The background of the book cover is a dark, textured image of leaves and branches. Overlaid on this is a large, semi-transparent red circle. Inside the circle, there are faint, overlapping lines that form a grid or a similar geometric pattern. The text is centered within this red circle.

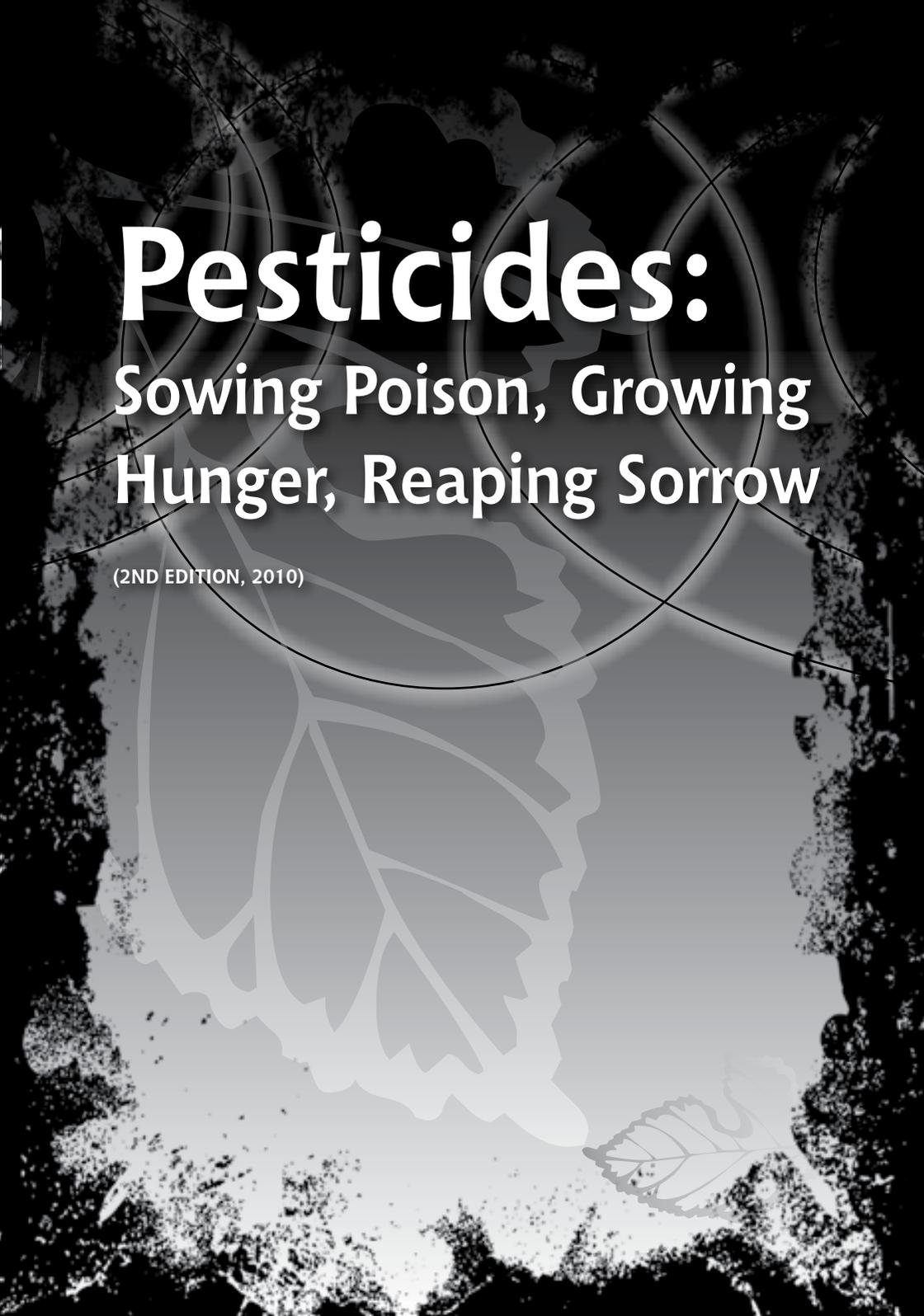
# Pesticides:

## Sowing Poison, Growing Hunger, Reaping Sorrow

(2ND EDITION, 2010)

Meriel Watts, PhD





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### About the Author

Dr Meriel Watts is currently co-ordinator of PAN Aotearoa New Zealand, a member of the PAN AP Steering Council, PAN AP's Senior Science Advisor, and is co-Convenor of its Task Force on Pesticides. Meriel has a Bachelor of Agricultural Science, diplomas in homoeopathic and naturopathic medicine and a PhD in pesticide policy. Meriel also has qualifications and experience in agricultural science, as a natural health practitioner, and is an organic grower. She has been a member of the New Zealand government pesticides registering authority and a member of numerous government committees on pesticides. Her published work includes *Poisons in Paradise: Pesticides in the Pacific*, *The Poisoning of New Zealand*, *Reducing Reliance*, and several monographs on pesticides.

### **Pesticides: Sowing Poison, Growing Hunger, Reaping Sorrow**

(2nd Edition, 2010)

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Comments and inquiries may be forwarded to:  
Pesticide Action Network (PAN) Asia and the Pacific  
P.O Box: 1170, 10850 Penang, Malaysia  
Tel: (604) 6570271/6560381 Fax: (604) 6583960  
E-mail: [panap@panap.net](mailto:panap@panap.net)  
Homepage: <http://www.panap.net>



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*Pouring paraquat, a highly hazardous pesticide, into spray tank by hand, Indonesia*

# 1. Introduction

Food security is the ultimate problem the world is facing today. An estimated 861.6 million people lack adequate access to food. Of these, 62 per cent (527.2 million) are in the Asia Pacific region, predominately in South Asia (299.6 million) and East Asia (162.9 million) (FAO 2008a). In the year 2000, 27 per cent of pre-school children in developing countries had stunted growth, with this figure rising to 50 per cent in East and Central Asia. The cause: poor quantity and diversity of foods leading to widespread deficiency of vitamins and minerals. Yet at the same time, 20-23 per cent of people in countries like USA and New Zealand are obese (FAO 2008b).

The relationship between food security and food production is a complex one, but food security is mainly a political problem—one of control, profit, inequality, over-consumption of the rich, and the lack of will to ensure people do not go to bed hungry at night. This is widely recognised and a well-canvassed territory. But the myth that more pesticides means greater productivity which means fewer hungry people, lives on and is still a powerful driver in agricultural policies worldwide. “If farmers use more pesticides, our food problems will all be solved”, has been the institutional mantra of the last 50 years. Now, added to that is the new version of the old theme: if farmers use modern biotechnology, we can banish hunger in developing countries. The corporate giants that control modern industrial agriculture have a vested financial interest in

prolonging the perpetuation of the myth that only using more of their products will feed the world. As more and more consumers in Europe demand organic produce, the chemical companies have intensified their sales pitch in the South, that part of the world with the richest tradition of sustainable food production—until the last 40 years brought these corporates striding across the Southern landscape. They have come to control the food production system for their own profits, not to ensure the hungry are fed. And now, as peak oil becomes a reality with rising costs of crude oil and diminishing reservoirs, they have also come to divert food and food-producing lands into the production of biofuels to feed the cars of world, at the expense of the people who most need food.

Increasing the yields of crops will not by itself solve the problem of hunger. What matters most is who produces the food, who has access to the technology and knowledge to produce it, and who has the purchasing power to buy it (Pretty & Hine 2001). And who has access to the land to grow it, for rural poverty is highly correlated to access to land (ESCAP 2002). Rising output has been accompanied by rising input costs and rising food prices, reducing the food purchasing power of the poor. In 2008, the world was stunned by the rapidly escalating food prices leading to widespread food shortages, food protests, hoarding and stockpiling. At the same time as the number of people lacking food is soaring, so are the profits of the transnational corporations that control the food trade, and those companies that speculate in commodities. 100 million more people faced hunger in 2008, and 37 developing countries were in urgent need of food, whilst Monsanto's net income doubled, the net income of Cargill—the world's biggest grain trader—soared by 86 per cent, and Archer Daniels Midland—one of the world's largest processors of soy, corn and wheat—increased its earnings by 42 per cent. As the credit crunch hit financial markets, investors turned their sights on commodity speculation—betting on the future price of foods—resulting in an almost fivefold increase in turnover in investment in grain and meat futures in one year (Lean 2008). Speculative investment in commodities



*Woman and child in vegetable farm where pesticides are commonly used, Indonesia (Source: Gita Pertiwi)*

reached a staggering US \$260 billion in March 2008 (Guzman 2008). Thus, the real reason for hunger is not a lack of production, but the trade liberalisation agenda that has delivered excessive control of the global food system into the hands of a small number of powerful corporations and financiers with the end result that both farmers and consumers are facing increasing poverty and hunger.

Women are disadvantaged in agricultural systems, producing up to 80 per cent of food, but owning little land and with access to less than 10 per cent of credit and extension advice (Pretty & Hine 2001). What land they do own or have access to, is often marginal land rejected by the industrial agricultural complex as worthless for production. The proportion of rural women to men is growing: in 1993 it was reported that 35-40 per cent of all households were headed by women, and this figure is likely to have grown over the ensuing 15 years (Mumtaz 1993). These

women are the poorest of all rural dwellers. Pretty & Hine (2001) put it very simply: “Women and children need more food”.

Food security requires that all people have physical, social and economic access to a sufficient supply and diversity of safe, nutritious food throughout the year, to meet their dietary needs and food preferences. Just as nature is not sustained by a monocultural system, neither are humans sustained by a mono-food industrialised diet. One of the features of many sustainable agricultural projects, which do not rely on pesticides, is the great increase in diversity of the food supply. This can be achieved simply by incorporating fish, crabs or shrimps into the production system, and growing vegetables on rice bunds and in kitchen gardens. It is not achieved by using pesticides.

This analysis therefore, sets out to lay to rest the myth that pesticides are needed to feed the world. It addresses the role of pesticides in



*Biodiversity based ecological agriculture, Philippines (Source: Lorenz Bachmann)*

an industrial complex which has eroded traditional and organic agricultural systems that once provided the food people need, causing a shift from the production of food to the production of crops for cash. It addresses the poisoning of people, the contamination of the environment, the advent of insect resistance, and the reduction in the biodiversity that sustains an agroecosystem. It explores the greater productivity that can be achieved by avoiding the use of pesticides at the same time as enabling farming communities to regain their dignity and independence.

Working with nature, encouraging biodiversity, and using traditional knowledge and local inputs: these are how the world's people can be fed. These require ensuring that small farmers gain control of their land and produce, and that they are empowered to make their own decisions, not have them dictated by international powerbrokers such as agribusiness conglomerates and financial institutions. These involve a decentralised, democratic approach, putting people not pesticides first. So, in essence, a focus on production does not ignore the political issues: removing pesticides from the equation leads inevitably to a change in the power relationships within the international agricultural system, delivering it back into the hands of farmers and communities. Pesticides are not primarily about production, but are really about power and greed. Ensuring that all people receive adequate food requires a focus on food sovereignty rather than on increased production, where those who need food have access to the land, resources, knowledge, and skills to provide a nutritious and varied diet for themselves, their families and their communities. 🐞



*Farmers in Barangay Dao, Alimodian, Iloilo (Philippines) rely on collective work ("dagyar") in achieving food security (Source: Masipag-Visayas)*

## 2. The industrial agricultural system

More than one-quarter of the world's land area is used for agriculture. Over the past 50 years, the destructive agricultural practices that are part of the industrial agricultural system have degraded almost two-thirds of this total area, through erosion, salination and nutrient depletion. Pesticides are the crutch of this system. They enable monocultural enterprises that are attractive to pests and that encourage erosion through use of herbicides to remove weeds which otherwise hold soil in place, provide habitat for beneficial insects, and feed people. Pesticides allow use of modern 'high-yielding' disease-susceptible hybrid seeds that are bred only to increase yield in a one-dimensional sense, e.g. to increase yield of grain at the expense of overall biomass per hectare or total productivity.

In their turn, these varieties require substantial inputs, leaving the farmer often in a vulnerable financial position, facing debts from which they may never recover if the crop fails or the market price drops too low. Pesticides allow use of chemical fertilisers that produce soft disease-prone plants, and contaminate waterways and groundwater. The chemical fertilisers that come with the pesticide package allow the farmer to boost yield without using compost. But the resulting failure to return organic matter to the soil eventually leads to a break down in soil structure and health, a build up of diseases and insects, and a loss of productivity. Take away the pesticides and the farmer is forced to return to a system

that enriches the soil, seeds that are naturally resistant, and a greater biodiversity that protects the crops and provides a greater level of overall production.

## **2.1 THE GREEN REVOLUTION**

Chemical fertilisers, pesticides, irrigation, new high-yielding varieties of staple crops, new crops such as cotton, oil crops, vegetables, fruits: these were the tools of the Green Revolution that took place in Asia from the late 1960s to 1980s.

The Green Revolution has been hailed by some because it increased yields for awhile, but it also brought with it poisoning of people and animals, loss of genetic diversity of crops, loss of traditional knowledge and practices, loss of local biodiversity, loss of soil fertility, farmer dependency on inputs with consequent indebtedness, and an increase in the number of people living in poverty in some countries in the region (IAASTD 2008).

The first pesticides used were insecticides, applied to the so-called high value crops, i.e. grown for cash: vegetables, fruit, cotton, plantation crops. Then in the 1970s and 1980s, herbicides were introduced to save on labour (Kaosa-ard & Rerkasem 1999).

Developing countries overall accounted for about half of all pesticides used (Agrow 2007a) in 1995. In 1998, Asia accounted for 16 per cent of global pesticide sales, but this rose to 23 per cent in 2006 (Agrow 2007a). Over the years 1977-1997, there was a per annum increase in pesticide use of 7.5 per cent, in terms of US Dollar value per hectare of arable land, averaging 9.94 kg/ha.

In the later part of that period (1994-96), the amount of pesticide used began to drop, to an average of 5.87 kg/ha, whilst use of chemical fertilisers escalated.

This is how the Asian Development Bank described the advent of pesticide problems in Asia:

***“The problem of pesticide use in foodgrain production is mostly associated with rice and is a consequence of the Green Revolution. In order to reduce crop losses from insect pests, the technology packages that delivered the first HYV (IR8) seed to farmers almost always included insecticides, usually one of the extremely potent organochlorines.***

***However, the organochlorines killed not only the insect pests but also their natural predators. Insect ecologists tried to draw attention to this from the early 1960s, but were ignored for the most part. Then, the pests began to develop resistance to the pesticides, especially to some of the organophosphates that were replacing organochlorines. Attempts to combat these developments proceeded by their increasing the dose or combining several chemicals into even more lethal pesticide “cocktails”. These only worsened the situation because they served to kill even more of the pests’ natural predators and further increased the evolutionary pressure on pests to develop even greater resistance to the pesticides.***

***“The Green Revolution technology itself has intensified the pest problem and in many ways, has stimulated the increased use of pesticides. Large monocultures and the year-round planting of single crops create ideal conditions for massive pest outbreaks. The high levels of nitrogen in the applied fertilisers make plants more susceptible to certain pathogens (e.g. blight in rice) and insects.”*** (Kaosa-ard & Rerkasem 1999, Ch1, p 70)

The Green Revolution’s ‘high yielding’ varieties had a disastrously eroding effect on agricultural biodiversity. The United Nations’ Economic and Social Commission for Asia and the Pacific (ESCAP 2002) expected

that by 2005, India would be producing 75 per cent of its rice from just 10 varieties compared with the 30,000 varieties traditionally cultivated.

The 'high-yielding' varieties needed water. In Thailand, for example, this led to the development of irrigation projects which required massive capital investment and the involvement of the World Bank. The World Bank required Thailand to develop national economic development plans.

The first of these was in 1961-66 which headed Thailand down an agricultural path that required improving yield and productivity, and on the one hand, provide foreign currency to finance the industrialisation scheme, and on the other, provide cheap food for the rapidly growing population. Double and even treble rice cropping ensued in the central plain area as farmers faced low prices and the need for massive applications of fertilisers and pesticides. Farmers caught between the input costs and the low output prices found that the Green Revolution further aggravated rural impoverishment and "has had tremendous negative impacts on rural natural resources, undermining the basic livelihood of rural farmers" (ESCAP 2002, p174). Millions of small farmers were driven to indebtedness and forced off their farmland.

In the Philippines, rapid agricultural growth in the 1970s and early 1980s, resulting from the introduction of the 'high-yielding' varieties and chemicals, was accompanied by decreased wages, increased unemployment, and seasonal indebtedness.

A study by the Agency for Community Education and Services, published in the mid-1980s as a book called *The Miracle That Never Was*, showed that rice farmers were economically better off before they shifted to the intensive monoculture of high-yielding varieties. Their previously diverse farming systems and sources of food and income made them less vulnerable to price manipulations and climatic effects (ESCAP 2002).

