrition
√ Improve biodiversity and the environment
√ Reduce climate change emissions
√ Improve climate change resilience

An explanation of agroecology has been provided, backed up by case studies that demonstrate how effectively it is being practiced in various parts of the world.

The economic benefits of agroecology spread far beyond the farm. UN Special Rapporteur Olivier de Schutter told the UN that, by improving the livelihoods of smallholders, agroecology can:[323]

√ Slow the trend towards urbanisation which places stress on public services of these countries
√ Contribute to rural development
√ Preserve the ability for the succeeding generation to meet its own needs
√ Contribute to the growth of other sectors of the economy by stimulating demand for non-agricultural products that would result from higher incomes in rural areas

The multifunctional benefits of agroecology have been well established by ample scientific and practical field-based evidence from all regions of the world. What remains now is for governments to take action to assist the implementation of agroecology in their countries. Because agroecology is grounded in ecology, which does not recognise human-made boundaries, the approach is best applied collectively across a number of farms, at a whole village or even regional level. Neither pests nor natural enemies respect borders, and pesticides that kill natural enemies on one farm, undermine the agroecological balance on its neighbours. Agroecology at the landscape level increases economic efficiency and enhances resilience to climate change.

"Agroecology is a coherent concept for designing future farming systems as it is strongly rooted both in science and in practice, and because it shows strong connections with the principles of the right to adequate food."

Olivier de Schutter, UN Special Rapporteur on the right to food, 2011

Biodiversity in this organic vineyard helps attract natural enemies of pests

Agroecology is not limited to one context: it applies to all forms of agriculture in all countries. It is already practised by millions of farmers on millions of hectares on all continents. But there is a need to expand this approach to all farms. It can be implemented to phase out all HHPs in all countries. This is not something that can happen overnight, but rather must be a planned and resourced process of assisting farmers to make the transition from chemical-based farming to biology-based farming, developing appropriate supportive infrastructure where necessary. The transition is

323 De Schutter O. 2011. Agroecology and the Right to Food. United Nations Special Rapporteur on the Right to Food. A/HRC/16/49. http://www.srfood.org/index.php/en/component/content/article/1174-report-agroecologyand-the-right-to-food

> ***"… transition towards a low-carbon, resource-preserving type of agriculture that benefits the poorest farmers … will not happen by chance. It can only happen by design, through strategies and programmes backed by strong political will, and informed by a right-to-food approach."***
>
> *Olivier de Schutter, UN Special Rapporteur on the right to food, 2011*

critically important; it must be considered and coherent, and government involvement is needed both to remove the existing barriers to sustainable agriculture and to put appropriate support in place. The following sections look at the policy and practical steps needed to start this transition.

10.1 A Three-step process

Step One – unlocking ideological barriers

The very first step in the process is to develop the political will to make this happen. This is no small task: most countries are under pressure from powerful multinational lobbies that make great profits by selling the expensive inputs for 'green' or 'gene' revolution farming, and from farmer lobbies influenced by the multinationals. Corporate domination of agricultural policy, research, and extension through aggressive lobbying and marketing has led to an institutional mindset that needs to be addressed here.

One part of this mindset is that monocultures and industrially-managed systems, or large farms, are more productive than diversified small-size agricultural systems, despite evidence to the contrary. Another part of this same mindset is that synthetic chemical pesticides are necessary, sometimes described as 'a necessary evil'. Many otherwise worthy scientific papers on pesticides introduce themselves with such statements. For example, here is one from the respected journal, "Toxicological Research": *"Pesticides are essential to control diseases and pests to increase food production and improve plant breeds on limited farmland"* (no reference).[324] And here is another one from the equally respected journal "Toxicology": *"Despite their toxicity and the environmental and health risks they bring about, pesticides are a necessary component of modern agriculture"* (no reference).[325]

Such statements are never referenced, except sometimes to each other, because there is actually no scientific evidence that pesticides are necessary. There is evidence that they kill pests, weeds and diseases efficiently and save crops, but not that they are the only means of doing so, or even the best. On the contrary, there are many volumes of scientific papers, and a wealth of practical farm experience showing that pests,

Ladybird beetles, an important group of natural enemies, are already moving into this young cotton crop managed without insecticides, Ethiopia *PAN UK*

324 Jang Y, Kim JE, Jeong SH, Cho MH. 2014. Towards a strategic approach in alternative tests for pesticide safety. *Toxicol Res* 30(3):159-68.

325 Colosio C, Alegakis AK, Tsatsakis AM. 2013. Emerging health issues from chronic pesticide exposure: Innovative methodologies and effects on molecular cell and tissue level. *Toxicology* 307:1-2.

weeds, and diseases can be managed successfully without pesticides using agroecological practices. Some examples have been provided in this book showing increased farmer profit through stopping pesticide use.

So the current received 'wisdom', that pesticides are necessary in modern farming, forms a huge obstacle to the advancement of sustainable agroecological practices.

There needs to be greater understanding, across government ministries and elected representatives, of what agroecology is, how agroecological practices can be applied by farmers, the benefits of such an approach, and the need to prioritize this approach to agriculture. There must be an understanding of the need for ministries, or government departments – those dealing with environment, agriculture, biodiversity, climate change, rural infrastructure, food security, nutrition, health, education, commerce, industry, economic development, science and research, women, foreign policy, trade – to work together. And the will to make this happen. Too often, only environment or trade ministries are represented at SAICM and the chemicals conventions, and agriculture and health ministries do not participate. This lack of engagement and resulting lack of interdepartmental communication has been a serious obstacle in global efforts to get HHPs phased out or listed in one of the Conventions. The inability of one major country to support a resolution at the 2014 Asia-Pacific Regional SAICM meeting, requesting FAO to provide a paper on alternatives to HHPs, is one such example. The only reason the country did not support the resolution was because their agriculture ministry was not represented, and no other delegate was authorized to discuss agriculture. Had that country's agriculture ministry been present, the Asia Pacific region could have passed the resolution as no other country objected to it.

"… need to develop and implement public policies that promote an agroecological transformation at local, regional, and national levels".

Steve Gliessman and Pablo Tittonell, Wageningen University. 2014. Agroecology for food security and nutrition. Agroecol Sustain Food Syst 39(2):131-3

Step Two – understanding what facilitates agroecology

The second step is to understand what factors facilitate the adoption of agroecology by farmers.

The case studies published here, and those reflected in other publications, have highlighted:

- √ The power of farmer-to-farmer transmission of knowledge and skills
- √ The power of FFS experimentation and learning in farmers' own fields

Agroecological practices are best adopted when they are not imposed top down but are shared farmer-to-farmer, and through a process called co-learning – farmers learning together as in FFS, and constructing their own scientific inquiry.[326]

In fact, to date, these have been the main ways in which farmers have learned the skills of agroecology. Farmer-scientist collaborations can also be extremely productive and meaningful when farmers identify the research questions of priority to their communities and interact as coequals with "professional" scientists who play a supportive role throughout a collaborative research process that is owned and driven by the farmers themselves.

[326] (i) De Schutter 2011, op cit. (ii) Pretty J, Bharucha ZP. 2015. Integrated pest management for sustainable intensification of agriculture in Asia and Africa. *Insects* 6:152-82.

Training on the preparation of biofertilzer. *Alter Vida Comunicación*

> ***"Horizontal (farmer to farmer) communication and exchange is a powerful mechanism and collaboration and networks on agro-ecological practices among different countries and continents can also be enhanced through FAO programmes."***
>
> *FAO. 2015. Final Report for the International Symposium on Agroecology for Food Security and Nutrition*

<u>*Farmer to Farmer*</u>

Farmers' organizations and networks have been vital in the process of transmitting knowledge amongst farmers, including the regional and global networks the AgriCultures Network, Asian Peasants Coalition, La Via Campesina and in Africa, Réseau des Organisations Paysannes et des Producteurs Agricoles de l'Afrique de l'Ouest (ROPPA), the Eastern & Southern Africa Farmers' Forum (ESAFF) and PELUM (Participatory Ecological Land Use Management). Country-wide networks include Assessoria e Serviços a Projetos em Agricultura Alternativa (AS-PTA) and Movimento dos Trabalhadores Sem Terra (MST) in Brazil, CEDAC in Cambodia, Kudubum in India and MASIPAG in the Philippines. These are just a few; similar networks exist in about 70 countries, encompassing millions of farmers, one million in Brazil alone.[327] These are an incredibly valuable 'resource' to help countries to move away from HHPs, improve their food security and improve their rural economies. But to do so requires working with these networks in a manner that supports them, not imposing a top-down approach.

The key to the growth of the Community Managed Sustainable Agriculture (CMSA) programme in India has been its development of Community Resource Persons (CRPs) - farmers who practice CMSA themselves and can demonstrate that it is profitable and applicable for other farmers. The CRPs each provide guidance and mentoring to farmers in five other villagers, from which, once trained, further CRPs will be appointed to spread the techniques to other villages. By this means, these farmer-led networks have rapidly expanded the programme at low cost and have helped CMSA become a social movement.

The case study in the Philippines, reported in Chapter 7, showed that the successful uptake of agroecology rested on the farmer-to-farmer diffusion model through the farmers' organization, MASIPAG. Farmer-trainers, selected within their communities on their ability to practice sustainable agriculture successfully, assist new farmers, using their own farm for demonstration purposes as well as farm exchange visits. The farmer-trainers speak the language and know the culture of their fellow farmers, which leads to good adoption rates.

<u>*Farmer Field Schools*</u>

Farmer Field Schools (FFS) have had tremendous success in reducing pesticide use. *"Over 25 years of experience with community-based FFS in 90*

[327] Parmentier S. 2014. *Scaling-up Agroecological Approaches: What, Why and How?* Oxfam-Solidarity, Belgium.

countries throughout the world has brought about higher rates of adoption of locally-adapted practices, an important step towards increasing the resilience of the local farming systems." [328] They have proven effective in helping farmers organize themselves and in stimulating continued learning.

In the West African IPPM programme, 67 percent of facilitators are farmers, usually from a co-operative or farmers' association.[329] Communities decide which farmers to train as facilitators, with the expectation that they will return with useful skills to benefit all – a strong motivating factor. The FFS sessions motivate more dynamic social action that can lead to the birth of other activities needed to meet the larger needs of the community. Trained farmers are usually keen to then link up with networks of other IPPM practitioners.

FFS are reported to be exceptionally good value for money too:[330]

- √ One review in Asia found that for a cost of US $5-33 per participant, there was US $49 per hectare savings in pesticide use
- √ In Bangladesh, US $4 of benefit for every US $1 spent on FFS
- √ In one region in Mali farmers netted US $380,000 benefits in savings on pesticides

FFS are reported to have been held in 90 countries and in all cases there have been reduced costs and improved crop productivity.[331]

The lesson from FFS and similar experiences is that building the technical competence of individuals and small groups through hands-on learning, leads to increased self-determination and the confidence to explore and innovate.

According to the report on the 2014 FAO International Agroecology Symposium, enhancing farmer-to-farmer knowledge, information and experience sharing must be at the centre of agroecological approaches.[332]

However, the success of the farmer-to-farmer networks and FFS does not provide a reason for complacency on the part of national governments. No case can be made for them to sit back and let the farmers and FAO do all the work. State support is vital to bolster the efforts of farmers. For example, Brazil's 2010 Act on extension and technical assistance for family farming and agrarian reform (Lei 12.188/2010) is said to prioritize support to rural extension activities in ecological

"Farmer field schools have been shown to significantly reduce the amounts of pesticides use, as inputs are being replaced by knowledge."

Olivier de Schutter, UN Special Rapporteur on the right to food, 2011

MASIPAG farmer-breeder Pepito Babasa shows a stick which serves as a marker to remind him which type of rice varieties are planted in his trial farm. *MASIPAG*

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[328] FAO. 2015. Final Report for the International Symposium on Agroecology for Food Security and Nutrition.

[329] Settle W, Hama Garba M. 2011. Sustainable crop production intensification in the Senegal and Niger River basins of francophone West Africa. *Int J Agric Sustain* 9(1):171-85.

[330] Pretty and Bharucha 2015, *op cit.*

[331] *ibid.*

[332] FAO 2015, *op cit.*

Brazil

"To stimulate this transition, the National Plan for Agroecology and Organic Production (PLANAPO) was launched to promote Agroecology as a model of production, cooperative farming and economic organization. This plan was conceived with the broad participation of civil society, social movements and unions."

H.E. Minister Müller (Brazil), 2015, International Symposium on Agroecology, FAO

Farmers conducting Cotton AgroEcosystem Analysis during a Farmer Field School session, Ethiopia. *PAN UK*

agriculture.[333] An enabling policy environment is absolutely vital to facilitating farmers' uptake of agroecology and this will be addressed in Step 3 below.

Step Three – developing policies and programmes

The third step is to develop the policies, programmes, and where necessary, legislation to enable the uptake of agroecology by farmers, as well as the phasing out of HHPs, and to re-orient public spending programmes. Government policies, programmes, legislation and subsidies have supported chemical-dependent farming over the last 50 years, in the process skewing the playing field and undermining agroecology. Now this must change.

New polices and programmes must allow for a phasing-in process: wholesale change at the farm level cannot be achieved sustainably overnight. However, there is an urgent need to start developing the policies NOW, so that policies, programmes and infrastructure can be put in place to support farmers to change in a managed way that does not jeopardize their production or markets.

Agroecology needs to be addressed in two directions: vertically, called 'scaling up', and horizontally, called 'scaling out'. Scaling out refers to the outward reach of farmers, the farmer-to-farmer transmission of knowledge that pulls more farmers and more land into agroecology. Scaling up involves creating an enabling framework for farmers to achieve this. This framework, and its associated policies should not be an exercise in political authority, but rather one of participation and social learning, involving the farmers and their communities and networks in the process. If they are not involved, uptake will be seriously impeded.[334]

Agroecology, Ecuador. *Heifer-Ecuador Foundation*

333 De Schutter 2011, *op cit*.

334 Settle W, Hama Garba M. 2011. Sustainable crop production intensification in the Senegal and Niger River basins of francophone West Africa. *Int J Agric Sustain* 9 (1):171-185

Box 10.1 Ecuador – Agroecology in the legal framework

Ecuador's Constitution (2008), starting with a preamble that acknowledges the age-old roots and wisdom of all cultures, recognizes the rights of Nature, and celebrates Mother Earth (Pacha Mama) as "vital for our existence", encourages a new agricultural model based on food sovereignty and agroecology. It includes articles on the following:

- Individuals and collectives are entitled to safe, continual access to healthful, sufficient, and nutritious foods, preferably produced locally and corresponding with their diverse cultural identities and traditions.
- Economic policy will have, among other goals, that of ensuring food and sovereignty.
- To achieve food sovereignty, the Ecuadorian Government assumes responsibility for: strengthening diversification and introducing ecological and organic technologies in agricultural production.
- It is in the public interest and a national priority to conserve the soil, especially its fertile topsoil layer.
- The State will provide support to farmers and rural communities for soil conservation and restoration, as well as to develop agricultural practices protecting them and promoting food sovereignty.
- The public's right is recognized to live in a healthy, ecologically balanced environment that will guarantee sustainability and 'Sumak Kawsay' (living well). It is declared in the public interest to preserve the environment, conserve ecosystems, biodiversity and the security of the country's genetic heritage, prevent environmental damage and recover degraded natural spaces.
- All forms of appropriating collective knowledge, in the field of sciences, technologies and ancestral knowledge are prohibited. Appropriation of the genetic resources contained in biological diversity and agrobiodiversity is also prohibited.
- Ecuador is declared free of genetically modified crops and seeds.
- Public procurement will comply with criteria of efficiency, transparency, quality, environmental and social responsibility. Priority will be given for Ecuadorian products and services, particularly those from the grassroots solidary, and from micro, small and medium production units.

Additionally, the General Law of Food Sovereignty (LORSA) (amended 2010) establishes the State's obligation to promote reconversion of conventional systems into agroecological systems and encourage sustainable (agroecological) agricultural systems. It includes:

- Encouraging consumption of healthful, nutritious foods of agroecological, organic origin, avoiding insofar as possible the expansion of monoculture and utilization of food crops to produce biofuels, granting priority to in-country food supply.
- The State, and individuals and collectives, will conserve ecosystems and promote the recovery, use, conservation and development of agrobiodiversity and of the ancestral knowledge related to it.
- The State as well as individuals and collectives will promote and protect the use, conservation, assessment and free exchange of all native seeds.
- The State will also ensure applied participatory research and create an extension system, to transfer the technology

generated in research, to provide technical assistance, based on dialogue and exchange of know-how with small and medium producers, valuing women's and men's knowledge.

- The State will promote sustainable reconversion of conventional productive processes to agroecological models and diversify production to ensure food sovereignty.
- The State will encourage agroecological, organic, sustainable production, through development mechanisms, training programs, special lines of credit and marketing mechanisms on the domestic and external market, among others.
- To reduce and eradicate under-nutrition and malnutrition, the State will encourage consumption of nutritious foods, preferably of agroecological and organic origin, by providing support for their marketing.
- The State will create the National Marketing System for Food Sovereignty and establish support mechanisms for direct negotiation between producers and consumers, and provide incentives for efficiency and rationalization of marketing chains and channels. It will also work to improve conservation of food products in post-harvest and marketing processes; and will foster associative mechanisms among microentrepreneurs, microenterprises or micro, small and medium food producers, to protect them from the imposition of unfavourable conditions to market their products, regarding large marketing and industrialization chains.

Extracted from: Heifer-Ecuador. 2014. *Agroecology is here to stay. Mapping agroecological farmers and the status of agroecology in Ecuador's Highlands and Coastal regions.* Heifer-Ecuador Foundation, Quito.

10.2 Policies that provide an enabling environment

UNESCAP noted six years ago that long-term food security in the Asia-Pacific region requires *"active State support"* that gives high priority to revitalizing small-scale food production based on ecologically-viable systems. Their recommendations for targeted government policy included the phasing out of pesticides and inorganic fertilizers as part of rejuvenating and converting national cultivable land for sustainable food production.[335] National policies need to be transformed to empower small farmers, and particularly women farmers, to implement agroecological practices. Policy development should involve the participation of small-scale farmers, including women farmers, and their organizations in an open and democratic decision-making process.[336]

Agroforestry, Ecuador. *Heifer-Ecuador*

335 UNESCAP. 2009. Sustainable Agriculture and Food Security in Asia and the Pacific. UNESCAP, Bangkok.

336 Pimbert M, Barry B, Berson A, Tran-Thanh K. 2010. Democratising Agricultural Research for Food Sovereignty in Africa. IIED, CNOP, Centre Djoliba, IRPAD, Kene Conseils, URTEL. Bamako and London.

The following five elements should be addressed:[337]

1. Place agroecology at the centre of policy

Agroecology should be acknowledged as the priority approach to agriculture, with food production prioritized as the primary purpose of agriculture, at all levels of farming from small-scale to large, and across all departments of the government. This should include urban and peri-urban production.

Ecuador's 2010 Food Sovereignty law prioritizes the development of culturally-appropriate food products and conversion to agroecological practices in farming. It requires that land fulfil its environmental and social functions, such as generating employment, distributing income equitably, and conserving and utilizing biodiversity productively. The law establishes a National Conference on Food Sovereignty with eight statutory members, including representatives for women, indigenous groups and peasant movements. It is responsible for deliberating implementation, new proposals, research, and options for translating the law into practice.[338] See Box 10.1 for more details.

2. Protect small-scale farmers and their resources

Small-scale farmers, particularly women, are the backbone of agricultural production worldwide. They produce 70 percent of the food consumed in Africa on less than 15 percent of available agricultural land;[339] in sub-Saharan Africa and Asia that figure rises to 80 percent.[340] Smallholder farmers produce more per hectare than large high input commercial farms.[341] Yet there is a powerful international push for an industrial model of agriculture in Africa that is likely to result in the displacement of small-scale farmers in favour of

Brazil

"Brazil is convinced that Agroecology is the best model for family farming, rural development and the production of healthier food. Through initiatives such as the International Symposium on Agroecology for Food Security and Nutrition, Brazil is committed to replicating the model of family farming and Agroecology in the regions of South America, Central America and the Caribbean."

H.E. Minister Müller (Brazil), 2015, International Symposium on Agroecology, FAO

Smallholder farms, Ethiopia. *PAN UK*

337 (i) De Schutter 2011, *op cit.* (ii) Parmentier S. 2014. *Scaling-up Agroecological Approaches: What, Why and How?* Oxfam-Solidarity, Belgium. (iii) Bachmann L, Cruzada R, Wright S. 2009. *Food Security and Farmer Empowerment: A study of the impacts of farmer-led sustainable agriculture in the Philippines.* MASIPAG, Laguna. (iv) FAO 2015, *op cit.*

338 Jiggins J. 2014. Adaptation and mitigation potential and policies for climate change: the contribution of agroecology. Chpt 123 in: Freedman B (ed), *Global Environmental Change,* Springer, Dordrecht.

339 IFAD, UNEP. 2013. *Smallholders, Food Security and the Environment*. International Fund for Agricultural Development, and United Nations Environment Programme.

340 HLPE. 2013. Investing in smallholder agriculture for food security. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.