## GREEN REVOLUTION DECREASES YIELDS

**In many cases, the Green Revolution did increase production of a single commodity, although often, at a terrible human cost. But it didn't always increase production: ESCAP (2002) recounts how historical evidence indicates yields were once comparable or even greater than those resulting from the Green Revolution technologies. In the eighteenth century, British engineer Thomas Barnard surveyed 800 villages near Madras, India. He found that the average yield of wet-land rice was 3.6 tons per hectare, with 130 villages reaching 8.2 tons per hectare, and others exceeding 10 tons per hectare—compared with present day average of 3.1 tons with extensive use of chemical fertilisers and pesticides. The impressive production was based on agroecological practices, together with the 30,000 varieties of rice “delicately fitted into their appropriate ecological niche”.**

It now seems that the claims made about the positive impacts of the Green Revolution may in fact have been rather overstated. It has been claimed that the Green Revolution is responsible for the drop in the World's hungry from 942 million to 786 million, over the period 1970-90. However, this 16 per cent drop in hunger disappears if China is taken out of the equation. In China, crop yields rose by 4.1 per cent per year from 1978 to 1984, the period during which that country introduced its third land revolution, the 'household responsibility system'. This system restored farmers' powers to make decisions about land use that they had been denied under collectivisation, and it also brought significant increases in the price of grain—corresponding with the increase in production. The number of hungry in China dropped from 406 million to 189 million—but was this due to the Chinese revolution rather than the Green Revolution? (Rosset et al 2000; Ching 2008)

If these figures for China are set aside, the number of hungry people in the world actually increased by 11 per cent during the Green Revolution, from 536 to 597 million (Paul & Steinbrecher 2003). “In South Asia, there was 9 per cent more food per person by 1990, but there were also 9 per cent more hungry people. Nor was it the increased population that made for more hungry people. The total food available per person actually increased. What made greater hunger possible was the failure to address unequal access to food and food-producing resources” (Rosset et al 2000).

Finally, the Green Revolution yields have not been sustainable. The first signs of failure appeared in the Philippines - in Luzon and Laguna, where yields peaked in the 1980s, levelled off and are now declining. In Bangladesh, during the Green Revolution, 1 kg of synthetic nitrogen fertiliser produced about 20 kg of grain; now, it produces only 8-10 kg (Hossain et al 2007). This pattern is emerging throughout Asia. It appears that the irrigation, compaction of soil through use of heavy machinery and the chemical inputs have had serious impacts on the soil health, reducing its ability to sustain healthy crops (Paul & Steinbrecher 2003). The organic matter content of a healthy productive soil should be about 3.5 per cent, but in the rice fields of Bangladesh it is now mostly less than 1.7 per cent (Hossain et al 2007).

## **2.2 THE CHEMICAL CORPORATIONS**

The main reason pesticides are so prevalent in the world today is that there is a huge multi-billion dollar industry behind them, exerting undue influence on international standard setting bodies, national governments, and local communities. The enormous influence these chemical corporations wield, because of their economic power, is a major factor in the persistence of pesticides in agriculture despite the mounting evidence of environmental contamination, human poisonings, and great-

## FROM WAR CHEMICALS TO AGROCHEMICALS

**The history of chemical inputs in farming reveals a close relationship between military technology and the agrochemical industry.**

**World War I:** At the beginning of this war, the Allied blockade shut off the Germans' access to Chilean nitrate, used for explosives. So, using the previously known but not commercialised Haber-Bosch process for fixing nitrogen from the air, the Germans developed enormous production capacity and huge stockpiles of nitrates. When the market for explosives disappeared after the war, these were diverted into nitrogenous fertilisers, and an agricultural input market was born (Lutzenberger & Halloway 1998).

**World War II:** This war gave birth to the pesticide industry. DDT's insecticidal properties were discovered in 1939, and throughout the war, the chemical was used to control the lice in Europe and mosquitoes in the Pacific that plagued soldiers (Whorton 1974). After the war, the huge production facilities found a ready market in agriculture and the era of poisoning began in earnest—even though the first environmental problems were recognised in 1944 (Wildavsky 1995), bioaccumulation was noted in 1945, and human health effects by 1950 (Laug et al 1950).

This war also gave a big push to the development of the organophosphate insecticides. Bayer, amongst others, carried out research into alternatives to the use of poison gases, and came up with the phosphoric acid esters. After the war, they turned their attention to agriculture, reasoning that what kills people should also kill insects (Lutzenberger & Halloway 1998). It is ironic that it has taken so long to convince governments that what kills insects also kills people. Many organophosphates are still widely used in agriculture throughout Asia, exacting a terrible human toll.

**USA/Viet Nam War:** this war is widely known for the inhumane actions of the United States in drenching the Vietnamese countryside with the

defoliant Agent Orange, a mixture of two agricultural herbicides 2,4-D and 2,4,5-T. What is not so well known is that these herbicides were developed during World War II. Shortly before the end of the war in the Pacific, an American freighter was on its way to Manila with a load of herbicides of the 2,4-D and 2,4,5-T group. The intention was to starve the Japanese by destroying their crops through aerial spraying of the herbicides. “The Boat was ordered back before it arrived. Another group of Americans had dropped the atom bomb . . .” (Lutzenberger & Halloway 1998).

er yields achieved when the chemicals are replaced by agroecological practices. As Dr. Neil Pearce (2008) of Massey University wrote: “For every independent epidemiologist studying the side effects of medicines and the hazardous effects of industrial chemicals, there are several other epidemiologists hired by industry to attack the research and to debunk it as ‘junk science.’”

But it does not stop there. Sunita Narain (2008) of India’s Centre for Science and the Environment describes the extraordinary lengths the Indian pesticide industry goes to in order to harass and intimidate people working to protect the environment and people from pesticides:

*“We have received dozens of legal notices from this industry, threatening dire consequences. Every time we have replied to these notices, stating the facts, but there has been no follow-up. Instead, another notice for some other frivolous reason gets sent, threatening dire consequences. A year ago, they hit a real low when they began circulating obscene cartoons of me. . . . Last week, they decided to up the ante—to target my house so that they can harass my 80-year old mother.”*

The pesticide industry is highly competitive, constantly jostling for control of the market. Over recent years, a series of mergers and buy-outs has resulted in over 95 per cent of the global pesticide trade being controlled by just 20 companies, with the top six companies accounting for 75 per cent of the market and all of these heavily involved in GE seeds as well. Monsanto, Dupont and Syngenta control 97 per cent of GE seeds (Dinham 2007). Between them, Bayer and Syngenta control 38 per cent of the pesticides market (Dinham 2007). Hence, these big six (the other members are BASF and Dow) control huge portions of the global agricultural system. And they continue to grow: in 2007, they all posted increased returns in pesticides sales between 8 and 14.2 per cent above their 2006 sales (Agrow 2007b).

**Table 1: Top 20 Pesticide Companies in 2006**

		<i>Sales (US\$ millions)</i>
1. Bayer	Germany	\$6,698
2. Syngenta	Switzerland	\$6,378
3. BASF	Germany	\$3,849
4. Dow AgroSciences	US	\$3,399
5. Monsanto	US	\$3,316
6. DuPont	US	\$2,154
7. MAI	Israel	\$1,581
8. Sumitomo Chemical	Japan	\$1,312
9. Nufarm	Australia	\$1,261
10. Arytisa LifeScience	Japan	\$941
11. FMC	US	\$767
12. Cheminova	Denmark	\$604
13. United Phosphorus	India	\$477
14. Chemtura	US	\$360
15. Isihara Sangyo Kaisha	Japan	\$359
16. Nissan Chemical	Japan	\$348
17. Sipcam-Oxon	Italy	\$341
18. Kumiai Chemical	Japan	\$336
19. Nippon Soda	Japan	\$312
20. Nihon Nohyaku	Japan	\$302

Source: Agrow 2007a.



Their *raison d'être* is to make money, not to feed the world. They push pesticides through aggressive multi-million dollar advertising campaigns that can be both coercive and underhand. They were reported in 2002 to spend an estimated US\$1 billion annually on advertising and marketing in Asia (EJF 2002).

By 2006, global pesticides sales had risen to US \$32.9 billion, and are expected to grow by only 0.8 per cent per annum between 2006 and 2010 (GM seeds are expected to grow by 6.2 per cent annually) (Agrow 2007a). The Asian pesticide market forms a substantial part of the global market: by the year 2000, the Asia-Pacific market was 25.4 per cent of the global market. In that year alone, sales in the region rose by 10.5 per cent, with total sales reaching US\$7.6 billion. But in recent years, the growth has slowed, even reversing at times, and had fallen to 23 per cent of the global market by 2006, with Eastern Europe taking over as the big growth area, and the Middle East and Africa expected to take over before 2010 (Agrow 2007a).

Bringing new products into the northern markets, which are generally static, requires heavy investment in research, and the costs of this are covered by the expansion of sales of older products into, particularly, the lucrative Asian market. The FAO and WHO have warned that 30 per cent of pesticides marketed in developing countries do not meet internationally accepted quality standards and “frequently contain hazardous substances and impurities that have been banned or severely restricted elsewhere” (SEPP 2000). Most of the top ten pesticide companies have their homes in Europe and USA, countries that have removed many of these hazardous pesticides from their own agricultural systems because of human health and environmental effects. Yet these companies are free to push the same poisons onto developing countries—Bayer Germany’s continued production of endosulfan, banned throughout Europe, is a classic example. Paraquat, the product of Syngenta of Switzerland, is pumped out in huge quantities, with 70 per cent of it going to Asia, Cen-

tral America, the Caribbean and South America—despite having its listing in the EU’s Annex 1 permitted list annulled by the European Court in 2007 (Court of First Instance 2007). This practice can only be described as immoral and a gross violation of human rights.

Yet, even these companies recognise that they and their products are tainted.

Aware of their poor image, stemming from Rachel Carson’s book *Silent Spring*, and the work of civil society groups like PAN, these companies are reinventing their public face. Together with their sibling, the biotechnology industry, they market themselves as the “LIFE SCIENCES”, in an effort to appear positive and to promote an image of superior scientific credibility. They have aggressively sought the moral high ground, branding their products as

- feeding the world
- protecting the environment
- able to be used safely in developing countries
- IPM-friendly (Dinham 1999).

In support of these claims, they have ‘invented’ the concept of conservation tillage, a benign sounding name for broadscale herbicide application, which at the same time, implies that traditional tillage is anti-conservation. Yet, farmers have used equivalent soil conservation strategies for hundreds of years without recourse to toxic herbicides. The corporations claim their products are IPM-friendly even when they destabilise the agroecological system: for example, Bayer’s fipronil and Syngenta’s lambda-cyhalothrin are reported to have negative impacts on natural pest controls and to have the potential to promote severe outbreaks of disease in Viet Nam (EJF 2002). Endosulfan is claimed by its manufacturers (ERMA NZ 2008) to be IPM-friendly, yet it is highly toxic to beneficial insects (e.g. Bostanian & Akalach 2006). It seems then that the chemical



*A Flux (Dupont) banner, India (Source: Thanal)*

companies' marketing strategies actually hinder attempts to expand sustainable agriculture (EJF 2002).

Further, in an attempt to 'green' the Green Revolution, they attempted to hijack the concept of ecological agriculture, re-branding it as 'ecoagriculture' with practices that are in direct contravention of the principles that define ecological agriculture and agroecology. Biotech and pesticide companies, such as Syngenta and Bayer CropScience, together with CropLife International, the global network representing the interests of the plant science industry, have become members of 'Ecoagriculture Partners', a consortium of organisations whose strategy to protect wildlife includes using chemically intensive agriculture, large scale plantations, and genetic modification (Altieri 2004). Yet, the principles of ecological agriculture promote something very different: the utilisation of natural methods of soil fertilisation and pest control in place of chemicals and

genetic modification, with a high degree of biological diversity within the agroecological system. It draws on the best practices of organic, biodynamic, regenerative, low external input, traditional and permaculture systems, and protects the rights and livelihoods of small farmers and rural communities (Watts 1991; Clunies-Ross et al 1992). Agroecology is described as “a truly pro-poor farmers’ science”, which encompasses land distribution, indigenous people and farmers’ rights, the impact of globalisation on food security, and of biotechnology on traditional agriculture, as well as measures to enhance functional biodiversity within the agroecosystem (Altieri 2004).

In one pernicious marketing campaign in Malaysia, ICI Agrochemicals (now Syngenta), took out huge print advertisements in 1992 declaring “Paraquat and Nature working in perfect harmony”, when in fact, paraquat accumulates in soil and poses a risk to non-target terrestrial and aquatic vegetation, is highly embryotoxic for amphibia, acutely toxic to birds, and poses a risk of sublethal poisoning for wildlife (US EPA 1997; Vismara et al 2000; Madeley 2002). In Guatemala, images of a scantily clad blonde woman were used, again by ICI, to promote the herbicide Fusilade (fluzifop-p-butyl) (Dinham 1999).

As a result of such seductive marketing campaigns, pesticides have become a status symbol in countries such as Cambodia. This may be in part because the Khmer translation for the word pesticide includes the word medicine. It may also be in part because of a perception that pesticides equate with modernity (EJF 2002).

These transnational corporations also lobby international organisations, such as FAO and Codex<sup>1</sup>, to weaken guidelines and they influence national governments to weaken regulations, if possible, replacing them

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<sup>1</sup> The Codex Alimentarius Commission was created in 1963 by FAO and WHO to develop food standards, guidelines and related texts such as codes of practice under the Joint FAO/WHO Food Standards Programme.

with voluntary codes that leave control in the industry's hands. For example, under industry influence, Codex progressively raised the maximum residue level for glyphosate in soybean first to 5 mg/kg and then to 20 mg/kg, without any public consultation or discussion. Monsanto then applied to the Australia New Zealand Food Authority to raise the allowable level in soybean in those countries from 0.1 mg/kg to 20 mg/kg, citing international harmonisation as the reason (PAN AP 1999).

The voluntary codes and guidelines give the appearance that the industry is cleaning itself up, that it is working to minimise problems, but in reality these codes are often window dressing, allowing business as usual behind a veneer of social responsibility. There are also numerous examples where companies even renege on their own codes and guidelines. For example, Syngenta violated the International Code of Conduct on the Distribution and Use of Pesticides, which it claimed to support, with its promotional activities with paraquat in Thailand, following the ban on paraquat by the Malaysian government. Article 11.2.18 of the International Code of Conduct states that promotional activities should not include inappropriate incentives or gifts, yet Syngenta blatantly offered jackets, t-shirts, and even motorcycles and a truck as inducements to purchase its product Gramoxone (PAN AP 2004).

### **2.3 PESTICIDES, CASH CROPS AND RURAL POVERTY**

The industrial agricultural system, rather than feeding the world, has added to the world's starving. One reason is that it has driven farmers to grow cash crops rather than food in order to pay the escalating costs of inputs. For example, in Malaysia, export production of non-food or luxury items—oil palm, rubber, cocoa, pineapple and pepper—covers three-quarters of the total cultivated land. The import bill for agrochemicals exceeds RM1 billion. Meanwhile, 26 per cent of smallholders live below the poverty level (ESCAP 2002).

In Sri Lanka, 40 per cent of the cultivated area is planted in plantation crops—tea, rubber and coconut—despite a national policy goal of being self-sufficient in the basic foods: rice, milk, sugar, fish and pulses. Poverty remains a serious problem for Sri Lanka, especially rural poverty and most particularly in female-headed rural households. Farmers who practice the traditional Sri Lankan agroforestry system (Kandyana Forest Gardens) enjoy a relatively better standard of living because the highly diversified system of nearly thirty crops, and even fish and livestock, provides a subsistence living as well as cash (ESCAP 2002).

Not only do the cash crops take up the good agricultural land removing it from local food production, they also soak up the pesticides. In India, 60 per cent of all pesticides are used on cotton crops, which account for only 4 per cent of the total crop area (Mancini et al 2005), and in Pakistan the figure rises to 80 per cent of all pesticide use (Siegmann 2008). Globally, 40 per cent of insecticides have been used on cotton: they do not produce food (Mota-Sanchez et al 2003).

In many poor communities, purchasing pesticides makes farming families even poorer. Pesticides are promoted as essential for production and poor farmers are persuaded that they must buy them, even at huge cost, in order to survive. The glib marketing practices of the pesticide companies are compounded by a lack of access to critical information on alternatives. Pesticides are purchased to increase the yield of cash crops, but they bring mounting problems in their wake—problems that affect the health and wealth of the families and inevitably deprive them of food. They are one facet of a seed / fertiliser / pesticide package that results in an upward spiralling cycle of debt and dependency. Inevitably, the package is focused on cash crops, not food, and with the pesticides, come less food produced and less money to buy food. Increased poverty, violence, suicides and child labour follow. This situation has become so bad that in Punjab, once regarded as the bread basket of the Indian sub-continent, whole villages have been put up for sale.

Globalisation of food trade, following in the footsteps of industrial agriculture, has compounded the problems that the Green Revolution bequeathed to the rural poor. With globalisation, a process dominated by the food and chemical transnational corporations and international financial institutions, there came increasing privatisation of land. As a result, more and more land has been converted into plantation cash crops, taking increasing amounts of land away from food production, and most importantly, taking land away from small farmers and the rural poor who have no other means of providing food for themselves. This loss of access to land has resulted in a loss of food sovereignty. Where once poor farmers could grow food for their families, now only flowers are grown for the rich in Europe and America, and in the new era of “biofuels”, food crops must also make way for fuel for the car and truck. And those that have lost the ability to grow their own food must now work in the plantations and factories and face the added indignity of daily assault with pesticides. Dependency and virtual enslavement to the external market have replaced dignity, food security, and democracy.

## **PUNJAB – FROM BREAD BASKET TO BASKET CASE**

In the Bathinda district of Punjab, farmers once used to own their brick and cement houses which stood on their own land. They practised traditional agriculture, growing a variety of food crops such as gawar, moth, gram, taramira and moong. They used to sow the indigenous variety of cotton, narma, which needed no pesticides but gave a good harvest.

Then came the first of the cotton hybrids, A-846, introduced by the Punjab Agriculture University in 1985-86. Next came the American bollworm in 1988, controlled initially by pesticides. But by 1992, the bollworm became so severe farmers lost their entire cotton crop. They increased their pesticide use indiscriminately: prior to 1992, they spent on average Rs500/acre.

By 2002, this had increased to Rs10,000/acre, with the price of cotton declining in inverse proportion. And as the price of cotton declined, the price of pesticides went up. So did the level of debt.