341 (i) FAO. 2014. *The State of Food and Agriculture; Innovation in family farming.* FAO, Rome. (ii) Parmentier S. 2014. *Scaling-up Agroecological Approaches: What, Why and How?* Oxfam-Solidarity, Belgium.

Smallholders - the key to crop biodiversity

"As much as 75 percent of global seed diversity in staple food crops is held and actively used by a wide range of small farmholders - workers of less than three to seven acres…. Small farmers, in many cases women, are the ones preserving landraces of food crops. A landrace is a locally adapted, traditional variety of a domesticated species. … While the livelihoods of small land users are often precarious, these landraces provide vital farm and food resources."

Penn State. World crop diversity survives in small farms from peri-urban to remote rural locations. ScienceDaily, 13 February 2015

high agrochemical input agriculture based on GM and hybrid seeds.

National governments should provide legal protection and institutional support for small-scale farmers and rural, community-based and indigenous peoples' communities from this kind of land-grabbing and resource appropriation. They should remove any policies that are likely to cause the displacement of small-scale farmers and indigenous communities, including policies, programs or agreements that enable foreign companies to gain access to local resources (land, water, seeds, etc.) to the detriment of smallholder farmers. Policies that undermine the ability of smallholder farmers to produce in a low input, cost effective manner must also be removed. Any policies aimed at helping foreign companies access local resources to the detriment of smallholder farmers must be avoided or, if already in place, replaced with policies that facilitate agroecological practice.

In their place are needed policies and programmes that ensure secure access to land and resources in order to encourage long-term investment by small-scale food producers. This may include fragmenting large land-holdings where there is a lack of access for farmers to productive land. Access to land also includes pastoralists' access to pastures, migration routes and sources of water and customary rights to the commons. It also includes agro-biodiversity. Agro-biodiversity is a key component of agroecology and its ability to meet climate change challenges, so it must remain accessible to small farmers at no cost. In-situ conservation of agro-biodiversity must be supported. Policies need to ensure secure land tenure for smallholder farmers, and assist community development of water harvesting and storage, such as storage dams, cisterns and irrigation.

Seed policies must guarantee the collective rights of indigenous peoples and farmers to use, exchange, breed, select and sell their own seeds. Genetic diversity should be encouraged and assisted. Governments must not allow intellectual property rights over indigenous seeds and traditional varieties to be granted to corporations or other private interests. Of particular concern are seed marketing laws that make it illegal to exchange or trade farmers seeds. For example, under the G8 New Alliance for Food and Nutrition,[342] the Mozambique government has agreed to adopt policies and regulations that promote the interest of private commercial business rather than those of farmers, including committing to cease the distribution of free and unimproved seeds.[343]

342 Launched in 2012, by the eight most industrialized countries, its aim is to mobilize private capital for investment in African agriculture. It has a 19-year time frame that facilitates access of foreign interests to African farmland, and requires participating African countries to, amongst other things, adopt seed laws that facilitate the marketing of their seeds, with no recognition of the importance of farmer-based systems of saving, sharing and exchanging seeds. The effect is to create large unified seed markets in which the only seeds on offer are restricted to commercially protected varieties. Farmers' rights to replant saved seeds become curtailed and the marketing of non-patented traditional varieties becomes prohibited. Farmers lose control of seeds regulated by commercial systems, and biodiversity diminishes.

343 AFSA, GRAIN. 2015. Land and Seed Laws Under Attack: Who is pushing changes in Africa? Alliance for Food Sovereignty in Africa and GRAIN.

Box 10.2: Smallholder land-grabbing in Cambodia[344]

Romas Phas is a 30-year-old mother of four children, living with her husband and children, ages 4–15, in Dal Veal Leng village in Ratanakiri province in northeastern Cambodia. She grows different kinds of green leafy vegetables, tomatoes, papayas, sweet potatoes, and various fruit trees. Raising chickens helps her add essential nutrients to her family's diet and earn more income from selling the surplus eggs or chickens. Land titling by the Cambodian government proceeds slowly, but at the same time the government has awarded parts of the land she and her family have been tilling for years to a private investor who logged the forest and carved out another rubber plantation. Romas' household is among half those in the village affected by illegal land acquisition practices, which have dramatically reduced the supply of wild meat and vegetables. Romas now needs to buy more food, especially meat. In addition, yields from Romas' rice paddies could decrease in the near future, because her remaining land will not allow her to maintain the traditional fallow periods, resulting in a further reduction in income and food security.

Such a focus on promotion of commercial, often hybrid seeds, often leads to farmers needing to increase inputs of chemical fertilizer and pesticides in order to make the 'improved' commercial seeds yield adequately.

Policy changes and programmes may be needed to assist the development of community seed breeding and seed banks.

In many countries policies and programmes are also needed to develop rural infrastructure that supports small-scale farmers – roads, electricity, storage facilities, and information and communication technology.

3. Enable women

Actions are necessary to ensure equal rights for women in every sphere, from access to and ownership of land, access to credit and resources, access to education and health care, access to markets, decision-making power and control over income, and labour rights. Programmes and projects must fully include women at all stages, from the earliest formulation through planning and application, with leading and decision-making roles. The number of women extension officers, along with programmes designed for women only, needs to be increased.

Land rights for women increases their confidence and sense of self-worth, and their bargaining power within the house and community, enabling better negotiating power for wages and in marketing. However, their rights to use common resources is also critical since they are the ones who usually gather and collect fuelwood, water, fodder, and food.[345]

4. Invest in knowledge: support research, extension and farmer networks

There is a large untapped potential in agroecological practices, and research combining modern science with local knowledge should be prioritized. Because agroecological knowledge is not available to the private sector for patents and private gain, it falls to national and international organizations to support such research needs. Governments need to ensure their research

344 Von Grebner K, Saltzman A, Birol E, Wiesmann D, Prasai N, Yin S, Yohannes Y, Menon P, Thompson J, Sonntag A. 2014. *2014 Global Hunger Index: The challenge of hidden hunger.* International Food Policy Research Institute, Concern Worldwide, Welthungerhilfe. Bonn/Washington, D.C./Dublin.

345 UNESCAP 2009, *op cit.*

South Africa

"There are 1.1 million small-scale food producers, mainly in the former homelands – 75% of them women."

Stephen Greenberg, independent researcher. Workshop on agroecology and agrarian change: Towards a democratic participatory agroecology, 2011, Cape Town

Local government supported programme for organic bananas, Ethiopia. *PAN UK*

programmes have an agroecological rather than biotechnological focus. Programmes should favour farmer participatory research in collaboration with scientists, including participatory plant breeding. Research programmes should be designed with farmers, including women, with their needs paramount. This should also include identifying, documenting and sharing successful local agroecological initiatives. Governments need to invest in participatory research in agroecological practices.[346]

Programmes and extension services should be developed, or altered, to support FFS and horizontal farmer-to-farmer transmission of knowledge, and to encourage farmers to identify innovative solutions. Caution is necessary though, to ensure FFS are the real thing: there are reports that the pesticide industry has misappropriated the FFS model to promote greater pesticide use.[347] Getting farmers motivated to take up alternatives requires more than one-off trainings, leaflets or demonstration days. In order to become confident users of agroecological pest management strategies, farmers need practical guidance, user-friendly monitoring and decision making tools, group discussions about what works well, where and under what situations and why things may go wrong, backed up with mentoring by more experienced farmers.[348] Refer back to Chapter 10.2 for more on this.

Governments need to invest in ecological literacy and decision-making skills in farmers. Technical assistance should be provided to farmers on all aspects of agroecological practices, including adjusting to and mitigating climate change, and conservation of soil and water resources.

5. Establish a supportive economic environment

This includes a supportive macroeconomic framework that provides protection from volatile prices and dumping of subsided products on local markets and ensuring farmers' access to local and regional markets.

Economic policies should strengthen local food systems, as opposed to focussing on export markets. Re-localizing food markets can help significantly reduce food losses due to spoilage that occur during storage and transport; and rural infrastructure development is also vital to reduce the spoilage of food designed for markets.[349] Marketing co-operatives can assist farmers by

346 For more on this in Africa, see Pimbert M, Barry B, Berson A, Tran-Thanh K. 2010. *Democratising Agricultural Research for Food Sovereignty in Africa*. IIED, CNOP, Centre Djoliba, IRPAD, Kene Conseils, URTEL. Bamako and London.

347 Pretty and Bharucha 2015, *op cit.*

348 Meir C, Williamson S. 2005. Farmer decision-making and Ecological Pest Management. In: Pretty J (ed). *The Pesticide Detox: Towards a more sustainable agriculture.* Earthscan, London, pp.83-96.

349 For updates on FAO's campaign to reduce food wastage see http://www.fao.org/save-food/en/

"It is a source of concern to the Special Rapporteur that, while women face a number of specific obstacles (poor access to capital and land, the double burden of work in their productive and family roles, and low participation in decision-making), gender issues are incorporated into less than 10 per cent of development assistance in agriculture, and women farmers receive only 5 per cent of agricultural extension services worldwide."

Olivier de Schutter, UN Special Rapporteur on the right to food, 2011

Women farmers preparing rice seedlings for planting out, Bangladesh. *SHISUK*

providing a central point for assembling produce from small farmers and preparing it for transport to markets.[350] Re-localizing markets provides greater opportunities for small-scale farmers to sell, improve food security, and reduce climate emissions from transport. Crops for local markets can be grown without the need to meet stringent external phytosanitary requirements (e.g. zero tolerance on certain quarantine insect pests), which can result in treatment with HHPs.

Policies need to ensure farmers have secure access to credit, certification and marketing infrastructure, as well improved bargaining power: where farmer co-operatives are supported to improve their business management skills and interact more effectively with government agencies and the private sector, they are in a much stronger position to negotiate good prices and find opportunities to expand their activities. Governments need to prevent global food chains dominating domestic markets and determining prices that farmers get paid as this often leaves them underpaid and struggling to survive. The power of supermarket chains needs better regulating to protect farmers.

Policies are needed to assist community development of local storage and marketing facilities, including guidance on effective preservation of grains and foodstuffs without use of HHPs.

Economic policy could include full-cost accounting for agriculture. Developing national 'green accounts' or 'total material flow estimates' enables a country to more accurately identify the true costs of food production, and consequently to better inform policy decisions. Sweden, for example, established a national policy to transition towards organic farming based largely on the findings of a full cost analysis of the climate-related, energy, water, environmental and other ecosystem service costs embedded in its "foodshed".[351]

Governments should consider replacing subsidies on agrochemicals with subsidies for agroecology. Pesticides receive an indirect subsidy unless their negative externalities (costs to human health and the environment) are reflected in the price farmers pay for pesticides, for example, by adding a tax. So subsidies on pesticides could also be replaced by taxes on pesticides, as some countries have already done; for example Sweden placed a tax on pesticides at 3 Euros/kg, Norway at

350 FAO. 2011. *Global Food Losses and Food Waste – Extent, causes and prevention*. FAO, Rome.

351 Johansson S. 2008. The Swedish foodshed: Re-imagining our support area. In: Farnworth C, Jiggins J, Thomas EV (eds). *Creating Food Futures: Trade, Ethics and the Environment*. Aldershot, Gower.

> ***"The transition towards agroecological systems, which are knowledge-intensive systems, should be based on a bottom-up approach and closely associate farmers and producers at every step of the process."***
>
> *H.E. Minister Le Foll (France). International Symposium on Agroecology, FAO (2015)*

Training farmers on phermone use, Kuruvai. *Resmi Deepak*

2.20 E/kg, and Belgium at 0.39 E/kg.[352]

Other financial support can include financial credits for those practising agroecology, for ecosystem services such as sequestration of carbon in soils and protection of biodiversity. It can also include tax exemptions for reducing reliance on pesticides, crop insurance, etc.

Public procurement programmes that prioritize goods from agroecology can be of great assistance in guiding farmers and consumers to make good choices. One example is the school-feeding programme in Brazil which supports family farming through its public procurement scheme. There is a significant groundswell of consumer support for agroecology in many countries; public procurement policies that support agroecology can assist farmers not only through direct sales, but also by example to consumers.

10.3 Removing the policies that hinder

There are a wide range of policies, programmes, legislation and agendas that support and incentivize non-sustainable industrial scale monocultures, which require the use of pesticides, and often HHPs, to manage pests in agroecosystems that have been stripped of ecosystem services such as natural enemies, and are lacking ecological functionality. These obstacles are too broad-ranging to address here, except to point out that significant shifts in economic policies, trade rules, laws governing ownership, access to and control over resources (including intellectual property) and policies regulating private sector actors and corporate concentration would better support agroecological approaches. This section focuses solely on pesticides.

Pesticides as the first option in the registration process

Policies, legislation and programmes that support pesticides as the first option for pest control need to be changed to reflect the modern approach to IPM, that of pesticide use only as a last option. The issue of subsidies and taxes has already been addressed in the preceding sector. However, one of the main problem areas is that of registration. This is a crucial area where change is long overdue. Registration processes for pesticides are absolutely necessary; that is not in doubt. But the fundamental assumption of registration processes needs to change.

The fundamental assumption is that pesticides are necessary; and that therefore, if a pesticide meets basic toxicological, ecotoxicological, and residue requirements and, in some countries, efficacy requirements, then the pesticide is to be registered. This assumption fails to recognise the extent of pesticide-related harm and its associated economic costs, particularly under the conditions of use prevailing in most low income countries. It

[352] Pretty and Bharucha 2015, *op cit.*

Costa Rica

"Legislation has helped to promote sustainable agriculture, including Agroecology. For example, Payments for Ecosystem Services schemes have been implemented for practices such as agroforestry. Criteria have been developed to certify coffee growers that are carbon neutral. The legal/policy approach has benefited, however, Agroecology needs to be up-scaled and extended further."

H.E. Minister Arauz-Cavallini (Costa Rica), 2015, International Symposium on Agroecology, FAO

Selling organic vegetables in a market in Thies, Senegal. *PAN Africa*

also fails to recognise the existence of safer alternatives.

Substitution

One improvement on this is the substitution approach which has begun to appear in legislation in some countries. At its most basic level, this approach requires the substitution of a hazardous pesticide with a less hazardous one. Broadly, if there is a less toxic product that is available and effective, then it should be registered/used instead of a more toxic product. However this 'limited' or 'chemical' substitution approach only considers replacing one pesticide with another, an approach which this book has argued is not in the best interests of farmers and society. It is an incomplete application of the substitution principle, which has been defined by the Swedish Chemical Agency, Kemi, as:[353]

"If risks to the environment and human health and safety can be reduced by replacing a chemical substance or product either by another substance or by some non-chemical technology, then this replacement should take place."

Kemi expanded on this by adding: *"All decisions on such substitutions should be based on the best available evidence. This evidence can be sufficient to warrant a substitution even if quantitative risk estimates cannot be made."*

The European Union Pesticide regulation for authorizing agricultural pesticides, 1107/2009,[354] does partially address this issue. Article 50 requires that, for pesticides which have been identified as of some concern (List of Candidates for Substitution), each member state must evaluate in a comparative assessment if they can be replaced (substituted) by safer chemical and non-chemical control or prevention methods. Most of the substances on the list have met two of three criteria for persistence, bioaccumulation, and toxicity; there are also other criteria for listing, including neurotoxicity, immunotoxicity, carcinogenicity, reproductive toxicity or endocrine disruption.

However, the regulation still starts with the premise that pesticides be registered unless they trigger certain thresholds of toxicity; and still weighs on the side of pesticides by requirements that the alternatives must be "significantly safer" and not present "unacceptable" economic or

353 Kemi. 2007. The Substitution Principle. Report Nr 8/07. Swedish Chemicals Agency, Stockholm.

354 Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC.

> ***"Organic agriculture is not directly and specifically supported by agricultural policy in most African countries; indeed, it is sometimes actively hindered by policies advocating the use of high-input farming management practices."***
>
> *Rachel Hine and Jules Pretty, University of Essex, and Sophia Twarig, UNCTAD, 2008*

Obsolete stock of endosulfan, India. *Jayakumar Chelaton*

practical consequences.[355] The interpretation of what is significant and unacceptable is determined by the values of the institutions carrying out the assessments, not by science. Yet despite the criticism, the EU approach is very much a step in the right direction. A draft list of 77 active ingredients for substitution was released on January 2015.[356] Interestingly, of these 77 substances that are currently approved by the EU, only 16 meet the JMPM criteria for an HHP, although 40 do meet the PAN criteria. Thirty-six do not meet either criteria, yet are regarded by the EU as requiring substitution if a safer alternative is available. This reinforces the point made in Chapter 1, that replacing an HHP with another pesticide that does not meet the criteria for an HHP may not be a sound choice.

Pesticides as the last option in the registration process

Rethinking the standard registration assumption is one of the best policy steps to putting into practice the ecosystem-based IPM approach to pest management – that of using a pesticide only as a last resort.

The currently dominant registration model and the incomplete substitution approach both fail to consider whether or not the pesticide is really needed at all. The pesticide registrant has no interest in determining whether there are better ways to manage a pest: they are only interested in registering a product for financial gain. It is the government's responsibility to determine

> ***"Experience shows that the market will usually not automatically ensure that substitution takes place. For the substitution principle to be efficiently implemented, regulators and public authorities have to take the lead."***
>
> *Swedish Chemicals Agency, 2007*

Horticultural fleece used as a physical barrier against caterpillar and other leaf-feeding pests.

355 http://ec.europa.eu/food/plant/pesticides/approval_active_substances/docs/qaa_candidates_substitution_en.pdf
356 http://ec.europa.eu/food/plant/pesticides/approval_active_substances/docs/draft_list_cfs_en.pdf

whether a particular pesticide is necessary. If there is a lower toxicity pesticide available that can control a pest, why should an HHP be registered or retain registration? Similarly, if there are effective agroecological practices available that can successfully manage the pest, at lower risk to humans and/or the environment, why should a pesticide be registered at all?

Pesticide registration processes need to be adjusted to include assessment of alternatives to HHPs, particularly agroecological practices, so that the lowest risk method, or the method causing the minimum harm, is the preferred way to manage a pest or pests. This would require working with successful agroecological farmers, researchers and extension agents to determine best approaches.

Instead of asking the questions 'What pesticides are available? How much harm from them is acceptable? What is a safe level of exposure? Which pesticides need protective equipment? What studies are needed to prove they are safe?', the first question that should be asked is 'How do we manage pests, weeds and diseases in ways that minimize harm to people and to the environment?' This is an expression of the principle of minimum harm,[357] a principle that has been around in one form or another for at least thirty years or so. It was spelled out by environmental philosopher Paul Taylor, in 1986, in his book "Respect for Nature".[358] The principle acknowledges that humanity necessarily causes damage to the environment in pursuit of its basic and non-basic needs, but prescribes that this damage should be minimized. The World Bank also acknowledged this in 1993: *"To be ethical the project with the least environmental impacts should be selected".*[359] In terms of pest management this becomes:

Choose the method that causes the minimum harm to humans and the environment whilst still being sufficiently effective.

The principle of minimum harm in pest management:

Choose the method that causes the minimum harm to humans and the environment whilst still being sufficiently effective.

Meriel Watts. 2000. "Ethical Pesticide Policy: Beyond Risk Assessment". University of Auckland

A release sachet for predatory mites hangs among cucumber foliage in a greenhouse using biological controls, Germany

The SAICM text, in fact, also proposes this approach, in the Global Plan of Action:

> Work Areas addressing Risk Reduction:
> *Highly toxic pesticides - risk management and reduction:*
> 26. Prioritize the procurement of least hazardous pest control measures…

In fact, this approach was expressed in policy in one country as long ago as 1989, when Sweden's National Board of Agriculture said:

"If equally effective, non-chemical methods are available for a certain control a pesticide will be banned for that control."[360]

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357 Watts MA. 2000. *Ethical Pesticide Policy: Beyond Risk Assessment*. University of Auckland, Auckland.
358 Taylor PW. 1986. *Respect for nature: a theory of environmental ethics*. Princeton Univ Pr., Princeton.
359 Montague P. 1996. Where are we now? *Rachel's Environ Health Week* #500. Environmental Research Foundation, Annapolis.
360 Liden CJ. 1989 May 18. [Swedish programs to reduce the environmental problems related to agriculture]. Jonkoping (Swed): National Board of Agriculture.

11. International implications[361]

Author: Marcia Ishii-Eiteman, PAN North America

"FAO is in a unique position, and must assume responsibility, for helping build a global agroecological network. The symposium emphatically demonstrated that they have everything needed to make the transformation happen. It just needs action, vision, responsibility toward future generations, and most of all courage."

Steve Gliessman and Pablo Tittonell, 2014, Wageningen University, Netherlands.[362]

The transformation of agrifood systems into ones that advance equitable and sustainable development goals in the 21st century requires the redirection of institutional and policy support at all levels towards ecosystem-based agriculture with agroecology as the central strategy. To achieve this transformation, international actors – including governments, UN agencies, bi- and multilateral development institutions, international research institutes, private and public donor agencies – will need to prioritize participatory community-based farmer-led agroecological research, extension and education. They will also need to act decisively to reform, or in some cases, dismantle the political and economic structures, social institutions (e.g. laws, rules and norms) and systems that currently prevent the scaling up and out of agroecology.