Then, the suicides began in 1999, and the pesticides became known as 'farmercides'. So indebted had the farmers become through purchase of ever-greater quantities of increasingly ineffective pesticides, that even when they sold their land they were still in debt and the debt continued to grow.

Source: Results of a survey by voluntary organisation, Kheti Virasat, as reported in AgBioIndia, 01 July 2002.

## TAKING CONTROL LOCALLY WITH LOW INPUT AGRICULTURE IN SOUTH INDIA

Small and marginal farmers in South India became caught in an exploitative debt spiral, using ever-increasing levels of external inputs in an attempt to achieve the Green Revolution promise of higher yields which would in turn realise the dream of extravagant lifestyles. Instead, trapped by the need to borrow to purchase inputs and by interest rates of up to 180 per cent, they reaped a harvest of poverty.

In Tamil Nadu, farmers groups from 80 villages met together in 2000 to evolve a solution. They adopted an approach that preserves agri-biodiversity to minimise risk to family food security, with an emphasis on greater control of material, skill and knowledge inputs, including local processing of produce. External inputs have been reduced by 50-80 per cent, replaced by local inputs and cultural practices—for example manure, local seed banks, and water conserving summer ploughing.

Food security has improved with the change from cash crop monocultures to mixed food cropping, including fruit, vegetables, and millets. Many farmers no longer need to borrow money from the loan sharks. They have formed their own self-help groups for saving and lending amongst themselves at reasonable rates, and this method now accounts for 50-70 per cent of crop loans. The landless are involved in preparation of compost and vermi-compost and processing of vegetables for pickles. This has increased employment by about 25 per cent in the off-season.

Source: Chanakya et al 2003.



*Vegetable farmer, Sri Lanka*

### 3. Poisoning the people

What is the point of, on one hand, using pesticides to supposedly increase food production and, on the other, poisoning the people who most need that food?

Pesticides, poverty, food, and health are inextricably linked in a vicious cycle. The greater the level of poverty, the greater the exposure to the worst pesticides, and the less the ability to do something about it—from saying no to pesticides, to seeking treatment for health effects. The greater the poverty, generally, the worse the adverse effects are likely to be. For where there is poverty, there is often malnutrition, and malnutrition can worsen the effects of pesticides: for example, low levels of protein resulting in low enzyme levels enhance vulnerability to organophosphate insecticides (Pronczuk de Garbino et al 2003), and increase the toxicity of pesticides such as diuron, monocrotophos, HCH, and endosulfan (Boyd & Krupa 1970; Benjamin et al 2006). Toxicity of organophosphates is increased in people suffering from gastrointestinal infection with nematodes—the world’s most common infection, affecting up to 25 per cent of the world’s population but a particular problem in some developing countries and especially for children (Farid & Horii 2008). And so the cycle of poverty and ill-health spirals upward, as the already malnourished become even less able, through pesticide poisoning, to provide food for themselves.

Unsurprisingly, the marketing efforts of the pesticide industry are often focused on developing countries, because the numbers of potential users are so great and the opportunity to make profits is huge. Regulations are weaker and the ability to enforce those that do exist, considerably less. Once upon a time, pesticides were a problem of the wealthy agricultural nations. But as these countries move slowly to reduce their own environmental contamination, their older, more hazardous pesticides find a home in the poorer nations—pesticides such as paraquat, endosulfan, terbufos, methamidophos, methomyl, monocrotophos, aluminium phosphide, aldicarb, carbofuran, and methyl parathion—where they are cheaper than the newer, less hazardous products. According to ESCAP (2002), poor farmers in Asia commonly use the most toxic pesticides, categorised as Toxicity Class I and II by the World Health Organisation. But it is precisely here that the risks of pesticide use are at their greatest—because of malnutrition, lack of access to training in how to use, lack of education about what to use and when, inability to read or understand the labels, unsafe storage, mixing with bare hands, lack of protective clothing and climatic conditions that make it impossible and/or undesirable to use anyway. The problem has become so entrenched that FAO's Director of Plant Production and Protection, Shivaji Pandey, called upon companies and governments to expedite the withdrawal of WHO Class I pesticides from developing country markets in line with recommendations in the International Code of Conduct on the Distribution and Use of Pesticides. China, Thailand and Viet Nam have prohibited the use of methyl parathion, monocrotophos and several other Class I pesticides, but there is a long way to go in these and most other developing countries (FAO 2006).

Even though the statistics are not precise, there is no question that the impact of pesticides on human health is of a huge magnitude and that it is the people of developing countries who are worst affected. It is here also that two of the most sensitive groups of people—women and children—are most exposed.



## KAMUKHAAN – A POISONED VILLAGE

Kamukhaan, a community of 170 families, in Mindanao, Philippines, was once a thriving village with a comfortable lifestyle, a place so rich in natural resources that people never went hungry. Trees and vegetation were abundant and the seas teemed with marine life. But the development in 1981, of the LADECO banana plantation right next door, marked the beginning of poisoning and poverty.

The plantation is aerially sprayed two or three times a month. Each time, the villagers smell strong fumes, even in their homes. Their eyes sting, skin itches, they experience feelings of suffocation, weakness and nausea, children come in coughing from their play. Skin diseases and other illnesses are rampant—fever, dizziness, vomiting. Others experience stomachache, backache, headache, asthma, thyroid cancer, goitre, diarrhoea, and anaemia. Infants are born with a range of abnormalities, from cleft palate to badly disfigured bodies, and experience impaired mental and physical development. There are constant deaths from disease. Food sources have diminished and poverty increased. Coconut trees stopped bearing fruit, the soil became infertile, crops became difficult to grow. Pigs and chickens would die

**every time spraying occurred. Animals that wandered on to the plantation or fed on grass nearby also died. Animals that drank from the streams died. The river and sea, once teeming with fish, is now heavily polluted and all but barren. What fish can be caught are contaminated causing the villagers, now desperate for food, to get sick. The loss of natural resources as a result of the spraying has forced most of the men in the community to find work on the plantation—increasing their exposure to pesticides and increasing their health problems. The spraying continues. So does the poisoning and poverty.**

Source: Quijano II 2002.

### **3.1 EXPOSURE**

Hundreds of millions of people are exposed to pesticides every year, primarily through agriculture: globally, 36 per cent of employed workers are employed in agriculture, that figure rising to almost 50 per cent in South Asia and South-East Asia and the Pacific, and to 66 per cent in Sub-Saharan Africa (ILO 2007). Others are exposed through non-agricultural occupational uses (such as fumigation), and many more people are exposed indirectly through contamination of food and water, household dust, spray drift, use on aircraft and in homes, and handling of cut flowers. A third form of exposure is intentional, i.e. self-poisoning.

There is no accurate data on the true extent of the effects of pesticides, “but the impact of pesticide use on human health is believed to be great” wrote the Asian Development Bank (Kaosa-ard & Rerkasem 1999 [Vol 2 Chapt 3, p139]). The World Bank (2008) reports an estimated 355,000 people are killed through unintentional exposure to pesticides worldwide every year: *that is 1,000 men, women and children killed every day by pesticides*. About 99 per cent of acute poisoning deaths are be-

lieved to occur in developing countries (WHO 1990), and in some of these countries more deaths result from pesticide poisoning than from infectious diseases (Eddleston et al 2002).

### **Occupational**

In some countries pesticide poisoning is considered serious and endemic because of the permanently high incidence of both acute and chronic health effects specifically related to occupational exposure (Pronczuk de Garbino et al 2003), especially in Sri Lanka (ESCAP 2002). Workers in Malaysian plantations average 262 spraying days/year, seven hours per day, mostly without protective clothing, with severe health consequences (Joshi et al 2002). ESCAP (2002) reports that pesticide poisoning has become “a serious health problem for millions of Thai farmers”. The average rate of increase of pesticide poisoning during the years 1971-1988 was 251 per cent per year, compared with the annual increase in pesticide use during that period of 18.5 per cent—up from 74 reported cases in 1971 to 2,170 reported cases in 1981.

Generally, estimates of acute (non-fatal) poisoning of agricultural workers range from 1-5 million (Goldmann 2004), through 25 million in developing countries alone (Jeyaratnam 1990) to 50-100 million (Kasasard & Rerkasem 1999). However, such figures reflect only the most severe cases, and are likely to significantly underestimate unintentional pesticide poisonings, because they are based primarily on hospital registries. Underreporting is endemic in all countries but especially in the poorer ones where few workers have access to medical personnel, and often symptoms are not recognised by either victims or medical personnel as resulting from pesticides. A surveillance exercise in Central America (Murray et al 2002) revealed that the problem may be very much worse than previously thought: the survey indicated a 98 per cent rate of underreporting of pesticide poisonings, with a regional estimate of 400,000

poisonings per year, 76 per cent of the incidents being work-related. That is just for Central America and it represents 1.9 per cent of the population being poisoned by pesticides each year. If the same percentage is applied to the current population of Asia, there will be approximately 71.7



*Women plantation workers prepare to spray, Malaysia*

million people in Asia being poisoned by pesticides each year. These figures do not include chronic effects such as cancer.

Although this figure includes non-agricultural poisonings, it may still be an underestimate even of agricultural poisonings alone: the Central American study on which it is based identified that 4.9 per cent of those who use or are exposed to pesticides, suffered poisoning episodes, but other studies have found much higher rates of poisoning:

- In Malaysia, between 1982 and 1993, 51-71 per cent of farmers surveyed in two granary areas experienced symptoms associated with pesticide poisoning (Arumugam 1992).
- Acetyl cholinesterase enzyme blood tests of 190 rice farmers in the Mekong Delta, Viet Nam, revealed that over 35 per cent of test subjects experienced acute pesticide poisoning, and 21 per cent were chronically poisoned (Dasgupta et al 2007).

- In a study carried out in a cotton growing region in South India, 10 per cent of the spray sessions were associated with three or more neurotoxic/systemic signs and symptoms, a functional definition of acute poisoning; 6 per cent of the workers' spray sessions were associated with serious neurotoxic effects, but none sought medical care or were hospitalized. Low-income marginal farmers were more often subjected to severe poisoning than landlords (Mancini et al 2005).
- In a study of Palestinian farm workers in the Gaza Governates, 87.5 per cent reported symptoms associated with pesticide exposures such as burning skin and eyes and chest symptoms (Mourad 2005).
- In Northern Tanzania, 68 per cent of vegetable growers reported having felt sick after routine application of pesticides (Ngowi et al 2007).
- A survey in Cambodia found that 88 per cent of farmers had had some experience of poisoning; there was evidence of moderate poisoning during or after spraying (vomiting) in 35 per cent of farmers, and a serious episode such as seizure or loss of consciousness in 1 per cent (Sodavy et al 2000).
- A survey of 123 farmers in Thailand found that 63 per cent had moderate symptoms of poisoning (DANIDA 2004a); a second survey of 124 farmers found that 80 per cent had moderate symptoms of poisoning (DANIDA 2004b); and a larger survey of 606 farmers found that only 6 per cent of the farmers reported no signs and symptoms of poisoning, with 56 per cent of the farmers having experienced moderate signs of pesticide poisoning (DANIDA 2004c).
- In a self-monitoring study in Sri Lanka, 52.5 per cent of farmers spraying pesticides felt mild acute poisoning symptoms within 24 hours (Vikalpani undated).

- In a survey of farmers in Indonesia, 21 per cent of the spray operations resulted in three or more neurobehavioral, intestinal, or respiratory symptoms (Kishi et al 1995).
- In a pilot programme in Indonesia, out of 1,798 recorded spray operations 61 per cent were associated with vague ill-define health effects and 31 per cent with at least one clear symptom (Murphy et al 2002).
- In a study of farmers in the Philippines, about one-third of those interviewed reported experiencing various symptoms of poisoning, including nausea, headaches and burning skin and eye irritation during and after application, but the measurement of spray deposition on their bodies indicated that all the farmers were at risk from the insecticides they used (Snelder et al 2008).
- In an industry-associated survey of 8,790 small holder farmers in 26 countries, 31 per cent reported ever having had an adverse effect from pesticide spraying, many of which were dismissed as minor by the author of the study because they did not receive medical attention or hospitalisation (Matthews 2008).

These observations indicate that between 10 and 94 per cent of agricultural workers applying pesticides in developing countries have been reporting signs of pesticide poisoning. The probable real incidence of pesticide poisoning is staggering.

### ***In the home***

Pesticide exposure is not simply a feature of the work place. Pesticides are carried into the home on clothing and equipment (Knishkowsky & Baker 1986; McDiarmid & Weaver 1993). The washing of pesticide-contaminated clothing can expose the whole family, but particularly women, to toxic burdens of chemicals. Pesticide contaminated dust finds

its way into the house, too. In one study in the USA researchers found that the concentrations of organophosphate insecticides in household dust in homes a quarter of a mile away from orchards was greater than in the orchards (Simcox et al 1995). Exposure can also be extreme with the “public health” fogging of residential areas with pesticides such as malathion for mosquito control. Insect sprays are used in many urban homes. These products are not safe: they can cause cancer, immune suppression and other health problems (e.g. Ma et al 2002). It has been reported that 85 per cent of US homes have at least one pesticide stored on the premises, and that about 10 per cent of pesticides used in the USA are used in and around the home (Gulson 2008). Similar levels of household use could be expected in Australia and New Zealand, with use in urban Asian households rising. And pesticides can linger in homes long after use ceases: residues of chlorpyrifos were found in all homes in a New York City study up to 2 and a half years after it was banned for residential use (Gulson 2008).

A few surveys have attempted to estimate the extent of non-occupational acute poisoning: 35 people per 100,000 of the general population in El Salvador and Nicaragua, and 17 per 100,000 residents in Belize (Thundiyil et al 2008).

## **Suicides**

There are an additional estimated 300-450,000 deaths from self-poisoning with pesticides globally every year, accounting for about one-third of the world’s suicides, with the estimated number of attempted suicides using pesticides being in the order of 1.3 to 2.6 million (Gunnell et al 2007a).

Of the estimated 500,000 deaths per year from self-harm in the Asia region, about 65 per cent are from pesticide poisoning. Of these, about 200,000 are from organophosphates, particularly where the WHO

Class I pesticides are available. The fatality rate is as high as 40 per cent in some areas (Eddleston et al 2008).

Suicide with pesticides has been reported throughout Asia (Gunnell et al 2007a):

- poisons were used in 36 per cent of suicides in Pakistan in 1996-7, and these were mainly pesticides
- similarly, in Bangladesh, pesticides were used for most of the 55 per cent of suicides caused by poisoning
- estimates for India suggest 30 per cent or more of suicides employ pesticides—as many as 126,000 deaths per year
- in 2005, 54 per cent of the suicides in Sri Lanka were with pesticides
- in Thailand (1998-2003), pesticides accounted for 16 per cent of suicides
- a survey in China concluded that 62 per cent of the suicides in one region involved pesticides, including rat poison
- in South Korea, 20 per cent of suicides are self-poisoning with pesticides.

Fatality from self-poisoning with pesticides may be very high, as high as 70 per cent when paraquat or aluminium phosphide, a fumigant used to protect stored grain, are used. Where organophosphates such as dimethoate and chlorpyrifos have been used, the fatality rate has been lower, 23 per cent and 8 per cent respectively (Gunnell et al 2007a).

Sri Lanka has had one of the highest pesticide-suicide rates in Asia, with 90 per cent of intentional self-poisoning carried out with pesticides (Manuel et al 2008). Three pesticides were responsible for almost all the fatalities: fenthion, endosulfan and paraquat (Pronczuk de Garbino et al 2003). However, after the regulatory authorities there banned WHO

Class I pesticides (including fenthion), and endosulfan, the suicide rate fell dramatically: between 1950 and 1995, suicide rates had increased by 8-fold to a peak in 1995, but by 2005 the rates had halved, and that drop is believed to be because of the removal of the most toxic pesticides from the market. A similar pattern was observed in Western Samoa: in the 1970s and 1980s, marked fluctuations in the import of paraquat were closely followed by similar fluctuations in paraquat self-poisoning and overall suicide (Gunnell et al 2007b).

Financial hardship and loss of land are often behind these suicides, and they are generally discounted when the effects of pesticides are examined because they are so-called 'self-inflicted' deaths. That these suicides often occur because of the spiral of debt perpetuated by the purchase of ever more pesticides to beat insect resistance to pesticides escapes such critics.

*"On average, one Indian farmer committed suicide every 32 minutes between 1997 and 2005. Since 2002, that has become one suicide every 30 minutes". (Sainath, 2007)*

Additionally, these deaths may not be quite as 'self-inflicted' as previously assumed: there is a concern that exposure to organophosphate insecticides may be part of the problem because these chemicals can cause depression. In Brazil, a high proportion of farm workers were found to have minor psychiatric disorders strongly associated with pesticide exposures (Faria et al 1999). In another study, Colorado farmers who sprayed organophosphate insecticides were nearly six times more likely to suffer symptoms of depression (Stallones & Beseler 2002).

## **Food residues**

Food that should nourish and sustain good health often contains remnants of the pesticides used to grow it. These pesticides may cause

acute poisoning even death if the levels are high enough, or chronic effects at low levels. Infants are especially susceptible to low levels of residues, since they eat eight times more food per kilogram of bodyweight than adults do—as well as having greater biological sensitivity. Their physiological and intellectual development may be impaired by these exposures (Gee undated).

ESCAP (2002) reports that, in Malaysia, newspaper accounts of high levels of residues in food crops are frequent, and that “indiscriminate use of pesticides, particularly by vegetable producers, has led to increasing concern over the safety of locally produced vegetables. High levels of illegal residues are also reported in China (Jiang et al 2003) and India (Kumari et al 2003; Mukherjee 2003). Even supposedly ‘clean, green’ New Zealand is reporting residues at more than 200 per cent of the legal maximum (MRL) (NZFSA 2008). Residues of pesticides in food are widespread where ever they are used, leading to growing concerns about the cocktail effect of the daily intake of mixtures of pesticides, even at permitted levels, let alone at the illegal levels.

Epidemic poisonings caused by accidental contamination of food, resulting in high mortality and morbidity rates, are not uncommon. Incorrect packaging, labelling or storage, together with similarity with foodstuffs, are factors. The contamination, often of flour or sugar, frequently occurs during transportation or storage. Other deaths occur after the eating of seeds dressed for sowing. Poisoning may also occur when women prepare pesticide formulations without any protective clothing, and then also, the food in the workplace or home.

## **FOOD THAT SHOULD NOURISH, BUT POISONS INSTEAD**

### **Case 1: India – malathion**

On July 6 1997, 60 men aged 20-30 attended a communal lunch in a community kitchen in India. That morning the kitchen, including raw ingredients stored in open jute bags, had been sprayed with the insecticide malathion. Within three hours of eating the chapatti, cooked vegetables, pulses and halva, all 60 men developed nausea, vomiting and abdominal pain. All were taken to primary healthcare centres. Fifty-six were discharged the same day; three developed muscle weakness, respiratory disease and lowered consciousness, eventually recovering, but the fourth man died 10 days later (Chaudhry et al 1998).

### **Case 2: India – endosulfan**

At a rural roadside food stall, a half-filled bottle of endosulfan, without its lid, was stored on a shelf. It fell into the flour used to make idlis. Forty-four people consumed idli and tea. They experienced nausea, vomiting, altered senses, seizures, diarrhoea, and abdominal pain. One died of asphyxia. Two people remained unconscious for 24 hours, and 30 remained unconscious for up to 18 hours (Venkateswarlu et al 2000).

### **Case 3: Taiwan – methamidophos**

Four people suffered a variety of symptoms after eating vegetables with high residues of methamidophos. The symptoms included vomiting, diarrhoea, abdominal pain, dizziness, headache, salivation, cold sweating,

weakness, tachycardia, and urinary incontinence. The vegetables contained residues up to 510 times higher than the maximum permitted level. Methamidophos is used illegally on leafy vegetables by many farmers because it is cheap and highly potent (Wu et al 2001).

#### **Case 4: Peru – methyl parathion**

Twenty-four children died and eighteen others were severely poisoned in the remote Andean farming community of Taucamarca en Cuzco in 1999. The school children were accidentally poisoned when they drank a powdered milk substitute that had been contaminated with the pesticide methyl parathion (Rosenthal 2003).

#### **Case 5: Philippines – carbaryl**

On March 9, 2005, a poisoning incident in Bohol, Philippines caused the death of 30 people and the hospitalisation of more than 100 others. After eating a cassava snack, most of the patients immediately experienced abdominal pains, dizziness, vomiting, salivation, headaches, diarrhoea, involuntary urination, convulsions and loss of consciousness. Some had pinpoint pupils. Red blood cell cholinesterase levels were severely depressed in most patients. These are all symptoms of organophosphate or carbamate insecticide poisoning, and it is suspected that the flour or coconut oil used in the cooking of the cassava snacks was contaminated with carbaryl (pers. comm. Dr Romeo Quijano, March 16 2005).

## Breast milk

Worldwide, women's breast milk is contaminated with a number of pesticides indicating exposure, not only to the women, but also to the newborn child transferred in breastmilk at a critical period of development when oestrogenic substances can have a profound life-long impact.

In 2003, infants in Bhopal, India were found to be consuming, through breast milk, 8.6 times more endosulfan and 4.1 times more malathion than the average daily intake levels recommended by the World Health Organization. They were also consuming methyl parathion and chlorpyrifos (Sanghi et al 2003).

In the Asia Pacific region, residues of the organochlorine pesticides aldrin, chlordane, DDT, dieldrin, endrin, endosulfan, HCB, heptachlor, lindane, and mirex have been found variously in breast milk in Australia, Cambodia, China, Hong Kong, India, Indonesia, Iran, Israel, Japan, Jordan, Kazakhstan, Kuwait, Kyrgyzstan, Malaysia, New Zealand, Pakistan, Papua New Guinea, Samoa, Saudi Arabia, Sri Lanka, Taiwan, Tajikistan, Thailand, Turkey, Turkmenistan, and Viet Nam. Permethrin, cyfluthrin, cypermethrin, deltamethrin, have been found in breast milk in South Africa, and dichlorvos in breast milk in Taiwan (Watts 2007).

For those women who are aware that their breast milk is laced with DDT and scores of other pesticides and industrial chemicals, the knowledge that they are passing these on to their children is profoundly distressing.

However, this does not mean that breastfeeding should be replaced with bottle-feeding. Breastfeeding should be maintained because, despite the residues, it confers major health benefits on both the infant and the mother. The solution to the problem is to stop the contamination of the breast milk in the first place, by stopping the use of the offending pesticides. In March 2004, the World Alliance for Breastfeeding Action (WABA) and the International POPs Elimination Network (IPEN) issued a

joint statement (WABA & IPEN 2004), which acknowledged that: “The contamination of breastmilk is one symptom of the environmental contamination in our communities. Responsibility for this problem belongs to the industrial sources of contamination, not to breastfeeding women.” It should be the right of every child to toxic-free food (Steingraber 2005).

But in order for children and women, to realise this right, the following recommendation from the UK Royal Commission on Environmental Pollution (Blundell 2003) must be put into effect worldwide:

*“We recommend that where synthetic chemicals are found in elevated concentrations in biological fluids such as breast milk and tissues of humans, marine mammals or top predators, regulatory steps be taken to remove them from the market immediately.”*

### **Drinking water**

Pesticides find their way into drinking water all over the world, at levels that can cause acute poisoning or chronic ill-health through ongoing exposure to low levels. On a tea plantation in Sri Lanka, herbicide spraying was carried out one morning in an area that included a very small stream of water, which led to the main water tank supplying the houses below the sprayed area. By midday, over 50 men, women and children became ill and had to be hospitalised (Pronczuk de Garbino et al 2003).

Even bottled water-based soft drinks have been found to contain pesticide residues. In India, a range of organochlorine and organophosphate insecticides were found in drinks such as Pepsi, Coca-Cola, Fanta, Sprite, Mountain Dew and 7 other bottled drinks all made by two American companies. Lindane and chlorpyrifos were found in 100 per cent of samples, malathion in 97 per cent, and DDT in 81 per cent, at levels that ranged up to 87 times higher than the amount considered accept-

able by the European Commission (Mathur et al 2003). A parliamentary investigation corroborated the findings, causing the parliament to ban its cafeterias from serving Pepsi and Coke and the defence ministry issued a circular ordering its clubs to stop selling the drinks (Singh 2004).

### **3.2 GENDER ISSUES**

Women are particularly susceptible to the effects of pesticides because of socio-cultural and economic circumstances, and certain physiological characteristics that render them more biologically sensitive. They are the poorest of the poor: almost two-thirds of rural women in developing countries are from low-income households, and the poorest amongst these are the women that head their household, often because of male migration in search of work. In some parts of Asia, women head 35-40 per cent of rural households (ESCAP 2002). Women eat the last, the least and the left-overs and so, where food is scarce, they suffer greater levels of malnutrition and hence, are more susceptible to the effects of pesticides.

In some countries, women make up 85 per cent or more of the pesticide applicators on commercial farms and plantations, often working whilst pregnant or breastfeeding. Even if they do not directly apply the pesticides, they work and raise their children in a toxic environment—mixing the pesticides, harvesting the pesticide-drenched crops, weeding whilst the insecticides are being applied, thinning sprayed crops, washing out the pesticide containers or washing pesticide-contaminated clothing. They are less likely to receive formal training in reduced risk handling practices. In Chile, there are at least two reported poisoning epidemics amongst women working in recently sprayed fields. In 1996, 58 of 64 reported poisonings were women; and in 1997, of the 120 reported poisonings 110 were women, nearly all employed in the flower industry (Wesseling et al 1998). In Southeast Asia, women provide 90 per cent

of the labour for rice cultivation (Dinham 2003). More than half of the plantation workers in Malaysia are women (Joshi et al 2002). They are severely over-exposed to pesticides.

### ***Biological sensitivity***

Women may absorb pesticides through their skin more easily than men—dermal absorption of the organochlorine lindane has been found to be three times greater than for men (PSD 1999). And once there, fat-loving pesticides may reside in the body longer in women than in men (Hardell 2003).

Because women have more body fat, they carry greater burdens of fat-loving pesticides in their bodies, toxic deposits that exert their effects long after exposure. They pass them on to the next generation across the placenta and in breast milk, creating an ever-greater burden of ill-health for future generations.

Women's higher level of hormonally sensitive tissues makes them more vulnerable to the effects of pesticides, especially those that are called endocrine disruptors, i.e. are capable of effecting profound changes on hormonally-sensitive tissues such as breast tissue. Their increased fat exchange, for example during pregnancy and lactation, together with the cyclic nature of hormonal changes, add to that greater sensitivity (Howard 2003). There is evidence that oestrogen enhances the effects of chemicals on the nervous system (Bell et al 1997). It is one of the reasons put forward to account for the significantly elevated level of multiple chemical sensitivity amongst peri-menopausal women, much of which is attributed to pesticides: 70-80 per cent of sufferers are women (Miller & Mitzel 1995).

### 3.3 HEALTH EFFECTS

There are two types of health effects resulting from exposure to pesticides: acute and chronic. Acute poisoning has generally been the most recognised form of effects. The other side of the coin, long-hidden from view but now gaining more attention, is that of chronic poisoning. In addition, pesticides may aggravate existing medical conditions, both acute and chronic, such as asthma and allergies, heart and immune system disorders.

**Table 2: Some acute symptoms of pesticide poisoning**

numb lips, tongue	weakness, fatigue, lethargy
sore throat	dizziness
blurred vision	disorientation, confusion
lachrymation	agitation
headache	inarticulate speech
salivation	depression
nose bleed	memory loss
swelling	difficulty in walking
chest pain, tightness, wheezing	anxiety, restlessness
suffocation, difficult breathing	involuntary twitching
sweating	hypotension, hypertension
burning skin	drop in blood pressure
itching	rapid pulse
blisters	muscular pain, stiffness
discoloured irregular nails	muscle weakness
nausea, vomiting	back pain
abdominal cramps	seizures
diarrhoea	paralysis
uncontrolled urination	coma
vaginal pain	death

Sources include: Timbrell 1991; Arumugam 1992; Joshi et al 2002; Habib 2003; Reeves & Rosas 2003; Vodouhe 2003; Eddleston et al 2008.

Acute effects—such as vomiting, headaches, respiratory problems, eye and skin irritation, and stomach troubles—are often confused with common illnesses, and so links with pesticide exposure have been easy to discount. On the other hand, chronic effects are complex and difficult to link back to pesticide exposure and, especially, to prove. Hence, chemical companies, government regulators, and other proponents of pesticide use have found it a simple matter to deny the suffering of millions of people caused by exposure to pesticides.

Chronic poisoning may arise as a long term sequel to an initial acute dose—for example, organophosphate insecticides, well known for being acutely very toxic, can also cause long term damage to the nervous system and undermine the immune system. More often, chronic effects are caused by the ongoing low dose exposure to mixtures of chemicals. Visible acute effects may just be the tip of the iceberg, with a lifetime of chronic suffering lying just below the surface. Increasing rates of skin

### **ACUTE POISONING OF CASHEW FACTORY WORKERS, KERALA, INDIA**

**On Monday, June 17th, 2002, workers entered the cashew peeling shed and were immediately taken ill - with nausea, vomiting, giddiness, breathlessness, and some fell unconscious. 103 women were hospitalised. Malathion had been sprayed on the previous Saturday to control insects. Between February 2000 and January 2003, there were at least 10 such incidents involving the pesticides chlorpyrifos, malathion or methyl parathion with, in one case, 227 women hospitalised. Other symptoms reported included diarrhoea, persistent headache, eye irritation, stomach pain, loss of appetite, and pain in joints.**

Source: Thanal 2003

lesions on women workers in Central America give rise to concern that although these women may not be acutely poisoned, they may suffer cancer or reproductive effects in the long term (Wesseling 2003).

## Children

The developing foetus and small child are especially vulnerable to the effects of pesticides and other toxic chemicals. Although links between exposures to toxic chemicals and health impacts have been known for centuries, recent research documents an expanding list of previously unrecognised effects after foetal or infant exposures (NRC 2000). During foetal and early childhood development, cells are rapidly dividing, and growth is dramatic. The development of the brain and endocrine, reproductive, and immune systems are extremely susceptible to disruption, resulting in effects that are often permanent. To compound this problem, children are often disproportionately exposed to chemical contaminants because of the way they breathe, eat, drink, and play. They have higher dietary intake in relationship to size and have greater body burdens of chemicals. Additionally, their immature detoxification pathways often result in increased impacts of toxic exposures when compared to adults (Schettler 2002). Newborn children can be 65 to 164 times more vulnerable than adults to the organophosphates chlorpyrifos and diazinon (Furlong et al 2006). Recent research from Sweden concludes that cancer risk is largely established during the first 20 years of life (Czene et al 2002; Hemminki & Li 2002). Other studies show that prenatal exposure to pesticides can result in a wide range of problems ranging from delayed development and reduced cognitive function to increased asthma and lung and middle ear infections (Eskenazi et al 2007, 2008; Wigle et al 2008). A US study found that children exposed, *in utero*, to chlorpyrifos in household use in the USA were likely to have lower birth weight and length, and to have reduced mental and motor development at 3 years of age, as well as more likely to manifest symptoms of attentional dis-

order, attention deficit hyperactivity disorder, and pervasive personality disorder, all of which, can lead to learning difficulties (Gulson 2008).

Exposure during childhood also carries significant risk: the Scientific Consensus Statement developed by the Collaborative on Health and the Environment's Learning and Developmental Disabilities Initiative included that "childhood exposure to pesticides, such as organophosphates, enhances the risk for developmental disorders including deficits in memory, poorer motor performance, and an array of other conditions" (ICEH 2008).

### **PESTICIDES AND CHILD DEVELOPMENT: THE CASE OF THE YAQUI INDIANS**

**Elizabeth Guillette and colleagues (1998) carried out a study among the Yaqui people of Mexico. They compared two groups of children sharing genetic, cultural and social backgrounds, one exposed to heavy pesticide use, and the other from an area where pesticide use was avoided.**

**When chemical pesticides and fertilisers were embraced by many of the residents in the Yaqui valley in the late 1940s, other residents moved into the foothills in protest at the change, and stayed there. In the valley, up to 90 separate applications of pesticides were made per year, including multiple organochlorine and organophosphate mixtures and pyrethroids. As well as this agricultural use, household insecticides were used each day throughout the year. In contrast, the ranching lifestyle of the highlands required no pesticide use, and the government DDT applications each spring for malaria control were their only contact with pesticides. The survey revealed no differences in physical growth or other outward manifestations, but it did reveal significant differences in functional abilities. In the following areas,**

the valley children showed a marked decrease in function relative to the highland children:

- physical stamina
- ability to catch a ball
- fine eye-hand coordination
- ability to draw a person, the valley children providing only random undifferentiated lines in comparison with the highland children's easily recognisable human figures
- recall after 30 minutes, although immediate recall was equivalent
- group play: the valley children were less creative, roaming aimlessly or swimming in the irrigation canals with minimal group interaction.

Additionally, the valley children were observed to be more aggressive, hitting siblings and becoming more upset by minor corrective comment by a parent.

The researchers concluded that the differences they found in mental/neurological functioning were indicative of brain dysfunction and held implications for learning ability and social behaviour. Whether the effects were the result of one chemical, or one class of chemicals, or a whole mixture of chemicals that may have been working additively, synergistically or independently, remains unknown. The findings, however, imply grave consequences for the future of the individual, the family, and society as a whole. They point to the necessity of considering the broader picture of pesticide exposure, rather than being limited by the toxicology of an individual chemical under laboratory conditions.



*Shruti lives in the Vaninagar area in Kasargod in Kerala, India. For more than 20 years, endosulfan had been aerially sprayed in the nearby government owned cashew nut plantation. She was born with three deformed limbs, a congenital anomaly. She hops around on one leg. Photo: Down to Earth Magazine, Vol 9. No 19 February 28, 2001.*

### **Chronic effects**

There is a very long list of chronic health problems linked to pesticide exposure. Absolute proof is very difficult to gather. So, frequently, the findings of scientists and communities are challenged by the chemical corporates and ignored by the government regulators. But nevertheless, scientific findings from laboratory trials and epidemiological studies of exposed people, together with community-based research provide overwhelming evidence of the cruel and lasting impacts of pesticides. The insidious effects of pesticides are continually unfolding and new connec-

tions are being made between exposure to pesticides and some of society's most rapidly escalating health problems, such as diabetes, obesity and metabolic disease, a condition associating obesity with hypertension, type 2 diabetes, and cardiovascular disease (Lee et al 2006, 2007; Rignell-Hydbom et al 2007; Jones et al 2008; Montgomery et al 2008).

### ***Endocrine disruption***

Endocrine disrupting pesticides alter the normal functioning of the endocrine system, potentially causing disease or deformity in the exposed person and/or their offspring. Until relatively recently, endocrine disruption was not even recognised as an outcome of exposure to pesticides, and most regulatory regimes still do not include it in their assessment of pesticides. But now, more than 127 pesticides are suspected of having endocrine disrupting effects (McKinlay et al 2008). This means that, although they may not have a direct toxic effect, they act on the body's hormonal system and can cause a wide variety of adverse health outcomes—including reduced fertility and fecundity, spontaneous abortion, skewed sex ratios within the offspring of exposed communities, male and female reproductive tract abnormalities including genital deformities, other birth defects, precocious puberty, polycystic ovary syndrome, impaired immune function and a wide variety of cancers (McKinlay et al 2008). They can also impair the nervous system and the body's detoxification processes (Lewis 2003). They have been linked to neurobehavioural deficits in children (Pronczuk de Garbino et al 2003) and early onset puberty (Krstevska-Konstantinova et al 2001; Schoeters et al 2008). Endocrine disruption occurs at levels of exposure far lower than normally considered toxic and can exert effects throughout the life of the exposed person, and even their offspring, especially if exposure occurs at the foetal stage of development.