Small-scale agroecological farming, Ecuador. *Heifer-Ecuador Foundation.*

Priority areas for action include:

- Empowerment of farmer organizations, especially those representing the interests of women, indigenous and small and medium scale farmers
- Democratization of decision-making throughout the agri-food system and opening of political, economic and social spaces for leadership from peasant, family, small- and medium-scale farmers and related grassroots social movements in designing priorities and pathways forward

361 Portions of this chapter are drawn from Ishii-Eiteman M. 2013. Democratizing control of agriculture to meet the needs of the twenty-first century. In UN Trade and Environment Review, *Wake up Before it is Too Late: Make agriculture truly sustainable now for food security in a changing climate.* UNCTAD.

362 Gliessman S, Tittonell P. 2014. Agroecology for food security and nutrition. *Agroecol Sustain Food Syst* 39(2):131-3.

- Adoption of progressive economic policies, financial incentives and market opportunities to create an enabling environment for scaling up and out agroecological practices and to counter perverse system incentives that favour an unsustainable commercial industrial agricultural model
- Establishment of strong and enforceable regulatory frameworks and legal mechanisms to reverse the damaging effects of resource-extractive industrial agriculture
- Establishment and implementation of mechanisms to curtail corporate influence over public policy, economic and market structures, and agricultural research, extension and practice in ways that undermine democratic process, food and livelihood security
- Reform, and in some cases dismantle, institutions such as regional and global trade arrangements and ownership laws that hinder the scaling up and out of agroecology;

> **"Small-scale diversified farming is responsible for the lion's share of agriculture globally. . . . greatest scope for improving livelihood and equity exists in small-scale, diversified production systems in developing countries."**
>
> *IAASTD Global Report, p379*

Box 11.1: Policies to promote agroecology[363]

The global IAASTD assessment identified promising policy options to advance sustainable and equitable development goals include the following. While many of these options can be taken up by local and national actors, the international community has a responsibility to support such efforts by aligning their funding, aid and all other development interventions accordingly.

- Strengthening the small-scale farm sector, in particular farmers', women's, indigenous and other community-based organizations, and increasing public investment in rural areas
- Building local and national capacity in biodiverse, ecologically resilient farming to cope with increasing environmental stresses
- Increasing local participation and leadership in agricultural research, direction-setting, policy-formation and decision-making processes
- Revitalizing local and regional rural economies and food systems, and more closely regulating globalized food systems to ensure public good outcomes
- Mobilizing public and private sector investments and providing market-based incentives to advance equitable and sustainable development goals
- Establishing equitable regional and global trade arrangements to support developing countries' food and livelihood security goals
- Revising ownership laws to ensure poor and/or vulnerable communities' equitable use, access to and control over land, water, seeds and germplasm
- Establishing new, transparent, democratically governed institutional arrangements to accomplish these goals and rebalance (democratize) power in the food system

In addition, applying a human rights framework to agricultural policies and practices can assist States, international agencies and private actors in fulfilling their obligations to respect, protect and fulfil the right to food.

[363] De Schutter O. 2011. *Agroecology and the Right to Food.* Report presented at the Sixteenth Session of the United Nations Human Rights Council, Agenda item 3A//HRC/16/49, Geneva.

Women farmers, India. *Tamil Nadu Women's Forum*

Paddy ready to be planted out, India. *Jayakumar Chelaton*

re-structuring and re-alignment of these institutions to bring them into conformity with state and non-state actors' obligations to respect, protect, and fulfil universal human rights to food, health and a safe working environment, and to advance equitable and sustainable development goals

- Significant new investments by public sector, donor and commercial actors in agroecological research, extension, education, product innovation and marketing.

This chapter will outline some of the key shifts in policy, research and action that a range of international actors can take to enable the vertical scaling up and horizontal scaling out of agroecology, beginning with the recently proposed UN-wide adoption of agroecology as a central strategy to address climate change and advance equitable and sustainable agrifood systems.

11.1 Institutionalizing supportive policies: Role of international actors

FAO and a UN-wide adoption of agroecology

At the FAO-hosted International Symposium for Agroecology in 2014, referred to in Chapter 2, international scientists called on the United Nations to launch a UN system-wide initiative on agroecology as the UN's central strategy for addressing climate change and building resilience in the face of food, water and energy crises.

The scientists noted that the UN Food and Agriculture Organization is uniquely positioned to spearhead such an initiative and to provide guidance to national governments as they develop and adopt policies to support their own national transition towards agroecology as the basis of local and national sustainable agrifood systems.

FAO Director-General José Graziano Da Silva affirmed FAO's commitment to facilitating three regional symposia on agroecology in 2015 in Latin America, Asia and Africa.

France declared its full support for these regional meetings, and offered to host a follow-up international meeting on agroecology in Paris in 2016. France further proposed the establishment of an international "Club of Countries" in support of agroecology, and recommended the establishment of an international network of scientists and farmers working together to improve the exchange of knowledge in locally adapted agroecological science and practice.

Such an international network could learn from and draw on the experiences of existing national and regional farmer-scientist collaborative networks for agroecology, such as SOCLA, the Latin American Scientific Society of Agroecologists, and

"FAO is in a unique position, and must assume responsibility, for helping build a global agroecological network. The symposium emphatically demonstrated that they have everything needed to make the transformation happen. It just needs action, vision, responsibility toward future generations, and most of all courage."

Steve Gliessman and Pablo Tittonell, 2014, Wageningen University, Netherlands. Agroecology for food security and nutrition. Agroecol Sustain Food Syst 39(2):131-3

Assessing some of the costs of agriculture – sampling rural drinking water for pesticide contamination, Ethiopia. *PAN UK*

MASIPAG in the Philippines, as well as the farmer networks that are already leading the way in agroecological practice and innovation on the ground, such as La Via Campesina and the Brazilian Landless Workers Movement (MST).

Final outcomes from the 2014 FAO Symposium for Agroecology included the recommendations that FAO operationalize agroecology into its Work Plan and provide leadership and assistance to governments in promoting national policy dialogue on agroecology, while encouraging international and national research institutes and development agencies to prioritize agroecological research.

Recommendations for the UN to prioritize agroecology as the most promising path towards development of equitable, resilient and sustainable agrifood systems are consistent with the recommendations of virtually every independent and UN-hosted international assessment of agricultural science, technology and practice that has emerged over the past 10 years (refer Chapter 2).

At the same time, FAO should provide policy and technical guidance to national governments on how to assess the social and environmental costs of conventional agriculture. One fundamental failure of global markets today is the lack of price signals that incorporate the full array of health, energy and environmental costs associated with agriculture. Consequently, policymakers base their decisions on inaccurate forecasts of the potential and actual costs of different agricultural models. FAO can provide guidance to national governments on how to undertake full cost accounting measures, by developing national green accounts or total material flow estimates that enable countries to more accurately reflect the true costs of food and agricultural industries, and consequently to better inform policy decisions.

UN Committee on World Food Security

Since 2009, the Committee on World Food Security (CFS) has provided an *"international and intergovernmental platform for all stakeholders to work together in a coordinated way to ensure food security and nutrition for all."*[364] The CFS has a mandate to provide assistance to country-led processes to support food security. With agroecology recognized today as a pillar of equitable and sustainable food systems, the CFS can and should provide guidance to national and regional bodies in how to develop and implement

364 Committee on World Food Security. http://www.fao.org/cfs/cfs-home/en/

> **"We face great challenges; however, we also have great possibilities and the commitment to overcome them."**
>
> *Director General of FAO, 2015. Final Report for the International Symposium on Agroecology for Food Security and Nutrition*

agricultural policies and programs based in agroecological principles.

United Nations Environment Programme (UNEP)

UNEP has a mission to *"provide leadership and encourage partnership in caring for the environment"* and a mandate to *"be the leading global environmental authority that sets the global environmental agenda, that promotes the coherent implementation of the environmental dimensions of sustainable development within the United Nations system and that serves as an authoritative advocate for the global environment."* As such, the agency is well situated to support member countries in transitioning from the environmentally damaging practices of high input, chemical-intensive agriculture towards agroecology.

Already, UNEP has contributed in important ways towards reducing the environmental costs of chemical-based agriculture and encouraging ecologically restorative approaches. As a co-sponsoring agency, UNEP provided institutional and intellectual leadership to the IAASTD process, which highlighted agroecology as a robust path towards equitable and environmentally sustainable development. UNEP subsequently produced two hallmark reports containing important economic analysis and policy guidance, calling for a shift from chemical-intensive to ecological agriculture: "Towards a Green Economy"[365] and "Costs of Inaction on the Sound Management of Chemicals".[366]

Dangerous spraying, Vietnam. *Research Centre for Rural Develeopment, An Giang University.*

International treaty agreements

UNEP hosts a number of international treaty mechanisms that aim to reduce incidence of pesticide poisoning or environmental contamination. They can play a major role in the transition away from hazardous, chemical-intensive agriculture to support the adoption of agroecology and other ecological agricultural practices in their stead.

Strategic Approach to International Chemicals Management (SAICM)

SAICM, in addressing the overwhelming desire of country and non-country participants for the phase out of HHPs, should recommend that, wherever possible, they be replaced by ecosystem approaches to pest management such as agroecology.

Stockholm Convention on Persistent Organic Pollutants

As described in Chapter 2, the Conference of the

365 UNEP. 2011. *Towards a Green Economy: Pathways towards Sustainable Development and Poverty Eradication*. UNEP, Geneva.

366 UNEP. 2013. *Costs of Inaction on the Sound Management of Chemicals*. UNEP, Geneva.

> **"Agroecology offers win-win solutions, to increase productivity, improve resilience and make more efficient use of natural resources."**
>
> *Director General FAO, 2015, International Symposium on Agroecology*

Parties to the Stockholm Convention agreed in 2013 that, in replacing endosulfan, priority should be given to ecosystem-based approaches to pest management. This should now become the norm for the replacement of all pesticides listed under the Convention, and funding and assistance should be made available through the secretariat to assist countries to achieve this.

Rotterdam Convention on Prior Informed Consent

Although the Rotterdam Convention does not require the phase out of pesticides, nevertheless, the Secretariat can assist countries with funding and information to replace listed pesticides and severely hazardous pesticide formulations with ecosystem-based alternatives.

Regional initiatives and associations

Regional associations can play a powerful role in advancing agroecology across a region, by facilitating the exchange of in-country knowledge, particularly through farmer-to-farmer learning exchanges and sharing of case studies and policy lessons learned, as well as by coordinating regional policy frameworks, initiatives and plans fine-tuned and adapted to the particular sensitivities and needs of a region or sub-region such as, for example a watershed like the Mekong Delta.