## ***Birth defects and other reproductive problems***

Pesticides have been linked to a number of reproductive problems including birth defects, infertility, delayed time to pregnancy, spontaneous abortion and still births, preterm birth, intrauterine growth retardation, perinatal mortality, endometriosis, and lowered sperm counts (Xu & Cho 2003; Wigle et al 2008).

Maternal exposure to endocrine-disrupting chemicals in particular appears to increase the risk of developmental abnormalities in the reproductive organs of female and male foetuses, as well as affecting the brain, skeleton, thyroid, liver, kidney and immune system (Colborn et al 1993).

Many chemicals can cross the placenta and act on the embryo during its most vulnerable period of development: the first three months of pregnancy, and particularly, between days 15 and 60 after conception. Chemicals that interfere in the development of the foetus in this manner are called teratogens. Pesticides that are known to be teratogenic from animal studies include the organophosphate insecticides like dimethoate, carbamate insecticides such as carbaryl, fungicides like benomyl, and herbicides such as paraquat (Garcia 2003). There are many more. Studies have linked phenoxy herbicides like 2,4-D and the herbicide atrazine with birth defects (Garry et al 1996).

Birth defects also occur as a result of mutagenesis, where chemicals cause the mutation of the male or female germ cells. A review of 65 pesticides found that 35 of them showed some degree of genetic activity, i.e. might be implicated in genotoxic effects (Garry et al 1996). Epidemiological studies show parental exposure to a variety of pesticides may result in neural tube defects, cardiac birth defects, cleft lip and cleft palate, musculoskeletal birth defects, urinary tract defects, and male genital defects (Wigle et al 2008).

Occupational studies have reported adverse reproductive effects linked to pesticide exposure in banana packing plants in Central America (Wesseling 2003), grape workers in India (Rita et al 1987), women in the Columbian flower industry (Restrepo et al 1990), and rural California women (Pastore et al 1997).

## **Cancer**

Over 160 pesticide active ingredients—found in insecticides, herbicides, fungicides—are listed as possible carcinogens (Jacobs & Dinham 2003). Some of these are obsolete, but many are still in use, particularly in developing countries. Many more may cause cancer through endocrine disrupting effects—98 pesticides, one adjuvant and two contaminants have been identified as increasing the risk of breast cancer through their action as endocrine disruptors or mammary carcinogens (Watts 2007).

Pesticides have been linked, either by laboratory evidence or epidemiological studies to many forms of cancer, including multiple myeloma, soft tissue sarcoma, Ewing's sarcoma, lymphoma, non-Hodgkin's lymphoma, leukaemia, melanoma, neuroblastoma, Wilm's tumour, germ-cell tumours, retinoblastoma (eye tumour); and cancer of the oesophagus, stomach, prostate, testis, breast, ovary, cervix, bladder, thyroid, lung, brain, kidney, pancreas, liver, colon, and rectum (Zahm et al 1993; Sharpe et al 1995; Viel et al 1998; Zahm & Ward 1998; Jaga & Brosius 1999; Porta et al 1999; Settini et al 1999; Vineis et al 1999; Wesseling et al 1999; Alavanja et al 2003; Miligi & Settini 2003; Reeves & Rosas 2003; Wigle et al 2008).

A number of studies have shown links between exposure of farmers to specific pesticides and particular cancers, including ovarian cancer with atrazine (Donna et al 1989); breast cancer with organochlorine and organophosphate insecticides, triazine herbicides, and others (Watts

## CHRONIC ENDOSULFAN POISONING IN KASARGOD, KERALA

For 25 years, the insecticide endosulfan was aeri-ally sprayed over cashew nut plantations in Kasargod Dis-trict. People residing in the vil-lages within the planta-tion experienced an unusu-ally large number of serious neurological, developmental, reproductive and other dis-eases, including cancer. 197 cases documented, from only 123 households, revealed high levels of cancer, cerebral palsy, mental retardation, epilepsy, congenital anom-alies and psychiatric disorders. The cancers reported include abdominal, uterine, liver, and neuroblastoma. Seri-ous growth retardation and delayed psychomotor devel-opment have been reported. Endosulfan is a known neurotoxicant, blocking inhibitory receptors of the central nervous system and de-stroying the integrity of nerve cells. It is also a known endocrine dis-ruptor, is mutagenic and causes chromosomal aberrations.

Source: Quijano RF 2002



*Children in the village of Kasargod in Kerala, India, are often born blind. While their eyes appear 'normal', the nerves are damaged and they are blind as a result of the neuro-toxicity of endosulfan. Photo: Shree Padre/ESPAC*

2007); soft tissue sarcoma, multiple myeloma and non-Hodgkin's lymphoma with phenoxy herbicides like 2,4-D (Vineis et al 1987; Zahm et al 1993); and prostate cancer with methyl bromide (Alavanja et al 2003).

### ***Neurological, developmental effects***

There is increasing concern about, and evidence of, the effects of pesticides on the central nervous system, peripheral nervous system, and the pre-birth developing brain. Pesticides are now linked to a growing list of neurological problems spanning our lives from autism in children (Roberts et al 2007) to dementia (The Press 2008).

A number of these effects have been mentioned already: the inferior developmental skills and increased aggression in children; the depressive effects of organophosphates possibly resulting in suicides; the intellectual disability in Kamukhaan and Kasargod. In Kasargod, epilepsy, cerebral palsy and psychiatric disorders are amongst other chronic effects linked to prolonged exposure to endosulfan (see separate box).

Additionally, organophosphate insecticides can cause delayed neuropathy, involving degeneration of the peripheral nerves in the limbs with muscular aches and pains and influenza-like symptoms. There may also be personality change, impulsive suicidal intent, impaired concentration and memory, language disorder, heightened sense of smell, deterioration of handwriting, impaired tolerance of exercise, and neuro-muscular deficits (Rosenstock et al 1991; Ahmed & Davies 1997; Wesseling et al 2002).

But it is not just organophosphate insecticides that cause chronic damage to the nervous system: in one study, French vineyard workers exposed repeatedly to fungicides were found to have long-term cognitive impairment (Baldi et al 2001). Van Wendel de Joode et al (2001) found chronic nervous system effects on malaria control workers with long-term exposure to the organochlorine DDT. Endosulfan, which has caused

such devastating effects in Kasargod, is another organochlorine.

Parkinson's disease is the most common degenerative disease of the nervous system, currently affecting about 1 per cent of the population, and there have been a number of reports linking it to exposure to pesticides in general. Additionally, several quite different specific pesticides are now indicated as being implicated. These include herbicides such as paraquat and 2,4-D; dithiocarbamate fungicides like maneb; organochlorine insecticides like DDT, lindane, endosulfan, and dieldrin; and rotenone. Other pesticides, such as chlorpyrifos, dimethoate and malathion, have been linked to parkinsonism, a disorder with symptoms like Parkinson's disease, but which may be reversible (Watts 2001; Dick 2006; Jia & Misra 2007).

### ***Immune effects***

The immune system is essential to everyday health and survival. It is an intricately balanced complex system, interconnected with the endocrine and nervous systems, and it is vulnerable to interference from chemicals. There are very many studies showing that pesticides adversely affect the immune system in laboratory animals making them more susceptible to disease and cancer. Pesticides have been found to alter the development of the key immune organs thymus and spleen, to reduce the number of white blood cells and lymphocytes and to impair their ability to respond to and kill bacteria, viruses and cancer cells (Repetto & Baliga 1996)—for example, DDT, chlordane, endosulfan, and heptachlor reduce the ability of Natural Killer T-cells to destroy tumour cells (Reed et al 2004). Organochlorines, organotins, organophosphates, carbamates, triazine herbicides, synthetic pyrethroids, fungicides are all implicated in immune system suppression (refer to Table 3).

Suppression of the immune system makes a person much more vulnerable to infections, viruses and other diseases, and it may explain the observation from Kamukhaan that the villagers are suffering from increased incidence of disease. It also increases vulnerability to cancer and other diseases of the immune system. There are millions of people worldwide who live with HIV: 12 million women in sub-Saharan Africa alone (Page 2003). The link with pesticides? Women whose immune systems are not daily assaulted by immune-suppressing pesticides have a better chance of living with HIV rather than dying of AIDS.

In conclusion: just because a regulatory risk assessment of a pesticide determines it is 'safe', that does not mean it actually is, under the real conditions of use, especially in developing countries, or to the people who are exposed to it. The legacy of poisoning briefly described here bears testament to that. Toxicological assessments of pesticides are based on the estimations of risk for healthy European males. But it is now known that the Asian population is much more susceptible to organophosphate poisoning than Europeans: 36-56 per cent of some Asian races lack a particular gene that helps protect against diazinon and chlorpyrifos, whereas only 9 per cent of those of Northern European origin lack it (Costa et al 2003; Furlong pers comm).<sup>2</sup> Add to that the conditions of malnutrition, breast feeding, and just being a woman, and it is plain to see that the adult male-based European risk assessment has nothing to do with the actual safety of women plantation workers in Malaysia, or cashew nut factories in Kerala, or small children growing up in Kamukhaan or Kasargod.

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<sup>2</sup> Dr Clement Furlong, Division of Medical Genomics, University of Washington, Seattle, February 2003.

**Table 3: Pesticides for which immunotoxic effects have been documented in the scientific literature**

2,4-D	dinitroresol	nickel sulphate
acephate	diquat	oxychlor dane
aldicarb	diuron	paraquat
allethrin	endosulfan	parathion
arsenic	endothall	PCNB (quintozene)
arsenic trioxide	endrin	pentachlorophenol
atrazine	EPN	permethrin
azinphos-methyl	EPTC	phenthoate
barban	fenitrothion	phorate
captan	fenthion	phosalone
carbaryl	fenpropathrin	piperonyl butoxide
carbofuran	fluometuron	pirimicarb
carbophenothion	formaldehyde	propanil
chlordane	glyphosate	propham
chlordecone	heptachlor	propoxur
chlordimeform	HCH	s-bioallethrin
chlorfenethol	hexachlorobenzene	simazine
chlorfenvinphos	lindane	sodium arsenite
chlormequat	malathion	tetrachlorvinphos
chloride	maleic hydrazide	thiram
chlorpyrifos	mancozeb	toxaphene
chlorobenzilate	maneb	tributyltin
chlorpropham	mercuric chloride	tributyltin chloride
copper	metam sodium	tributyltin oxide
crufomate	methiocarb	trichlorfon
cycloheximide	methoxychlor	trichloroethane
cypermethrin	methyl dithiocarbamate	trichloroethylene
DDT	methyl parathion	triisopropylphosphate
diazinon	metribuzin	triphenyltin chloride
dichlorvos	mevinphos	triphenyltin
dieldrin	mirex	hydroxide
dimethoate	molinate	zineb
dimethyl	monocrotophos	ziram
sulfoxide	naled	

Source: PAN UK undated

## 4. Poisoning the environment

The history of environmental problems began with agriculture, with water deficits and erosion dating back to the Sumerian and Babylonian cultures at least (Bosselmann 1995).<sup>3</sup> But it is in the use of pesticides and now, also the genetic manipulation of plants and animals to satisfy purely human greed, that the ecosystem-destroying nature of humanity's system of sustenance has become apparent. Pesticides contaminate soil, water, aquatic sediment, and air throughout the planet. They are found in polar snow, in fog and in rain. They are found in the body tissues of wild animals and the bark of trees, worldwide. They are found at the tops of remote mountains including the grasses on Mt. Everest. Endosulfan alone is found in all of these places (see Watts 2008 for details). Pesticides are implicated in mass die-offs of marine mammals, and population crashes of birds, amphibians and alligators (Johnston & McCrea 1992; Newton & Wyllie 1992; Woodward et al 1993; Colborn et al 1996; Graf 1999). Some of them, such as the halogenated compound methyl bromide, contribute to destruction of the ozone layer (UNEP 2006). It has been widely assumed, without rational review of the evidence to the contrary, that humanity's existence depends on this nature-destroying approach that characterises modern chemical-based agriculture. But the folly of de-

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<sup>3</sup> WC Lowdermilk (1953) of the US Department of Agriculture's Soil Conservation Services also "found fields that had been farmed for thousands of years without soil or environmental deterioration" (Kirschenmann 1999).

stroying that which provides our food is becoming increasingly apparent. The life-support systems of Planet Earth are intimately connected and it is not possible to affect one without ultimately affecting them all.

Contamination of the environment with pesticides is rife throughout Asia. Endosulfan contamination is everywhere (Watts 2008), but other pesticides are also a problem. ESCAP (2002) reports contamination of water and fish in rice ecosystems in Malaysia, and pollution of air, soil and water in Sri Lanka. It also reports (p.178) that in Thailand,

“an estimated 70 per cent 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”.

Many of the pesticides still in widespread use in Asia are broad spectrum and therefore, continue to have negative impacts on beneficial insects, birds and other non-target organisms, diminishing natural and agroecological biodiversity (ESCAP 2002). Endocrine disrupting effects of pesticides are just as profound on wildlife and fish as they are on humans, resulting in birth defects, reproductive failures and sexual abnormalities, and eventually, population crashes (Colborn et al 1993, 1996; Guillette et al 1994).

One of the more recent environmental calamities attributed to pesticides is that of Bee Colony Collapse. This disorder, in which adult bees simply disappear from hives, was first reported in USA and then, in Europe. In both regions, there has been widespread collapse of bee-hives, with consequential financial implications for the bee industry, and for horticulture because of the lack of bees to pollinate crops. The new generation neonicotinoid insecticides, and particularly clothianidin and imidacloprid, are believed to be the main culprits, probably in combination with viral or fungal disease and/or the Varroa mite. The insecticides



*Aerial spraying, Davao del Sur, Philippines (Source: PAN Philippines)*

are believed to disturb the immune function and possibly, behavioural responses leaving the bees defenceless against disease and parasites. In May 2008, Germany suspended both of these pesticides, along with 2 others, all used as seed treatments and believed to be implicated in bee deaths (Cummins 2008a, 2008b).

Environmental effects reported from the Kasargod district in India, where many villagers are ill from aerially applied endosulfan, include deformed calves and disappearing honeybees. Chickens, jackals, frogs, birds and cows have all died. Calves have stunted growth. Miscarriages, bleeding, infertility and deformities in domestic animals have been reported. High levels of endosulfan have been found in soil, water and plant tissues (Quijano RF 2002).



# 5. Nature fights back

It is inconceivable that the constant pumping of poisons into the agri-ecosystem can continue without repercussions, and so, it is not unexpected that nature is fighting back with a consequent adverse effect on production.

## 5.1 SECONDARY PEST INFESTATION

Insecticide use upsets the balance of the ecosystem, wiping out many beneficial insect species. This sometimes results in the development of new pest species, a process called secondary pest infestation. Perhaps one of the most graphic illustrations of this is the brown planthopper epidemic. This insect had previously been “an inconsequential inhabitant” of Asian rice crops, but as its natural predators disappeared, under the barrage of insecticides, it became a menace to the rice crops, the severity of that menace increasing in direct proportion to the intensity of insecticide use. In Northern Sumatra, Indonesia, farmers were treating their rice crops 6 to 20 times over a period of 4 to 8 weeks—with no success. In fact, the density of the pest population increased with the increase in frequency of spraying (Kaosa-ard & Rerkasem 1999).

## 5.2 INSECT PEST RESISTANCE

The resistance of insects to pesticides was first reported as long ago as 1914—the San Jose scale to lime sulphur in the state of Washington, USA—and has since become recognised as a problem of considerable proportions. New resistance was reported steadily from 1943 (two-spotted spider mite) when synthetic chemical insecticide use began to escalate. By 1991, 504 arthropod species were reported to be resistant to one or more of over 200 insecticide compounds. By the year 2000, 533 species were resistant to one or more insecticides. Unfortunately, only 3.5 per cent of these were natural pest enemies such as predators and parasites (Mota-Sanchez et al 2003).

By 2005, insects were showing resistance to a total of 316 different chemical compounds, involving 542 species (Whalon undated). The overwhelming majority of reported cases involve resistance to organophosphates (39.5 per cent) and organochlorines (40.4 per cent) (Whalon undated). This is not surprising as these classes of compounds have been used for more than half a century, but there is a trend of increasing resistance to the newer compounds where these older ones are removed from the market, for example, in the USA. Generally, the first cases of resistance have been reported within 3-5 years after a compound has been extensively used—for DDT it was 1947, following its rapid post-war re-deployment from military human health use to agriculture.