'Missing in action': WHO and the World Bank

Several key UN and international bodies have the potential and, indeed, responsibility to take an active role in promoting ecosystem-based approaches such as agroecology. Yet these bodies have remained largely silent, missing a critical opportunity to advance their missions and contribute to global transition towards healthy and sustainable livelihoods.

Rasing awareness about pesticide hazards and exposure for young people on farms, Moldovia. *PAN UK*

The UN World Health Organization (WHO) has a mission objective to improve people's health outcomes. As a co-sponsor of the IAASTD, the WHO has had ready access to the findings that spelled out in detail the harmful connections between public health and exposure to hazardous pesticides on the one hand, and the public health benefits on the other hand (derived not only from consumption of a pesticide residue-free, diversified diet but also from the reduced hunger and poverty that is associated with the establishment of equitable and sustainable agrifood systems). Thus, WHO has a role and responsibility to weigh in through policy statements and development of health initiatives that support the scaling up and out of agroecological farming, and that protect and fulfil the universally recognized human rights to health, to food and to a safe working environment.

The World Bank, regional development banks and international financial institutions (IFI) have a mission to promote sustainable development, and are likewise obliged to respect, protect and fulfil the right to food. As indicated by the current and past UN Special Rapporteurs on the Right to

Food, and as concluded by the IAASTD (of which the World Bank was a sponsoring agency), one of the most effective, well-evidenced and powerful approaches towards the reduction of poverty and hunger, is ecosystem based agriculture: *"The greatest scope for improving livelihood and equity exist in small-scale, diversified production systems in developing countries,"* not in the "business as usual" model of industrialized input-intensive commercial agriculture more commonly featured in World Bank interventions, which have been widely critiqued.[367] The World Bank and IFIs should redirect the focus of their agricultural and poverty-reduction programs to assist countries in transitioning towards equitable and sustainable agroecological systems.

11.2 Research, extension and education

International and regional research institutional arrangements should prioritize agroecological research, extension and education. Research programs should draw from the rich history of participatory action research and community-based monitoring, and encourage leadership from farmers, especially women and indigenous peoples, in problem-identification, experimentation, innovation, analysis and recommendations.

From 2008-2012, farmers and citizen juries in West Africa heard testimony and assessed evidence regarding public research priorities and outcomes, and produced nearly 100 recommendations for more appropriate, targeted and democratically determined agricultural research agendas and processes.[368] This multi-year exercise, part of an international participatory action research initiative, "Democratizing the Governance of Food Systems," illustrates the profound improvements to the relevance of agricultural research and efficacy of extension and education when farmers are in leadership positions.

Examples of successful participatory community-based field research include the pathbreaking approach of Farmer Field Schools in IPM (pioneered by FAO in the 1980s and then continually modified and developed to meet particular cultural and agroecological contexts and interests by local communities, NGOs and FAO across Asia, Latin America and Africa); participatory plant health clinics of Latin America; and the work of farmer-scientist partnerships such as SOCLA in Latin America and MASIPAG in the Philippines.

11.3 Investing in agroecology: Role of funding agencies and foundations

Multilateral and bilateral funding agencies as well as private foundations have an essential role to play in supporting the scaling up and scaling out of agroecology. These agencies should fund the strengthening of small-scale and women farmer networks, as well as participatory agroecology research, extension, and practice. All funding agencies and foundations should undertake portfolio reviews to evaluate to what

367 (i) Broad R. 2006. Research, knowledge and the art of paradigm maintenance: The World Bank's Development Economics Vice-Presidency. *Rev Int Politic Econ* 13(3):387-419. (ii) Clapp J. 1997. Adjustment and agriculture in Africa: Farmers, the state and the World Bank in Guinea. St. Martin's Press, NY. (iii) Ishii-Eiteman M, Ardhianie N. 2002. Community monitoring of integrated pest management versus conventional pesticide use in a World Bank project in Indonesia. *Int J Occup Environ Health* 8:220-31. (iv) Liebenthal A (Ed). 2002. Promoting environmental sustainability in development - an evaluation of the World Bank's performance. World Bank, Washington DC. (v) SAPRIN (Structural Adjustment Participatory Rev. Int. Network). 2002. The policy roots of economic crisis and poverty: A multi-country participatory assessment of structural adjustment. SAPRIN, Washington DC.

368 Pimbert M. 2012. Putting Farmers First: Reshaping Agricultural Research in West Africa. IIED Briefing. London, UK. See also www.excludedvoices.org and www.excludedvoices.org/democratising-agricultural-research-food-sovereignty-west-africa

"Training, awareness and extension services to farmers' organizations must be a key part of this transformation. We need support from FAO and the United Nations to share knowledge among partners."

H.E. Minister Nouri (Algeria). 2014. FAO International Symposium on Agroecology

Mixing of pesticides with bare hands, India. *Jayakumar Chelaton*

extent their investments, loans or grants are supporting continued or increased reliance on chemical-, water- and energy-intensive models of agriculture. Where this is found to be the case, agencies and foundations should swiftly reorient their interventions to support transitions towards agroecological farming instead.

Project funders often need to adopt a more participatory approach to projects. A study by MASIPAG, the farmers' network in the Philippines, identified that project planning and implementation are often top down, and that project beneficiaries need more voice in and control over the design and implementation of projects. Development should not be designed on behalf of farmers but by them, and should be guided by a fundamental commitment among all partners to the empowerment and self-determination of farming communities. The farmer-led approach developed by MASIPAG provides an excellent model for the design and implementation of genuinely participatory systems.[369]

Funding in support of community-led, ecosystem-based agriculture must also have a long-term element. A 20-years partnership between MASIPAG and the funder Misereor enabled the development of a productive and constructive partnership, with strategies steadily improving over time. Currently many projects are funded on too short a timeframe for full benefits to be realised. Three-year funding cycles are not conducive to sound, long-term partnership-based implementation of agroecology across communities.

11.4 International obstacles hindering scaling up and scaling out

International policy action by all state and non-state actors is needed to reverse the harmful impacts of unregulated trade and misguided international development policy and initiatives that hinder local, national and regional transformation towards ecologically appropriate, equitable and sustainable food and farming systems. Recognizing these obstacles is a critical first step to overcoming the roadblocks to effective international policy support of the agroecological transition.

Ideological bias in multilateral development aid and loan programs

Bias within institutional arrangements – shaped by unconscious assumptions, professional inertia and "path dependency," and upheld by geopolitical concerns and the influence of vested interests –

369 Bachmann L, Cruzada R, Wright S. 2009. *Food Security and Farmer Empowerment: A study of the impacts of farmer-led sustainable agriculture in the Philippines.* MASIPAG, Laguna.

Students harvesting paddy at their school, India. *Jayakumar Chelaton*

> **"The EC is committed to Agroecology and will ensure Agroecology is central to agricultural policies that reflect all dimensions of sustainability. … The EC will provide financial resources and experiences from Common Agriculture Policy and capacity development to support agroecological projects in all areas of the world."**
>
> *H.E. EU Commissioner Cioloş, 2015, Final Report for the International Symposium on Agroecology for Food Security and Nutrition, FAO*

can strongly privilege one development model over others.[370] In the case of agriculture, politically and economically dominant actors, such as the World Bank, international research centres, and many high income country aid and trade agencies, played a formative role in establishing the "Green Revolution" model as one to be replicated and emulated, at the expense of alternative models that emphasized more holistic, ecological and farmer-led approaches.[371]

The persistence of these biases today is reflected in the number of strategic initiatives of major international donors that seek to promote the adoption or purchase of external inputs designed for use in commercial or industrial agriculture by farmers in low income countries, despite evidence that reveals the damaging effects of this approach and the need to strengthen site-specific farmer-led ecological approaches that provide multi-functional benefits instead. For example, emphasis on maximizing near-term productivity in commercial agricultural systems through the research, development and marketing of modified seed, patented products and controversial biotechnologies (among other inputs) – developed almost entirely by Northern scientists or researchers at multinational biotechnology companies, without input or leadership from peasant farmers – underpins *the United States' Feed the Future Initiative*,[372] the *Agricultural Biotechnology Support Program* of the United States Agency for International Development (USAID),[373] the vast majority of agricultural development grants from the world's largest private foundation (the Bill and Melinda Gates Foundation) and the institutional orientation of leading members of Consultative

370 Dreyfus F, Plencovich C, Petit M, Akca H, Dogheim S, Ishii-Eiteman M, Jiggins J, Kiers T, Kingamkono R. 2009. Historical analysis of the effectiveness of AKST systems in promoting innovation. In: McIntyre B Herren HR, Wakhungu J, Watson RT (eds). *Agriculture at the Crossroads. Global Report*. IAASTD. Island Press,Washington, DC.

371 (i) Brooks S, Leach M, Lucas H, Millstone E. 2009. Silver bullets, grand challenges and the new philanthropy. STEPS Working Paper 24. STEPS Centre, Brighton. (ii) Dreyfus et al 2009, op cit. (iii) Cullather N. 2010. The Hungry World: America's Cold War Battle against Poverty in Asia. Harvard University Press, Cambridge, MA, and London. (iv) Brooks S. 2010. *Rice Biofortification: Lessons for Global Science and Development*. Earthscan, London. (v) Brooks S. 2011. Is international agricultural research a global public good? The case of rice biofortification. *J Peasant Studies* 38(1): 67-80

372 Feed the Future Biotechnology Program. http://www.federalgrants.com/Feed-the-Future-Biotechnology-Partnership-46219.html

373 This USAID programme partners with biotechnology industry leaders such as Monsanto, Mayco and Bayer. For details, see: http://www.absp2.cornell.edu/

> **"Agroecological approaches will be essential to achieve the goal of carbon neutrality."**
>
> *H.E. Minister Arauz-Cavallini (Costa Rica). FAO. 2015. Final Report for the International Agroecology Symposium*

Group on International Agricultural Research.[374]

Many of the aforementioned development initiatives and alliances are closely interwoven and share the same corporate and government partners. These types of bilateral and multilateral development interventions provide an effective vehicle for market entry and domination by transnational corporations, (often including the introduction or overhaul of national biosafety and seed laws to ensure protection of industry investments), but ultimately hinder the establishment of socially sustainable, ecosystem-based agriculture.

Laws of ownership over seeds, water and land

Security of tenure and access to productive resources are vital to enable farmers to invest in longer term resource-conserving strategies and meet livelihood and food security goals at household and national levels. The lack of national laws or adequate and enforceable international agreements to secure small-scale farmers' tenure, secure access to and control over productive resources (e.g. seeds, germplasm, land, water) undermines efforts to promote a conversion to sustainable practices.

Farmers' control over their own seeds is vital. *Tamil Nadu Women's Forum*

Spraying paddy, India. *Jayakumar Chelaton*

Intellectual property (IP) laws in particular have privatized seed resources, transferring ownership to commercial interests and criminalizing farmers for saving, innovating, improving, exchanging and trading seed, as agrarian societies have done for millennia.[375] Corporate ownership rules have also

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374 (i) Edwards M. 2008. *Just another emperor? The myths and realities of philanthrocapitalism*. Demos and The Young Foundation, New York. (ii) Brooks S. 2010. *Rice Biofortification: Lessons for Global Science and Development.* Earthscan, London. (iii) Brooks S. 2011. Is international agricultural research a global public good? The case of rice biofortification. *J Peasant Studies* 38(1): 67-80. (iv) Tuckey B. 2010. Starving Africa's future? Foreign Policy in Focus, 11 August. Washington, DC, Institute for Policy Studies. (v) GRAIN, 2014. How Does the Gates Foundation Spend Its Money to Feed the World? *Against the Grain,* 04 November 2014. Accessed July 4, 2015 at: https://www.grain.org/article/entries/5064-how-does-the-gates-foundation-spend-its-money-to-feed-the-world

375 McIntyre et al 2009, *op cit.* See also: LVC/GRAIN. 2015. Seed laws that criminalise farmers. Harare, Zimbabwe and Barcelona, Spain.

“Economic logic and free trade have hindered Agroecology. We need to seek new paradigms that allow for local control of seeds, trade rules that help to internalise the environmental costs of agriculture and restructuring official government agencies, research and extension services.”
H.E. Minister Arauz-Cavallini (Costa Rica), 2015, International Symposium on Agroecology, FAO

Food festival celebrating local, organic food. *Tamil Nadu Women’s Forum*

contributed to the erosion of genetic diversity, local knowledge, social equity and food sovereignty.[376] Thus corporate ownership of both productive resources and IP has not only constrained agricultural transformation towards ecosystem-based practices, but has also undermined the very foundations of equitable and sustainable development.[377]

A number of high level global and regional initiatives and public-private partnerships have emerged in recent years that have been sharply criticized for restricting farmers’ legal rights to save, access and exchange seed, while promoting chemical-intensive commercial agricultural models and increasing peasant farmers’ risk of land loss and their vulnerability to poverty and hunger. One such example is the G-8’s Global Alliance for Food Security and Nutrition led by industrialized countries, which seeks to mobilize private capital for investment in Africa. Alliance partners include multinational grain, seed, pesticide and fertilizer companies (Cargill, Monsanto and Yara among others). Nine of the 10 participating African countries have already agreed to modify their national seed laws in ways that encourage private sector investment in and protect corporate ownership of patented seeds, while curtailing farmers’ rights to plant saved seed and prohibiting the marketing of traditional seed varieties.[378]

As reported by the IAASTD, the type of technologies manufactured and owned by these agribusinesses have “primarily benefited the better-resourced groups in society and transnational corporations, rather than the most vulnerable ones” and have been assessed as therefore unlikely to address persistent hunger and poverty, and more likely to exacerbate these conditions.[379]

Likewise, African countries participating in the G-8 Alliance or receiving funding from the US Millennium Challenge Corporation (MCC) have typically been required to modify their land ownership policies to encourage private investment in land, often transforming or replacing customary and traditional systems with Western-type formal markets and establishing and formalizing mechanisms for future large-scale land acquisitions by foreign and domestic corporations.

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376 Dreyfus et al 2009, *op cit.*

377 (i) Brennan M, Pray C, Naseem A, Oehmke J. 2005. An innovation market approach to analyzing impacts of mergers and acquisitions in the plant biotechnology industry. *AgBioForum*, 8: 89-99. (ii) Pray C, Oehmke J, Naseem A. 2005. Innovation and dynamic efficiency in plant biotechnology: An introduction to the researchable issues. *AgBioForum*, 8: 52-63.

378 AFSA, GRAIN. 2015. Land and Seed Laws Under Attack: Who is pushing changes in Africa? Alliance for Food Sovereignty in Africa and GRAIN.

379 McIntyre et al 2009, *op cit.*

When peasant farmers lack secure access to land, water and seed, they are unable to invest their labour and knowledge in the long-term ecological recovery and rejuvenation of their land. Yet long-term soil, land and water management, along with seed and crop biodiversification, security of land tenure and access to and control over seeds are fundamental elements of ecosystem-based agriculture. The intervention of the G-8 Alliance and the MCC in African agriculture and the mobilization of private foreign capital and investment in Africa's agricultural and natural resources undermines local and regional efforts to adopt biodiversified agroecological farming and threatens the future of food and livelihood security of African peasant farmers.

Corporate influence over public policy and agrifood systems

Growing market concentration in multiple agricultural arenas, coupled with successive rounds of deregulation, have led to unprecedented levels of corporate influence over global and regional food and agricultural systems.[380] As corporations based in Europe and North America have extended their operations into Latin America, Asia and Eastern Europe, their global influence has expanded, with adverse consequences for small- and medium-scale farmers around the world.[381] The result has been a dramatic reduction in competition and fair access to markets for small and medium-scale producers, labour, independent retailers and consumers.

The lack of adequate anti-trust and competition laws at national and international levels, and weak judicial systems that are unable to properly enforce existing laws have supported the unprecedented pace of corporate consolidation and adverse effects on family farming over the past two decades.[382]

As consolidation has increased, a handful of transnational agribusinesses have gained growing influence over the production and distribution of food and farming, both domestically and internationally.[383] The world's largest three corporations control over half (53 percent) of the world's commercial seed market; the top 10 control over three-quarters (76 percent) and one corporation (Monsanto) controls fully one quarter of the global market.[384] This in turn has enabled them to exert significant political influence over public policy and research at national, regional and global levels, driving decisions and investment priorities consistently towards industrial models of agriculture that rely on the continual purchase of industry products such as chemical pesticides, fertilizers and patented seed.

Agribusinesses spend billions of dollars lobbying public agencies and officials, in both national and international policy-making arenas, and have, in many instances, influenced policy decisions to their benefit.[385] This influence undermines government resolve to launch

380 Hendrickson M, Miele M, Burt R, Chataway J, Cotter J, Darcy-Vrillon B, Debailleul G, Grundy A, Hinga K, Johnson BR, Kahiluoto H, Lutman P, Madden U, Navrátilová M. 2009. Changes in agriculture and food production in NAE since 1945. In: McIntyre et al, eds. 2009b. *North America and Europe Regional Report*. Vol. IV of *Agriculture at a Crossroads.* IAASTD. Island Press, Washington, DC.

381 (i) McIntyre et al 2009, *op cit.* (ii) McIntyre et al 2009b, *op cit.*

382 (i) De Schutter O. 2009. *Agribusiness and the Right to Food.* Report of the Special Rapporteur on the Right to Food to the United Nations Human Rights Council, A/HRC/13/33, Geneva, 22 December. (ii) Hendrickson et al 2009, op cit.

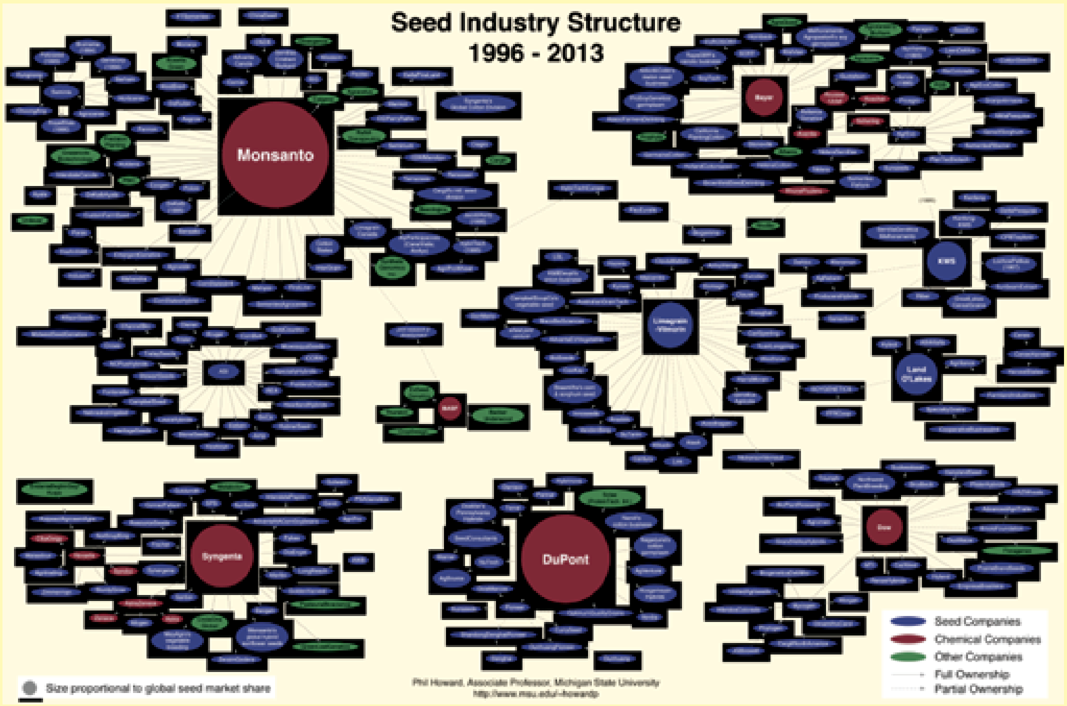
383 (i) Hendrickson et al 2009, *op cit.* (ii) Hubbard K. 2009. Out of hand: Farmers face the consequences of a consolidated seed industry. Farmer to Farmer Campaign. (iii) De Schutter O. 2010. Addressing concentration in food supply chains. Briefing note 03. United Nations Human Rights Council, Geneva, 1 December. (iii) see also Figure 11.1.

384 ETC Group. 2013. "Putting the cartel before the horse… and farm, seeds, soil, peasants, etc." Communiqué No. 111. September 2013, www.etcgroup.org

385 Ishii-Eiteman M. 2013. Democratizing agriculture to meet the needs of 21st century agriculture. In UN Trade and Environment Review, *Wake Up Before it is Too Late: Make agriculture truly sustainable now for food security in a changing climate.* UNCTAD.

country-wide transitions towards knowledge-intensive agroecological farming practices that do not ensure continual sale of industry products. It also weakens government commitment to more strictly regulate commercial actors, remove perverse incentives that favour corporate profit over public interest, revise ownership laws and restore public access to and control over productive resources (e.g. seeds, land, water) that have been privatized.