Even the biological insecticides such as *Bacillus thuringiensis* are now showing resistance problems (Mota-Sanchez et al 2003). By 2003, seven insect species had shown resistance to *Bacillus* species, spanning mainland USA, Central America, Brazil, Hawaii, Philippines, Thailand, India, Malaysia, and France. The insects involved include those resistant to many chemical compounds, including tobacco budworm, Colorado potato beetle, house mosquito, beet armyworm and diamondback moth (Mota-Sanchez et al 2003). By 2008, that number had risen to 12 and now, also included cotton bollworm, pink bollworm, European corn borer, Indian

**Table 4: Arthropods resistant to pesticides**

Rank	Common name	Species	Hosts	No. of compounds resistant to
1	Two-spotted spider mite	<i>Tetranychus urticae</i>	cotton, flowers, fruit, vegetables	69
2	Diamondback moth	<i>Plutella xylostella</i>	crucifers, nasturtium	69
3	Peach-potato aphid	<i>Myrzus persicae</i>	fruit, vegetables, trees, grains, tobacco	68
4	Cattle tick	<i>Boophilus microplus</i>	cattle	40
5	German cockroach	<i>Blattella germanica</i>	urban	40
6	Tobacco budworm	<i>Heliothis virescens</i>	chickpea, corn, cotton, tobacco	39
7	Colorado potato beetle	<i>Leptinotarsa decemlineata</i>	eggplant, pepper, potato, tomato	38
8	European red mite	<i>Panonychus ulmi</i>	fruit trees	38
9	Mosquito	<i>Culex pipiens</i>	humans	33
10	Whitefly	<i>Bermisia tabaci</i>	greenhouses crops, cotton	32
11	Egyptian cotton leafworm	<i>Spodoptera littoralis</i>	alfalfa, cotton, potato, vegetables	32
12	Dawson aphid	<i>Phorodon humuli</i>	hop, plum	32
13	Mosquito	<i>Culex quinquefasciatus</i>	humans	28
14	Cotton/melon aphid	<i>Aphis gossypii</i>	cotton, vegetables	27
15	House fly	<i>Musca domestica</i>	humans, animals	26
16	Bollworm, earworm	<i>Helicoverpa armigera</i>	cotton, corn, tomato	25
17	Red flour beetle	<i>Tribolium castaneum</i>	stored grain, peanuts, sorghum	25
18	Sheep blowfly	<i>Lucilia cuprina</i>	cattle, sheep	24
19	Bulb mite	<i>Rhizoglyphus robini</i>	ornamental plants, stored onions	22
20	Malaria mosquito	<i>Anopheles albimanus</i>	humans	21

Source: Mota-Sanchez et al 2003

meal moth, Egyptian cotton leafworm, soybean looper, and cabbage looper (Whalon 2008).

**Table 5: Arthropod resistance: total cases and compounds in 2003**

Chemical class	No. of compounds with resistance	No. of cases of resistance	Percentage
Organophosphates	112	1136	44.1%
Organochlorines	26	844	32.6%
Pyrethroids	33	224	8.5%
Carbamates	35	202	7.9%
Bacterials	38	46	1.8%
Miscellaneous	30	46	1.8%
Fumigants	6	21	0.8%
Insect growth regulators	10	21	0.8%
Arsenicals	2	13	0.5%
Organotins	3	8	0.3%
Formamidines	2	6	0.2%
Avermectins	2	6	0.2%
Chloronicotinoids	1	6	0.1%
Rotenone	1	2	0.1%
Sulphur compounds	2	2	0.1%
Dinitrofenols	1	1	0.04%
Phenylpyrazoles	1	1	0.04%
<i>Total</i>	<i>305</i>	<i>2,585</i>	

Source: Mota-Sanchez et al 2003

Resistance is a micro-evolutionary process of genetic adaptation through selection. It comes about through repeated exposure to pesticides. After 60 years of synthetic insecticide applications, insects all over the world have been exposed to, and selected by, one or more pesticides making it very difficult to find any insect pests that can be considered non-selected. Some insects are now resistant to so many different classes of compounds that farmers are forced back to where they started: using cultural practices as control measures. For example, in some places in the USA, the Colorado potato beetle has developed resistance to more than 38 insecticides involving nearly all chemical classes, and farmers now use propane flammers and plastic lining of trenches to protect their crops (Mota-Sanchez et al 2003). In some species, resistance is confined to particular geographical agroecosystems. With other species, such as the diamondback moth, resistance is found throughout the insect's global range.

The global impact of pesticide resistance has been estimated to be more than US \$4 billion annually. Crop loss, economic failure, environmental contamination, food residues, human ill-health and even suicide are attendant upon pesticide resistance (see box "Punjab: from bread basket to basket case"). High levels of insecticide use can be a consequence, as well as a cause of resistance. In Tapachula, southern Mexico, high levels of insecticide use, together with high temperatures, frequent rain and high levels of pest incidence led to applications of more than 29 litres of active ingredients per hectare. Three principal mosquito varieties—*Culex pipiens*, *Culex quinquefasciatus*, and *Anopheles albimanus*—have developed resistance to many insecticides. Malaria alone, carried by *Anopheles*, results in the death of about 2 million people per year. *Anopheles* exhibits higher resistance also because of indirect selection through the intense insecticide selection pressure on insect pests in cotton, which also indirectly selects immature stages of mosquitoes in breeding sites and adult stages in resting sites (Mota-Sanchez et al 2003).

Many plants are capable of defensive chemistry, i.e. producing toxins to protect themselves against herbivorous insects. The insects in turn have a very long history—perhaps as long as 350 million years—of evolving their own mechanisms to defeat these toxins. It is not surprising therefore, that they can so quickly evolve mechanisms to defeat the human-applied toxins. The evolutionary endpoint is the same: resistance through selection. The lesson for humanity is that the application of toxic chemicals against insects will always be unsustainable in the long run, as the insects are likely to continue to evolve to beat the new chemistry, whether it be synthetic chemicals or biopesticides. There is no reason to believe that scientists will devise a chemical that an insect cannot find its way around. Therefore, devising and implementing cultural and management practices that keep insects in check, rather than relying on being one chemical step ahead of the insects, would better serve the interests of feeding the world.

### **5.3 HERBICIDE RESISTANCE**

Herbicide resistance is also a growing problem, even without the threat of genes escaping from plants deliberately engineered to be resistant to herbicides. The first cases were reported in the 1950s, but it was not until the 1980s that the incidence of resistant weeds started to skyrocket, continuing to increase throughout the 1990s and showing no sign of tailing off.

As of September 2008, there are 320 biotypes of 185 species in over 290,000 fields worldwide that have been recognised as being resistant to herbicides (Heap 2008). Resistance has been found to at least 117 herbicide active ingredients, approximately 40 per cent of the total registered herbicide active ingredients. But this may not be the full story: many of the lesser-used actives have not been tested on resistant populations. Given this, and that most herbicide modes of action have cases of resist-

**Table 6: Herbicide Resistance in Asia & Pacific (excluding Australia, NZ)**

<b>Countries (no. of weeds)</b>	<b>Weeds</b>	<b>Herbicides</b>
China (8)	American sloughgrass	atrazine
Fiji (1)	Annual bluegrass	azimsulfuron
India (1)	Arrowleafed monochoria	bensulfuron-methyl
Indonesia (1)	Asian marshweed	benthiocarb
Japan (14)	Asiatic hawksbeard	butachlor
Malaysia (12)	Azena	chlorotoluron
Philippines (2)	Azetogarashi	cinosulfuron
South Korea (6)	Barnyardgrass	clefoxydim
Sri Lanka (2)	Black nightshade	clodinafop-propargyl
Taiwan (1)	Disc water hyssop	cyclosulfamuron
Thailand (3)	Dwarf arrowhead	cyhalofop-butyl
	Globe fringerush	2,4-D
	Goosegrass	diquat
	Gooseweed	ethoxysulfuron
	Guyanese arrowhead	fenoxaprop-p-ethyl
	Hairy fleabane	fluazifop-p-butyl
	Horseweed	glyphosate
	Inu-hotarui	halosulfuron-methyl
	Japanese foxtail	imazosulfuron
	Kikashigusa	isoproturon
	Little seed canary grass	mesosulfuron-methyl
	Livid amaranth	metsulfuron-methyl
	Low false pimpernel	paraquat
	Marshweed	propanil
	Mizohakobe	propaquizafop
	Mizuaoi/moolokzam	pyrazosulfuron-ethyl
	Philadelphia fleabane	quizalofop-p-ethyl
	Redflower ragleaf	simazine
	Redroot pigweed	sulfosulfuron
	Saramollagrass	tribenuron-methyl
	Smallflower umbrella sedge	
	Sprangletop	
	Sumatran fleabane	
	Tarweed cuphea	
	Yellowbur-head	
<b>11 countries</b>	<b>35 weeds</b>	<b>30 herbicides</b>

Source: Heap 2008

ance, weed scientist Dr. Ian Heap, who is compiling resistance figures, estimates that the true percentage of actives with a degree of resistance would be closer to 80 per cent (Heap *pers com* 13/8/03). In Asia and the Pacific Islands, herbicide resistance has been found in 11 countries, involving 35 weeds and 30 herbicides. Of these 35 weeds, four make it into the worldwide top ten “most important herbicide-resistant species”: redroot pigweed, barnyard grass, goose grass and horseweed.

The problem can become quite severe where farmers have come to rely on chemical herbicides to manage weeds in their crops. Resistant barnyard grass affects more than 800,000 hectares in China. The use of isoproturon for controlling little-seed canary grass in the rice-wheat system in the Harayana and Punjab regions of North-western India has resulted in resistant weeds infesting more than one million hectares of

**Table 7: Crops affected by fungi resistant to fungicides**

Apple	Eucalyptus	Pea
Artichoke	Flowers	Peach
Asparagus	Grapes	Peanut
Avocado	Grass	Pear
Banana	Leek	Pecan
Barley	Lettuce	Pepper
Bean	Lucerne	Pistachio
Blackcurrant	Maize	Potato
Brassicas	Mango	Quince
Capsicum	Melon	Raspberry
Carrot	Millet	Rice
Celery	Mushrooms	Soybean
Cherry	Nectarine	Strawberry
Chickpea	Oats	Sugar beet
Citrus	Oeillet	Tobacco
Coffee	Oilseed rape	Tomato
Cowpeas	Onions	Watermelon
Curcubits	Ornamental trees	Wheat
Eggplant	Passionfruit	Yam

Source: FRAC 2006

wheat. The area is reported to be increasing. In a bid to find a solution to the problem, other herbicides were tried unsuccessfully, according to the weed science website (Heap 2008):

- cross-resistance to diclofop-methyl was observed after two applications in the field
- inconsistent results with pendimethalin were found under field conditions
- lower level of resistance has also been observed with clodinafop-propargyl and fenoxaprop-P-ethyl in the fields.

#### **5.4 FUNGICIDE RESISTANCE**

There are about 150 different fungicidal compounds in use, and nearly half of that use occurs in Europe (Brent & Holloman 2007). Resistance to fungicides has been increasing worldwide since the introduction of systemic<sup>4</sup> fungicides in the early 1970s, and is now widespread, with at least 196 species of fungus resistant to one or more fungicides (FRAC 2006). Resistance has been found to 34 of the 53 classes of fungicides (FRAC 2007). Even the newest fungicide group, the strobilurins, experience spreading resistance. Resistance can develop very rapidly with some pathogens: wheat powdery mildew developed pathogen resistance to six different chemical classes within 2 to 5 years (FRAC 2005).

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<sup>4</sup> Capable of being absorbed and transported throughout the plant.



*Environment friendly rice production,  
Sri Lanka (Source: Vikalpani)*

## 6. Feeding the world better without pesticides

Study after study has shown that if more food is needed to feed the world's population, the best way to provide it is to give up the pesticide addiction. Yet, the myth that pesticides are essential for adequate production lives on in the minds of many. The myth survives only because its perpetrators have focused attention on a narrowly-defined set of criteria appealing to the reductionist mentality that fails to grasp the broad and long-term understanding of what sustainable production really is, and because it suits the profit interests of the transnational corporations that peddle the pesticides.

Pesticides are a fundamental prop of the industrialised agricultural system. This system is underpinned by a narrow type of science that reduces a complex ecological system into a small handful of parameters: inputs and outputs. It ignores the interrelationships between the elements of the system and how they support and sustain each other. Monoculture is the norm, with productivity defined by the yield of a single crop. Production focuses on the short-term maximum yield of the crop—inevitably, to the eventual detriment of that yield, and to the detriment of the nutritional status of farmers in developing countries.

In the pesticide-dependent agricultural system, biodiversity is minimised. This occurs either intentionally through single species planting and weed eradication, or accidentally, through the extermination of ben-

eficial and complimentary insect species as by-kills of insecticide use. Beneficial fungal and bacterial relationships suffer the same fate. The removal of the beneficial organisms allows an escalation of pests and diseases that are otherwise held in balance by the complex natural and introduced biodiversity, and hence creates a self-perpetuating need for chemical pesticides in an attempt to exert control over the unstable monocultural agroecosystem. The resulting situation is not sustainable, and chemical pesticides have to be continually applied to control pests and diseases, thus perpetuating the suppression of beneficial diversity and system imbalance.

Feeding the world better depends on an agriculture that is sustainable, that places emphasis on incorporating a diversity of local natural resources not imported synthetic chemicals, and that places emphasis on the autonomy of farmers not their subservience to multi-national chemical/seed companies and banks. It integrates natural regenerative practices such as nutrient and water recycling, nitrogen fixation and soil rejuvenation, improving the ability of the soil to provide sustained yields over time (Pretty & Hine 2001). It encourages biodiversity that functions both as a diversification of yield and as natural managers of pests and weeds. It promotes social cohesion, encouraging people to work together to solve local problems, to utilise traditional knowledge, and to be innovative and skilful producers of good quality food whilst conserving resources and enhancing the environment. It recognises that farmers and rural communities are part of the agroecosystem. It requires a focus on feeding the family and community rather than the cash economy. Feeding the world sustainably requires an ecosystem approach that nurtures the ecological, biological and social processes that in some countries have supported food production for many thousands of years.

The ESCAP (2002) report *Organic Agriculture in Asia and Rural Poverty Alleviation* found a positive interrelationship between organic farming and improvements in rural livelihoods, noting that:

*“In addition to the positive effects on employment and income, the production of food crops together with commercial crops is beneficial for household food security. The generally higher biodiversity on organic farms, the significant increase in the yield of staple crops, the cultivation of vegetables for home consumption and sale, the integration of food crops into unpolluted cotton fields and the combination of crops and animals including aquaculture where this is applicable, all this increases the availability of food at household level. At the same time, products are available for marketing. In the Nayakrishi movement in Bangladesh, an improvement of the health status of their members could also be observed.”*

In 2007, the International Conference on Organic Agriculture and Food Security, under the auspices of the FAO, came to similar conclusions:

*“Organic agriculture improves food access by increasing productivity, diversity and conservation of natural resources, by raising incomes and by reducing risks for farmers. Improvement also results from the sharing of knowledge among farmers. These benefits lead to poverty reduction and a reversal of rural outward migration.”*

FAO (2007) also concluded that sustainable intensification in developing countries through organic practices would increase production by 56 per cent.

Based on model estimates developed using data from 293 comparisons of organic and conventional production systems, Badgley et al (2007) concluded that organic/ecological agriculture could feed the world’s current population and potentially, a substantially larger one without increasing the agricultural land base, perhaps even decreasing it. Studies they reviewed showed that although the adoption of Green Revolution methods in developing countries has increased yields, so too has conversion to organic agriculture, for example in the ‘System of Rice Intensification’ (see later for more detail). Consistently, higher yields were

found in developing countries with organic/ecological systems. Use of nitrogen-fixing green manure crops can provide sufficient nitrogen, that is held more stably in the soil than synthetic nitrogen, as well as increase soil moisture retention and reduce vulnerability of plants to diseases. These systems can absorb more labour spread more evenly over the season, reducing unemployment, and would increase food security for developing countries. They concluded that if research efforts comparable to those focused on conventional agriculture over the last 50 years were applied to organics there could be further improvements in yields as well as soil and pest management.

Despite this lack of research, China is experiencing an organic revolution. It now has the second largest organic acreage under cultivation in the world, with an eleven-fold increase in just one year, from 2005 to 2006, adding 12 per cent to the world's area of land under organic management. China's modern day organic movement dates from only 1990; and much of the recent increase is attributed to leadership from the top: in 2001, Communist Party General Secretary Jiang Zemin urged a move "to develop organic and pollution-free food" (Paul 2007).

Recently, the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD 2008) concluded, after four years of work by more than 400 scientists, that if we are to feed the people of the world we can not continue to practice agriculture as we have over recent years: "Business as usual is no longer an option". Instead, a holistic, systems-oriented approach is needed, with farmers empowered "to innovatively manage soils, water, biological resources, pests, disease vectors, genetic diversity and conserve natural resources in a culturally appropriate manner". Food security can be assisted by reducing transaction costs for small-scale producers and strengthening local markets, and sustainability improved by innovative techniques for organic and low-input systems, breeding for temperature and pest tolerance, biocontrols for current and emerging pests and pathogens, biologi-

cal substitutes for agrochemicals, and reducing the dependency of the agricultural sector on fossil fuels.

There are many studies which demonstrate that yields have been increased by removing pesticides from the system. Some of these focus on the single output parameter of crop yield and, even so, show that increases can be achieved by reducing or removing pesticides. But this simplistic approach undervalues the non-pesticide systems—traditional, organic or ecological agriculture—for they usually deliver much more than mere increased production. They deliver food security, better health, a cleaner environment, the reversal of land degradation, local control and retention of land ownership. They can produce crops on marginal land where industrial agriculture can not: in high mountain regions in Bolivia, some of the most difficult growing areas in the world, farmers have increased potato yields three-fold by using green manures; and in Peru, restoration of Incan terraces has brought 150 per cent increases in yields and the ability to withstand floods, droughts and frosts at nearly 4000 metres altitude (Scialabba & Hattam 2002). Sustainable agroecological systems can out-produce industrial agriculture in times of drought (Peterson et al 1999). The importance of this should not be overlooked, for about 39 per cent of Asia's population live in areas prone to drought and desertification.<sup>5</sup> There are 350 million hectares of degraded land in China, India and Pakistan alone, in large part due to deforestation and agricultural activities. The Asian Development Bank has estimated that, in total, about one third of Asia's agricultural land has been degraded over the past 30 years (ESCAP 2002). Rural poverty is worst in these areas.

There are many interwoven threads that contribute to the successful productivity of non-pesticide dependent farms, and in turn to the provision of sufficient food within a socially just framework. Sustainable

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<sup>5</sup> The rural population is 60% of the total population in Asia, with that figure rising to 65% for Pakistan, 71% for India and 75% for Bangladesh - in contrast with Europe's 27%, USA's 19% and New Zealand's 14% (ESA 2005).

agricultural practices tend to be synergistic, having a multiplying effect on productivity that defies the analysis of the reductionist method of measuring a single variable at a time (Pretty & Hine 2001). Sustainable systems must be viewed as whole systems.

## **ORGANIC AGRICULTURE**

- \* **improves household nutrient intake**
- \* **improves micronutrient intake and provides a healthier diet**
- \* **establishes self-reliant food systems especially at household level**
- \* **offers employment opportunities**
- \* **contributes to sustainable livelihoods**
- \* **contributes to rural development**
- \* **contributes to improved social wellbeing**
- \* **has low energy footprint**
- \* **maximises efficiency of resource use, energy and nutrient recycling**
- \* **restores functional biodiversity**
- \* **conserves environmental services**
- \* **decreases transport and transaction costs through community-supported food short-supply chains**
- \* **establishes vibrant local food supplies that decrease food-import dependency and import surges**
- \* **helps re-localise food systems where the poor and hungry live**

Source: FAO 2007

## MASIPAG - CONSERVING AND DEVELOPING BIODIVERSITY IN THE PHILIPPINES

Some scientists have estimated that, before the Green Revolution, rural communities worldwide had generated more than 140,000 rice varieties and landraces (local adaptations). Currently, there are 99,132 rice accessions (germplasm of varieties) held at the International Rice Research Institute. Rice collected from the Philippines alone accounts for 4,419 accessions.

But the Green Revolution displaced these with just a few high yielding varieties that often did not produce enough, especially under poor soil conditions and when chemicals were not applied. Even with increased rice yield in some circumstances, the net income diminished because of the cost of inputs.

In 1985, a national conference in the Philippines that brought together farmer-leaders, non-government organisations, academics, administrators and policy-makers strengthened the farmers' resolve to look for new approaches to rice farming. In 1986, the Farmer-Scientist Partnership for Development or MASIPAG, was born.

MASIPAG has a holistic approach with resource-poor farmers at the centre, and with seed/genetic resources, technology, and land as integral components. Its goal is to improve the quality of life of the farmers and empower them through participatory planning and development, effective and efficient utilization of locally available resources, and access to and control of production resources. It is pursued through a farmer-scientist partnership with a bottom-up approach, using traditional varieties, and with the research agenda identified by farmers. MASIPAG gives prime importance to social equity and cultural sensitivity.

Trial farms are established with organised groups of farmers, and each is given 50 to 100 varieties of rice to plant. There are 286 farmer-managed trial farms for rice and 16 for corn. Here, the farmers learn to observe, characterize and monitor agronomic characters such as tillering capacity, days to maturity, height, length of panicle, and number of grains per panicle. They are trained in rice and corn breeding, soil nutrient management, green manuring, alternative pest management, seed propagation, handling and storage, food processing,

herb production, livestock characterization, and diversified and integrated farming systems. They select seeds and breed them to develop diverse, more stable and location-specific cultivars.

Eighteen years on, MASIPAG is a partnership of 32,000 farmers in 542 farmers' organisations, 33 NGOs, 40 church-based organisations, and 15 scientists. It is estimated that there are three times as many farmers planting the MASIPAG seeds.

MASIPAG has a collection of 859 traditional rice varieties and has developed 826 improved rice selections. Of these, 227 are locally adapted selections. Fifty traditional corn varieties have been collected, and four open-pollinated varieties developed. Genetic characterization of local and indigenized breeds of livestock and poultry has started, with breed improvement to follow.

The enhanced varietal diversification of rice, reinforced by crop rotation and farm diversification, is creating a more stable and sustainable rice farming system than that of chemical farming. Soil health has improved with the replacement of chemical fertilisers by local materials such as rice straw, animal manure, and green manure. The avoidance of pesticide use has further contributed to a more balanced and stable agro-ecosystem, and benefits to health.



*Seed sample in Nueva Ecija, Philippines (Source: Achim Pohl)*

**There are economic benefits from the avoidance of chemical inputs. The yield of MASIPAG rice selections is comparable to, and often higher than, that of 'high-yielding varieties'. Net income, in most cases, has been greater in MASIPAG than in conventional farming.**

**MASIPAG farmers are proud and articulate.**

Source: Medina 2007

### **CASE STUDY: ORGANIC JASMINE RICE AND BABY CORN PRODUCTION IN THAILAND**

**Two studies of organic production projects in Thailand show decreased input costs and greater returns for farmers without reducing yields, and even with increased yields in the case of baby corn, in both cases turning financial losses into profits. Costs and prices are in Thai baht.**

#### **Jasmine rice**

	<i>Conventional</i>	<i>Organic</i>
fertilisers	220	150
pesticides	12	0
self-labour	780	960
yield (kg/rai)	350	350
price	7	10
net profit	-185	767

#### **Baby corn**

	<i>Conventional</i>	<i>Organic</i>
fertilisers	845	500
pesticides	68	0
self-labour	3,000	3,360
yield (kg/rai)	150	173
price	20	30
net profit	-1,733	2,243

Source: ESCAP 2002

## **CASE STUDY: THE MAIKAL BIO-COTTON PROJECT IN MADHYA PRADESH, INDIA**

In 1992, an organic cotton-growing project was set up as a response to severe pest problems despite repeated pesticide application. Whitefly had developed resistance to pesticides, and farmers' returns were declining. Locally prepared biodynamic preparations and a range of organic techniques, such as trap and host crops, and compost making, replaced the chemical inputs. Seven years later, more than one thousand farmers had joined the scheme, cultivating more than 6,000 hectares. Organic cotton, grown on around half this area, is rotated with a wide range of other crops.

### **Results after seven years:**

- average cotton yield 20 per cent higher than on neighbouring conventional farms
- up to 20 per cent higher yields of other rotational crops – wheat, soya, chilli
- 30 per cent higher yields for sugar cane and a higher price for the cane because of a higher sugar content
- pest incidence reduced to a minimum
- labour requirements substantially reduced
- production costs 3-40 per cent less than for pesticide-dependent cotton crops
- significantly higher farmer margins

Source: Parrott & Marsden 2002; ESCAP 2002

## CASE STUDY: ORGANIC RICE IN TAMIL NADU, INDIA

**A comparison of costs and benefits of conventional and organic paddy cultivation in Tamil Nadu showed the latter to be the clear winner:**

	<i>Conventional</i>	<i>Organic</i>
Total costs	6,550 Rs	3,998 Rs
Total Income	8,700 Rs	11,050 Rs
Cost-benefit ratio	1:1.32	1:2.76

Source: Quintal et al 2007

### 6.1 SOME IMPORTANT FEATURES OF SUSTAINABLE AGRICULTURAL SYSTEMS

There is no clear definition of what is meant by 'sustainable agriculture', and the term is often used to encompass organic, biodynamic, agroecological and traditional agricultural systems. Key principles include:

- integrated biological and ecological processes such as nutrient cycling, nitrogen fixation, and soil regeneration
- enhanced resilience, biodiversity and environmental services such as watershed management, clean water and groundwater recharge, wildlife habitats, carbon sequestration
- minimised use of non-renewable inputs and inputs that harm the environment, farmer or consumer
- productive use of the knowledge and skills of the farmer, improving their self-reliance
- socially just access to productive land and resources
- provision of sufficient quantity of good quality food, fibre and fuel.

### **6.1.1 Farm size and access to productive land**

Smaller farms have been found to be 2-10 times more productive per hectare in total output than larger farms, in both industrialised and developing countries (Rosset 1999). Large farms tend to be extensive monocultures, in which the vacant spaces between crop rows are inviting to weeds that are then usually managed with herbicides. On small farms, these potentially vacant spaces are characteristically filled with other useful species (intercropping), perhaps also with animals rotated over the same ground. Thus, the total output is the sum of everything a small farmer produces: various grains, fruits, vegetables, fodder, animal products, etc. Land reform, in which large tracts of land held by landlords or corporate interests and farmed extensively or in monocultural plantations are returned to smallholder farming families, may provide a much greater boost to productivity than pesticide use could ever achieve. The sustainable agriculture projects reported by Pretty & Hine (2001) and summarised below in section 6.2, averaged < 2 hectares per farmer.

Small farms also are often the centres of innovation, with successful techniques spreading to larger farms, as happened with the rice-fish and rice-IPM systems developed in Bangladesh (Pretty & Hine 2001).

Of course, land reform has far greater benefits than just increase in productivity:

*“In traditional farming communities, the family farm is central to maintaining community and to the sustainability of agricultural production. On the small farm, productive activities, labour mobilization, consumption patterns, ecological knowledge and common interests in long-term maintenance of the farm as a resource, contribute to a stable and lasting economic and family-based enterprise. Work quality, management, knowledge and relationships are intertwined and mutually reinforcing. Short-term gain at the risk of degrading essential resources not only in-*

*vites community sanction, but also places the family and the farm at risk of collapse.” (Rosset 1999)*

Genuine land reform offers to improve productivity and food security together with community empowerment and social cohesion, something pesticides can not achieve.

### **6.1.2 Conserving the soil and restoring its fertility**

Conservation practices reduce erosion, improve soil physical structure, and improve water-holding capacity and nutrient balances. Restoring fertility requires using nitrogen-fixing plants, adding animal manures, composts and other organic matter back into the soil.

Planting mucuna beans, for example, has transformed poor soils in Latin America. Mucuna produces as much as 100 tonnes of organic material per hectare, fixes nitrogen from the atmosphere, and creates rich, friable soils in just a few years. Subsequent crop yields have been found to double or even treble (Pettifer 2001).

The 150 year long Broadbalk Experiment at Rothamsted Experimental Station in the UK, comparing plots that are organically fertilised with those that are chemically fertilised, has shown that the soil organic matter and nitrogen levels in the organic plots have increased by 120 per cent, whilst those of the chemical plot have increased only by 20 per cent (Jenkinson et al 1994).

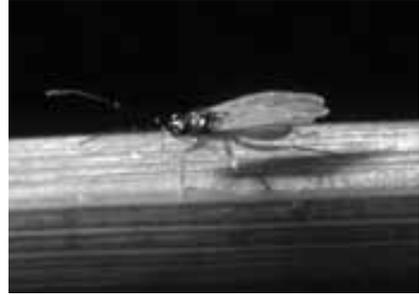
A 15 year study of maize/soybean agroecosystems at the Rodale Institute in the USA showed that organic techniques improved the soil's ability to absorb and retain moisture, and that during one of the worst droughts on record, the organic soybeans yielded 30 bushels/acre whilst the chemically grown beans provided only 16 bushels/acre (Peterson et al 1999).

### 6.1.3 Biodiversity

Encouraging biodiversity in the agroecosystem is a key ingredient of increasing production and managing pests, weeds, and diseases without using pesticides. It is a key strategy in many of the successful farming systems reviewed here. There are many important aspects to biodiversity, only some of which are mentioned below. One of the most important is that of increasing the diversity of productive outputs and the total farm productivity, as will be discussed in more detail in section 6.2.

Other aspects of biodiversity relate to the functioning of the agroecosystem:

- i. Mixed plant species increasing yield through complementary relationships*
  - A study by Tilman et al (2001) comparing a number of plots of different plant species including grasses, legumes, flowering herbs and woody species, found that the mixed species plots produced 39 per cent greater above-ground biomass and 42 per cent greater total biomass than single species plots after five years. The positive effects of the biodiversity were increasing over time. Discernible complementary relationships among specific species and functional groups appeared to contribute to this increase in productivity, as well as to a reduction in weed invasion.
  
- ii. Mixed crop varieties reducing disease incidence*
  - In Yunnan, China, farmers in ten townships on 5,350 hectares switched from growing monocultures of sticky rice to growing alternate rows of sticky rice and hybrid rice. The sticky rice fetches a higher price but is susceptible to rice blast. In the first year of the experiment, the rice blast was reduced by 94 per cent and yields increased by 89 per cent. Fungicides previously applied



*A rich biodiversity of natural enemies keeps the brown plant hopper in check (Source, Ooi, 2010)*

eight times a season were no longer required and it was found that the more farmers joined the project and the larger the area involved, the more effective the technique became. The hybrid variety acted as a kind of firewall between the disease prone blocks. Gross income per hectare increased by 15 per cent, even without including the saving on fungicides (Stoll 2000; Pretty & Hines 2001).

### *iii. Predator and parasitic insects controlling pest insects*

- Farmers in Viet Nam use weaver ants to control pests on citrus. In trials over two years, the ants reduced infestation of citrus stinkbug by 94 per cent, of swallowtail butterfly larvae by 92 per cent, of citrus aphid by 67 per cent, and leafminer damage by 12 per cent. As a bonus, they also produced shinier fruit with greater consumer appeal (Stoll 2000).
- Research on 18 commercial Californian tomato operations showed that there was no difference in pest damage between organic and conventional operations. Arthropod biodiversity was one-third greater on the organic farms, indicating that beneficial species were keeping the pests under control (Letoumeau & Goldstein 2001).

- In Bangladesh, a project begun in 1995 to promote non-chemical means of pest-control relies primarily on natural enemies and on the ability of the rice plant to compensate for insect damage. Yields are consistently higher and net income has risen by 56 per cent (Barzman & Das 2000).

iv. *Using weeds to control weeds and insects*

- In East Africa, maize and sorghum face two major pests: stem borer and the parasitic plant *Striga*. The field margins are planted with a local weed, Napier grass (*Pennisetum purpureum*), the odour of which attracts stem borer away from the crop (Pearce 2001). The grass also produces a sticky substance that kills the stem borer larvae. The crops are interplanted with two legumes to fix nitrogen, and also with molasses grass, *Desmodium uncinatum*, which repels both stem borer and *Striga*. Crop losses are reported to have been reversed by removing pesticides from the system (Ho & Ching 2003), and profits increased (Khan et al 2008).

v. *Multi-tasking ducks: insect and weed control, plus diversity of output*

- A Japanese organic farmer developed a rice growing system that utilises weeds and pests as resources for raising ducks. The ducks eat the insect pests and golden snail that attack rice, and they eat weed seeds and seedlings. When they use their feet to dig up the weeds they aerate the water and provide mechanical stimulation that causes the rice stalks to strengthen. The duck-rice system has been adopted by 10,000 farmers in Japan and by others in South Korea, Viet Nam, Philippines, Laos, Cambodia, Thailand and Malaysia. Yields are reported to have increased 20-50 per cent in the first year (Ho 1999). Now, this system is also becoming popular in Bangladesh (Hossain et al 2007).

#### **6.1.4 Traditional indigenous knowledge, seed conservation, and participatory technology development**

An essential ingredient in improving food security through sustainable agriculture is recognising the value of traditional indigenous knowledge, together with conserving traditional varieties of seeds through farmer-based evaluation and local seed banks (Ho & Ching 2003). Numerous case studies from India, Brazil, Iran, Thailand and Uganda show the benefits of traditional knowledge, innovation and agroecological approaches, which include increased productivity and economic benefits, and enhanced social relationships within communities (Scialabba & Hattam 2002).

As a consequence of work by the LEISA (Low External Input and Sustainable Agriculture) Network, farmers in 80 villages across Tamil Nadu were able to reverse the land degradation and poverty that had resulted from a shift away from traditional farming to a high external input/cash crop system. They achieved this reversal by incorporating traditional knowledge with innovative agroecological techniques:

*“Pests and their natural predators are closely observed in the field and a balance maintained between them to control pests. Other methods include growing repellent crops, trap crops, and inter-crops, and the use of light traps (to attract and trap pests), bird perches, herbal decoction sprays (including neem oil sprays) and bio-control techniques (use of parasites). Natural plant growth promoters are also developed and used (for example, cow’s urine, vermi-wash, panchakavya and tender coconut water for rice).*

*In all these, the farmers identify their own problems and try to find their own solutions. In this process, several new techniques have been developed by the farmers themselves. The participatory technology development process has become a vehicle for resource, skill and knowledge enhancement with minimum risk to these resource-poor farmers.*

*It has also increased their confidence. Though the process has largely addressed crop protection and fertility management, it also extends to socio-economic aspects.*

*As a result of all these practices, externally purchased inputs have been reduced by 50-90 per cent, especially inputs for plant protection. This has brought down the cost of production (offering, for instance, a better cost-benefit ratio of 1:1.8 in rice farming with the new low external input and sustainable agriculture compared to 1:1.4 in conventional farming with chemicals). Besides, the land is now healthier with greater moisture-holding capacity and pest resistance, and the food is poison-free. As small and minor millets are resistant to drought and pest, the farmers have started cultivating more of these crops for food security at the family and the village levels. There is a shift from mono-crop to multiple crops and from cash crops to food crops.*

*Because of the decrease in the use of external inputs and the consequent reduction in expense, the farmers are also being liberated from the debt trap and loan sharks ... Value addition to agricultural products further helps generate additional income and provide better employment opportunities, particularly for the landless ... Because of this greater employment, there is less migration now, leading to the improvement of the village economy.” (Chanakya et al 2003)*

## **6.2 THE EVIDENCE**

In 2001, Jules Pretty and Rachel Hine published the results of an extensive survey of sustainable agricultural projects in 52 countries. These projects involved 8.98 million farmers on 28.92 million hectares: 3 per cent of the arable and permanent crops in Africa, Asia and Latin America. Of the 208 projects, 23 were in India, 8 in China, 7 in the Philippines, 4 in Bangladesh, with others in Sri Lanka, Nepal, Pakistan and Vietnam.