Figure 11.1: Structure of the global seed industry, reflecting consolidation over the period 1996–2013



Source: Reproduced with the kind permission of Associate Professor PH Howard, Michigan State University. 2015. http://www.msu.edu/~howardp/seedindustry.html

Unregulated trade and biased trade agreements

Global trade has significant potential to support robust national and regional economies and drive a transition towards ecological agriculture. However, trade liberalization that has opened developing-country markets to international competition too quickly or too extensively has undermined the rural sector and degraded the environment.[386] As a result, developing countries have been left with diminished capacity for food production, making them more vulnerable to international food price and supply volatility, and reducing their food and livelihood security.[387]

386 (i) McIntyre et al 2009, *op cit.* (ii) McIntyre et al 2009b, *op cit.*

387 Khor M. 2008. The impact of trade liberalization on agriculture in developing countries: The experience of Ghana. Third World Network, Penang.

A fundamental reform of global trade rules towards fair and ecological agriculture has been proposed and described by a number of experts.[388] Yet progress towards establishing a new and fair trade regime remains constrained by the influence of a few powerful countries and commercial interests operating in global policy arenas such as the World Trade Organization (WTO). Anti-democratic processes and asymmetrical power relationships within the WTO prevent civil society and governments of developing countries from securing reform of the global trade regime recommended by, for example, the IAASTD and UNCTAD.[389]

Agroforestry in a tea plantation, India. *Jayakumar Chelaton*

11.5 Policies to democratize the food system: A requirement for successful transformation to agroecology

Robust policy and practice options to enable a global transformation towards ecosystem-based farming – best exemplified by agroecology – exist and were identified at the start of this chapter (Box 11.1). However, powerful commercial interests, weak or captured public sector actors and lack of political will continue to hamper the establishment and meaningful implementation of these progressive options. The constraints – outlined in section 4 above – are systemic; a few superficial changes will not make a significant enough difference to achieve concrete outcomes. Rather, highly targeted and strategic interventions are needed that tackle the core of the problem and thereby rebalance power in the agrifood system.

Transplanting paddy, India. *Jayakumar Chelaton*

The democratizing of institutions that shape global food and agriculture requires both courage and sustained engagement by visionary political leaders, researchers, private sector actors and all sectors of civil society. The participation of all stakeholders, particularly historically marginalized

388 e.g. (i) Izac AM, Egelyng H, Ferreira G, Duthie D, Hubert B, Louwaars N. 2009. Options for enabling policies and regulatory environments. In: McIntyre et al 2009, op cit. (ii) UNCTAD 2013, *op cit*.

389 World Network, Penang. (ii) Khor M. 2009. The food crisis, climate change and the importance of sustainable agriculture. *Environment & Development Series* 8. Penang, Third World Network. Paper presented at the High-Level Conference on World Food Security: The Challenges of Climate Change and Bioenergy, Rome, 3–5 June. (iii) UN-DESA/UNEP/UNCTAD. 2011. *The Transition to a Green Economy: Benefits, Challenges and Risks from a Sustainable Development Perspective.* Report by a Panel of Experts to the Second Preparatory Committee Meeting for United Nations Conference on Sustainable Development. Prepared under the direction of: Division for Sustainable Development, UN-DESA, United Nations Environment Programme and UN Conference on Trade and Development. P. 69-74.

Waiting for a pest. *Jayakumar Chelaton*

rural communities in developing countries, as equal partners – and not simply as stepping stones in a "consultative" process – is an essential ingredient for revitalizing local and regional food systems, driving innovation that meets global food and livelihood needs, and building robust local economies.

A progressive approach to overcoming the institutional and market-power constraints identified above should include commitment by international actors to undertake the following:

- UN agencies assist national governments and regional bodies in undertaking a full cost analysis of national, regional and global food and agricultural systems
- International donor and development agencies provide institutional support for small-scale farmers, and women's and workers' organizations that strengthens their negotiating power in markets dominated by transnational buyers
- National and international competition policies need to be strengthened and broadened, to reverse trends in farm and agribusiness concentration, end unfair business practices across the global food production and supply chain, and curtail dominant buyer power which threatens small-scale farmers' food and livelihood security[390]
- Private-public partnerships and public policy-making processes need to be governed by strong, enforced codes of conduct, in order to minimize potential conflicts of interest which unfairly or inappropriately benefit private sector actors
- An International review mechanism should be established, to investigate agri-food sector concentration, anti-competitive practices and impacts across national borders, develop standards of corporate behaviour and recommend policy options
- Intellectual Property and other ownership rules and incentives should be revised in order to reorient public policy and research towards equitable and sustainable development goals
- Conflict of interest in partnerships, investments and policy-making processes must be prevented by establishing an appropriate process
- Developing countries' capacities for trade analysis and negotiation should be improved, leading to more equitable trade rules. Strategic impact assessments could provide useful empirical evidence of the social, environmental and economic trade-offs of various trade instruments
- Financial speculation over food commodities that distorts markets and price signals must be retrained
- Democratic decision-making processes must be established and strengthened, including increased civil society participation in politics and in policy-making processes

A twofold approach is necessary to enable local, national and indeed global transformation towards ecosystem-based agriculture. On the

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390 see De Schutter O. 2010. Addressing concentration in food supply chains. Briefing note 03. United Nations Human Rights Council, Geneva, 1 December.

one hand, international actors must support small-scale farmers and their organizations in their transition towards agroecology; build local and national capacity in agroecological research, extension and education; and establish supportive economic policies, financial incentives and market opportunities for farmers practicing ecosystem-based agriculture. At the same time, international actors must commit themselves firmly to overcoming the political, institutional and market-power constraints that prevent the scaling up and out of agroecology, by restraining corporate power and influence over public agencies and democratizing the agri-food system at all levels and across all relevant institutions.

Glossary of acronyms

a.i. = active ingredient

BRS+ Basel, Rotterdam and Stockholm Conventions

CAN = Community Agroecology Network

CBB = coffee berry borer

CMSA = Community Managed Sustainable Agriculture

ESCAP = The United Nations Economic and Social Commission for Asia and the Pacific

FAO = Food and Agriculture Organization of the United Nations

FFS = Farmer Field Schools

GEF – Global Environment Facility

ha = hectare

HHPs = highly hazardous pesticides

IAASTD = The International Assessment of Agricultural Knowledge, Science and Technology for Development

IPM = Integrated Pest Management

IPPM = Integrated Production and Pest Management

JMPM = FAO/WHO Joint Meeting on Pesticide Management

NGO = non-governmental organization

OPs = organophosphate insecticides

PAN = Pesticide Action Network

SAICM = The Strategic Approach to International Chemicals Management

UNCTAD = The United Nations Conference on Trade and Development

UNDP = The United Nations Development Programme

UNEP = The United Nations Environment Programme

WHO = The World Health Organization

Additional Resources

The Development Fund, Norway. 2010. *A Viable Food Future.*

University of California Berkeley: Ponisio et al. Diversification practices reduce organic to conventional yield gap. Proc, Royal Society London, 10 Dec 2014. http://rspb.royalsocietypublishing.org/content/282/1799/20141396

Oxford University: Tuck, S. et al. Land-use intensity and the effects of organic farming on biodiversity: a hierarchical meta-analysis. J Appl Ecol 51(3):746-55.

Chapter 8.1 and 8.2:

Visit the ***Growing Coffee without Endosulfan Project*** webpages: http://www.4c-coffeeassociation.org/resources?category=endosulfan-project to download:

- Set of 4 YouTube videos on Experiences of certified farms in managing coffee berry borer: (1) Using cultural controls (2) Use of biopesticides based on the fungus *Beauveria bassiana* (3) Using traps (4) Monitoring and decision making (*videos available in English, Spanish, Portuguese and French versions*)
- 19 Farm Case Studies
- Interactive comparison table of different IPM methods for CBB
- Experiences with: Cultural Controls: *Beauveria* biopesticide; Monitoring and decision-making; Use of traps with attractant; Use of chemicals: Risks of using endosulfan and stewardship issues (*contain practical guidance compiled from farmer and technical support staff*)

Chapter 9.1

A lot of further reading sources will inevitably be in French, primarily but not exclusively online. The French government has published a number of English background documents at intervals. Here is a small selection:

- Web page about the Loi d'Avenir in English: http://agriculture.gouv.fr/changing-production-models-to-combine-economic-and-environmental-performance
- Downloadable English guide to the Loi d'Avenir: http://agriculture.gouv.fr/IMG/pdf/ProjetGB_cle8a75db.pdf
- Web page about the first phase of Ecophyto in English: http://agriculture.gouv.fr/Ecophyto-in-English-1571
- Downloadable English guide to Ecophyto published in 2008: http://agriculture.gouv.fr/IMG/pdf/PLAN_ECOPHYTO_2018_eng.pdf

Replacing Chemicals with Biology:

Phasing out highly hazardous pesticides with agroecology

About the authors:

Dr Meriel Watts

Dr Meriel Watts and her partner run a small organic farm on Waiheke Island in New Zealand. They supply the local market with a great diversity of foods including more than 25 types of vegetables and fruit, as well as flowers, herbs, eggs, honey and olive oil. Meriel has been involved in the organics sector in New Zealand for more than 20 years. She has also been involved in pesticide issues for more than 25 years, including as a member of New Zealand's registering authority. She is Senior Technical Advisor to PAN Asia and the Pacific, co-chair of IPEN's Pesticide Working Group, Co-ordinator of PAN Aotearoa New Zealand, one of the founders of New Zealand's Weed Management Advisory, and a committee member of Australia's National Toxic Network. Previous books include *Poisoning the Future: Children and Pesticides* and *Pesticide and Breast Cancer: A Wake Up Call*, both published by PAN Asia and the Pacific. Her PhD was on *Ethical Pesticide Policy: Beyond Risk Assessment*.

Dr Stephanie Williamson

Dr Stephanie Williamson trained as an ecologist/biologist, with an MSc in Integrated Pest Management (IPM) and PhD on pesticide use and impacts on African smallholders. Formerly at CABI Bioscience working on biological control and IPM training, she joined Pesticide Action Network UK in 2000. She has over 20 years' experience relating to pesticide issues and sustainable agriculture in Africa, Latin America, Asia and Europe. Her work covers promotion of ecologically informed alternatives to hazardous pesticides, pesticide policy assessment and advising food and fibre sustainability standards and companies on strategies for pesticide use and risk reduction. She authored three chapters for *The Pesticide Detox* (Ed. Pretty, 2005) and has written course modules for the University of Cape Town Diploma in Pesticide Risk Management. She works closely with Rotterdam Convention staff at FAO and UNEP to raise policymakers' awareness on ways to phase out Highly Hazardous Pesticides.

About PAN

Pesticide Action Network (PAN) is a network of over 600 participating nongovernmental organizations, institutions and individuals in over 90 countries working to replace the use of hazardous pesticides with ecologically sound and socially just alternatives.

PAN was founded in 1982 and has five independent, collaborating Regional Centers that implement its projects and campaigns.

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