**Table 8: Some successful traditional and innovative methods in the LEISA project in Tamil Nadu**

<b>Problem</b>	<b>Method</b>
Ear head bug	Bugs collected, crushed, mixed with water & sprayed on crop Spray pepper water Spray garlic water Broadcast dry fish powder
Blast disease	150gm asafoetida and ginger made into a juice, diluted in 9 litres water and sprayed
Field cracking	Stamping the field after irrigation Dissolve cow dung in irrigation channel
Water scarcity	Spread human hair and plough it into soil in preparing a nursery plot for water retention Broadcast <i>Azospirillum</i> (bacteria) and tea dust
Seepage of water	Form a bund with red soil, plaster it and plant with <i>Cynodan tactylon</i>
Aphids - cotton	Sheep dung and ash mixed together and sprinkled
Stem rot disease - chilli	1kg <i>Albizzia amara</i> leaves, pounded & soaked in 2 litres of fermented butter milk for 10 days
Green larva and pod borer - cow pea	Garlic, ginger, green chilli, and khadi soap decoction sprayed
Trips - paddy nursery	Broadcast wood ash
Bollworm - cotton	Intercrop with castor, sunflower, marigolds Light traps Pheromone traps Release of green lace wing Release of <i>Trichogramma chilonis</i> parasite

Source: Chanakya et al 2003

Many of these projects achieved very large reductions in pesticide use: for example, with the adoption of IPM through the farmer field schools in rice production, Vietnamese farmers cut the number of sprays from 3.4 to 1 per season, and in Sri Lanka, the reduction was from 2.9 to 0.5.

Many also cut pesticide use completely:

- in Bangladesh, 80 per cent of the 150,000 farmers using IPM no longer use any pesticides and rice yields have not fallen
- 40 per cent of farmers in the Mekong Delta in Viet Nam no longer use any pesticides on rice
- India's National IPM programme has brought a 50 per cent reduction in pesticide use with rice yields increased by 250 kg/ha
- in Indonesia, the National IPM Programme in rice reduced pesticide use on average from 2.9 to 1.1 applications per season, and by 1999, one quarter of all farmers had stopped using them altogether; at the same time, rice yields increased by 0.5 tonnes/ha on average
- in the Philippines, the IPM programme for vegetables in the Highlands brought an 80 per cent reduction in pesticide use in the wet season (55 per cent in the dry season), with a 20 per cent increase in vegetable yields; in parts of the Philippines, 75 per cent of farmers no longer use pesticides on vegetables.

Significant increases in household food production were also reported:

- for 4.2 million farmers on an average of 0.8 hectares, production per household increased by 74 per cent
- for 146,000 farmers on an average of 3.7 hectares, production increased by 150 per cent

- for larger farms in Latin America (>90 hectares), production increased by 46 per cent.

The increased food production came in part from increased yields, typically of 50-100 per cent, even up to 200 per cent in cereal production. It also came from increased diversity through improved use of microenvironments—such as fish, shrimp and crabs in rice fields and garden ponds, vegetables on rice bunds and in kitchen gardens, multi-layer tree gardens with root crops at ground level. Eighty-eight per cent of the projects made better use of locally-available resources.

### **Social consequences**

As a direct result of the increased total farm productivity, domestic consumption of food increased. Pretty & Hine (2001) found that women and particularly children were frequently the main beneficiaries of the increased food production. Children had better opportunities to attend school. They found that migration reversals occurred—in India (Maharashtra, Gujarat and Tamil Nadu), seasonal migration from rainfed projects declined as better water management meant water was available for cropping during the dry season, women particularly benefiting from being able to remain at home all year.

In China (Jiangsu Province), there has been a measured reduction in malaria where a rice aquaculture system has been developed with larvae-eating fish added to the rice fields. For example, in Quanzhou County, the incidence of malaria fell from 11.6 cases per 100,000 people to only 0.1 cases as the area of rice-fish cultivation grew from zero to 43 per cent of the area over a ten-year period. The rice yields have also increased by 10-15 per cent and 50 kg of fish can be produced annually per *mu* (one fifteenth of a hectare). The use of agricultural chemicals is greatly reduced (Pretty & Hine 2001).

Korean researchers have found that avoiding pesticides in paddy fields encourages the muddy loach fish, which predate mosquito larvae, effectively controlling the spread of malaria and Japanese encephalitis (Bonner 2002).

Farmer field schools have been one of the most significant models for social learning to emerge in the last 15 years. Ninety-two per cent of the projects provide improved human 'capital' through various learning programmes (Pretty & Hine 2001).

### **FARMERS FIELD SCHOOLS IN INDONESIA**

**In 1992, in response to farmers' loss of control over agricultural resources, the impact of pesticides on health and environment and the marginalisation of women farmers as a result of the Green Revolution and trade liberalisation, Gita Pertiwi, an NGO in Central Java, organised an IPM training programme for farmers. The programme, using farmer field schools in which farmers learn directly from experience, has benefited over 8,000 farmers. It has substantially reduced and in many cases eliminated the use of pesticides, improved farmers knowledge, skills and self-reliance, increased crop yields, and lowered the cost of production.**

Source Dewi 2003

## **6.2.1 Analysis of some growing systems**

### **Wetland Rice systems**

Eighty one per cent of the global rice production occurs in Asia, some 484 million tonnes in 1999 (Pretty & Hine 2001).

Farmer field schools using an agroecological IPM system have brought sharp reductions in pesticide use together with small increases



*Woman carries manure to fertilise her rice field in Cambodia*

in rice productivity. Fish, crabs and prawns introduced into the fields to improve nutrient recycling and improve disease control have increased protein production, increasing total system productivity. So have the vegetables cultivated on the rice field dykes, with a synergistic interaction between the fish and vegetable cultivation. Social cohesion developed through farmers' groups has led to better sharing of water resources especially in times of scarcity.

In Bangladesh, 80 per cent of the farmer field school participants no longer use any pesticides. Their rice-fish-vegetable systems brought in an additional income of US\$250/ha, and as a result, all the participating households became food secure throughout the year (Pretty & Hine 2001).

In Sri Lanka, a national integrated pest and crop management programme brought substantial reductions in pesticide use—from 2.9 to 0.5

applications per season—with increases in rice yields up to 50 per cent, and of vegetables up to 44 per cent (Pretty & Hine 2001).

If increased production of the main crop is the only goal, this can be achieved through changes in management techniques rather than the use of pesticides. For example, the System of Rice Intensification (SRI)



*Rice planting, Sri Lanka and seedling selection, Nepal*

developed first in Madagascar has achieved yield increases from the usual 2-3 tonnes per hectare to typically 8 tonnes, even up to 15 tonnes on soils that were nutrient deficient and acidic. This was achieved without recourse to purchased pesticides and fertilisers, simply by changing the way that plants, soil, water and nutrients are managed. The methods used include transplanting rice seedlings after 15 days instead of 30 days to minimise damage to roots; planting single seedlings instead of groups of 3 or 4; spacing plants more widely apart at densities of 15-20 per square metre instead of the usual 100; periodic drying of the fields which encourages growth; more frequent weeding which increases root aeration; and use of manures and composts (Parrott & Marsden 2002; Ho et al 2003). The SRI approach has spread to 28 countries including most of the rice-producing countries of Asia as well as some in Africa and Latin America (Uphoff 2007).

**Table 9: Sustainable wetland rice production**

Country	No. of Farmers	Hectares	Productivity
Sri Lanka	55,000	33,000	rice yields up 30-50%
Vietnam	108,000	162,000	rice yields up 9%
Indonesia	1,000,000	500,000	rice yields up 5-10%
Madagascar	20,000		rice yields up from 2 to 6-11 tonnes/ha
Bangladesh	150,000	90,000	rice yields up 7-9%
China - Jiangsu	103,000	70,000	rice yields up 10-15% plus fish, crab, shrimp

Source: Pretty & Hine 2001

### ***Rainfed rice and maize***

Changes to the rainfed maize, wheat and rice agroecosystems have brought significant increases in yields. These changes include:

- incorporation of legumes into rotations as cover crops and/or as green manures, or as a weed suppressant

## BENEFITS OF SUSTAINABLE RICE INTENSIFICATION (SRI)

- more tillers (30-50 more per plant), larger panicles, heavier grains
- water saving – 25-50 per cent
- higher milling outturn – because of fewer unfilled or shattered grains
- resistance to lodging – because of stronger roots
- reduced incidence of pest and diseases
- shorter crop cycle – crops mature 1-3 weeks earlier
- lower costs of production – about 20 per cent
- higher productivity – rice yield per hectare, per unit labour, per volume water, and per capital investment
- environmental improvements – less water use, enhanced soil and water quality through less use of agrichemicals.

Source: Uphoff 2007

- agroforestry with maize/rice for soil nitrogen-fixing and phosphate-releasing
- biological control of pests, including semiochemicals released by some grasses that push-pull predators, parasites and pests
- watershed and catchment management programmes (Pretty & Hine 2001).

**Table 10: Sustainable rainfed rice and maize production**

Country	No. of Farmers	Hectares	Productivity
China, Yunnan	150	300	maize up 33-250%
India	4,000	5,000	rice up 180% (wet season), 87% (dry)
Nepal	3,000	1,300	rice up 240%
	580	350	rice up 50%, maize up 33%
Philippines	277	206	maize up 15-25%
	450	520	rice up 113%, maize up 227%

Source: Pretty & Hine 2001

## **Wheat and maize intensive rotations**

Of the 583 million tonnes of wheat produced worldwide in 1999, 20 per cent was produced in China on 31 million hectares, and 11 per cent in India on 24 million hectares. Kazakhstan (13m ha) and Pakistan (8m ha) are also significant producers. Improvements in yield came with adoption of cover crops and green manures, and with farmer participatory breeding in India and Nepal. In the Hebei Province of China, water use has been reduced by 30 per cent, fertiliser use by 20 per cent, with a net improvement in returns of 30 per cent. In East Gansu, rainfall collection techniques, water conservation, and animal manures have contributed to significant increases in yields, decreased pesticide and fertiliser use, and greater availability of drinking water (Pretty & Hine 2001).

**Table 11: Wheat and maize rotations**

<b>Country</b>	<b>No. of Farmers</b>	<b>Hectares</b>	<b>Productivity</b>
China			
- East Gansu	100,000	70,000	maize up 38%, wheat up 40%
- Hebei Plain	224,000	100,000	wheat up 17%; maize up 9%
Pakistan	690	1,000	wheat up 10-25%

Source: Pretty & Hine 2001

## **Arid and semi-arid millet and sorghum**

Millet and sorghum are vital staple foods in dryland India and China where 16 million and 8 million tonnes, respectively, were grown in 1999. Farmers growing these crops are very poor and input use is low. Improvements in yields have been brought about by using water harvesting techniques that have either increased yields on existing land or brought previously unproductive land into production; and by use of animal manures, compost, rock phosphate and soil conservation measures. In India, yields have risen from 200-400 kg/ha to 700-900 kg/ha in the wet

**Table 12: Sustainable home gardens and microenvironments**

Country	No. of Farmers	Hectares	Productivity
Bangladesh	60,000	11,000	vegetable up 39%
India	338	380	milk up 60%
Pakistan	5,000	3,500	mango & citrus up 150-200%
Philippines	1,720	1,720	cabbage up 21%

Source: Pretty & Hine 2001

season, and from 1200 to 2000kg/ha in the dry season. In some places, the dry season crop was not grown before, but the land is now producing 500kg/ha (Pretty & Hine 2001).

### ***Home gardens and microenvironments***

Luckily for many households, these are seldom paid attention by agribusiness in its drive for control of the cash crop economy—for the food produced here are mostly for home consumption or local sales. That is why they are of central importance in ensuring that food insecure people receive adequate nutrition from a diversity of foods. In Indonesia, the garden area (pekarangan) can contain up to 250 species of useful plants, with productivity per square metre higher than for field crops (Pretty & Hine 2001). Significant increases in productivity can be gained with biointensive gardening, including double-dug beds for year-round fruit and vegetable production, fish ponds in gardens, the addition of 1 or 2 units of livestock (cow, chicken pig, goat), and development of microenvironments that might otherwise be uncultivated such as silt traps. Importantly, too, it is the most food insecure members of a family—women and children—who benefit most from these efforts.

There are also examples where less pesticide use has resulted in a decreased yield of the cash crop but an increase yield of food for the workers. This occurred in the Ambootia tea estate in Darjeeling, India.



*Home garden, Sri Lanka (Source, Vikalpani)*

This 350 acre tea garden in the foothills of the Himalayas, in common with most other tea estates, faced declining yields of tea as a result of over-intensive farming that caused the depletion of soil fertility and decreased resistance to disease. A biodynamic management system was introduced, involving locally made compost, doubling of the dairy herd to provide manure, leguminous ground covers, tree planting to shade and stabilise the hilly land, and promotion of ecological diversity to improve pest control. Initially, a 17 per cent reduction in tea yields was experienced but the social benefits have been significant—including increased milk yields that have improved the workers' diets. The prevalence of respiratory disease has also dropped with the abandonment of pesticide use (Parrott & Marsden 2002).



*Children are particularly vulnerable to the effects of pesticides, Cambodia*

## 7. Conclusion

Most countries remain locked in a pesticide culture, a culture of chemical addiction, and denial: denial of adverse effects and denial of a different and better way, one that provides profits and good health to the people who grow food rather than to the purveyors of poisons.

It is not pesticides that will feed the world; it is community-centred, biodiversity-based sustainable agriculture. The use of agroecological practices instead of pesticides has been repeatedly found to increase food supplies, increase food access, reduce malnutrition, increase incomes, and improve the livelihoods of the poor (Uphoff & Altieri 1999). These practices can provide year-round self-sufficiency where high input systems do not. They lead to more stable levels of total production per unit area than high input systems, at the same time, ensuring soil protection and enhanced biodiversity. Additionally, these yields are under the control of the farmers and communities that produce them, meaning that the people get fed.

Feeding the world is about far more than just increasing production. It is about ensuring food security and access to food. It requires food sovereignty. Farmers must have control of their own agrisystems instead of being enslaved to money lenders and TNCs. This can be achieved by an agricultural system that relies on local inputs rather than expensive agrochemicals that fail at crucial times. It is achieved by fostering agri-

biodiversity that is more resistant to the vagaries of nature and the harvest of which is less likely to fail completely. A broader range of crops with mixed intercropping, a range of species and more varieties of the same species give the best insurance against starvation. Single crop productivity should not be the judge of agricultural productivity, nor of whether or not the world can be fed. The health of farmers, families and communities is an equally vital part of measuring the production benefits of an agricultural system. Sustainable agriculture honours the knowledge of traditional agriculture, and the wisdom of women farmers and seed-keepers.

Pesticides, on the other hand, have brought ill-health and suffering, starvation and suicide. They have brought disrupted communities, broken families and poisoned environments to places like Kamukhaan and Kasargod.

Pesticides are developed and distributed not to feed the world but to feed the greed, for ever more profit, of rapacious chemical corporations caught up in the economic growth cycle. These companies exploit cynical marketing techniques and cosy relationships with national and international powers for their own ends, to ensure regulations suit their needs, or to at least minimise the effects on their profits - irrespective of the havoc they wreak on communities throughout Asia, and for the rest of the world.

Only by facing up to the devastating effects that pesticides have wrought on people and the environment can we truly understand the urgent need to shift agriculture away from its chemical dependence and move it towards a sustainable future, one that embraces agroecological practices and traditional knowledge, the rights of farmers and especially of women farmers. Only then can the world achieve its promise of food security and sovereignty for all.

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About this publication:

This Policy Research and Analysis on “Pesticides: Sowing Poisons, Growing Hunger, Reaping Sorrow” has been produced for information sharing and exchange with our network partners, the media, and the public at large. It addresses the role of pesticides within the industrial complex. This has eroded traditional and organic agricultural systems that provided for people’s food needs, causing a shift from production of food to crops for cash. It addresses the poisoning of people, the contamination of the environment, the advent of insect resistance, and the reduction in the biodiversity that sustains agro-ecosystems. It explores the greater productivity that can be achieved by avoiding the use of pesticides at the same time as enabling farming communities to regain their dignity and independence. Working with nature, encouraging biodiversity, ensuring people’s food sovereignty, and using local and indigenous knowledge and local inputs: this is how the world’s people can be fed.

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Pesticide Action Network Asia and the Pacific (PAN AP) is one of the five regional centres of PAN, a global network dedicated to eliminating the harm caused to humans and the environment by pesticides and promoting biodiversity-based ecological agriculture.

PAN AP’s vision is a society that is truly democratic, equal, just, and culturally diverse; based on the principles of food sovereignty, gender justice and environmental sustainability. It has developed strong partnerships with peasants, agricultural workers and rural women movements in the Asia Pacific region and guided by the strong leadership of these grassroots groups, has grown into a reputable advocacy network with a firm Asian perspective.

PAN AP’s mission lies in strengthening people’s movements to advance and assert food sovereignty, biodiversity-based ecological agriculture, and the empowerment of rural women; protect people and the environment from highly hazardous pesticides; defend the rice heritage of Asia; and resist the threats of corporate agriculture and neo-liberal globalization.

Currently, PAN AP comprises 108 network partner organizations in the Asia Pacific region and links with about 400 other CSOs and grassroots organizations regionally and globally.



PESTICIDE ACTION NETWORK (PAN)  
ASIA AND THE PACIFIC  
P.O Box:1170, 10850 Penang, Malaysia  
Tel: (604) 6570271/6560381  
Fax: (604) 6583960  
E-mail: panap@panap.net  
Homepage: <http://www.panap.net>

