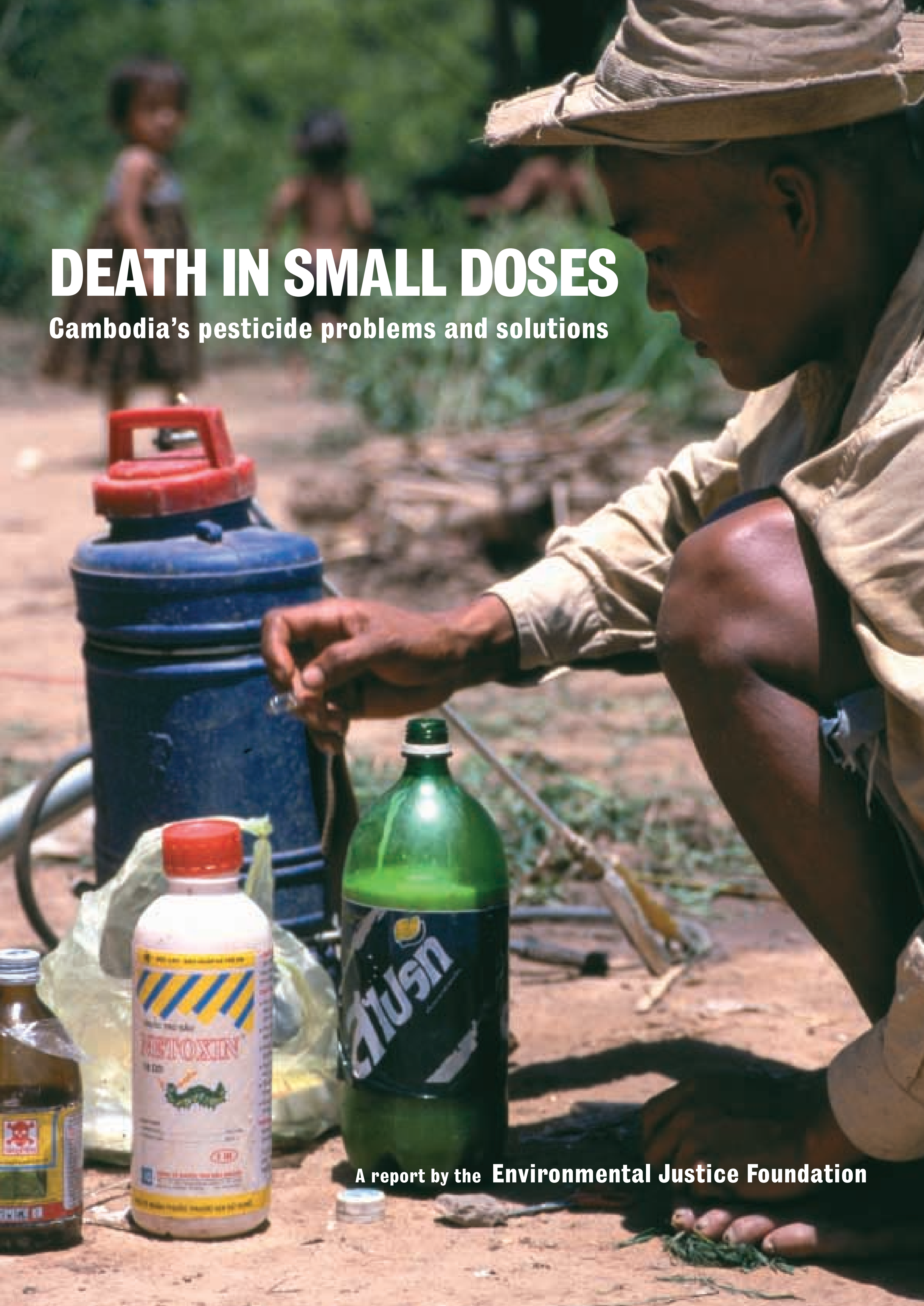


DEATH IN SMALL DOSES

Cambodia's pesticide problems and solutions

A report by the **Environmental Justice Foundation**

Contents

Acronyms used in this report

APCPA	Asia-Pacific Crop Protection Association
ASEAN	Association of South-East Asian Nations
CEDAC	Centre d'Etude et de Developpement Agricole Cambodgien
CIAP	Cambodia-IRRI-Australia Project
CSIRO	Commonwealth Scientific & Industrial Research Organisation
CTBS	Community Trap Barrier System
DDT	Dichloro-diphenyl-trichloroethane, a persistent organic insecticide
FAO	The United Nations Food and Agriculture Organisation
FFS	Farmer Field Schools
GDP	Gross Domestic Product
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
IUCN	International Union for the Conservation of Nature
LD50	Lethal Dose 50
NGO	Non-Governmental Organisation
PIC	The Prior Informed Consent procedure of the Rotterdam Convention
POPs	Persistent Organic Pollutants
RGC	Royal Government of Cambodia
UNEP	The United Nations Environment Programme
WHO	World Health Organisation
WFP	World Food Programme

Acknowledgements

This report was written, edited and produced by the **Environmental Justice Foundation** (**Sylviane Nguyen-Vaucheret, Dr Mike Shanahan, Juliette Williams** and **Steve Trent**). Printed on 100% post-consumer waste paper.

Design by **Dan Brown** (dan.brown@ukf.net).

We wish to thank the following individuals who allowed us to use their images to illustrate the report, provided critical reviews of earlier drafts, or assisted in other ways: **Andrew Bartlett, David Glover, Yech Polo, Nop Poeuv, Colin Poole, William Murray, Bert van Durren, Em Sorany, Ngin Chhay, Merle Shepard, Jim Puckett, Barbara Dinham, Rob Nugent, Rosie Sharpe, The Traveladdicts, Jan Suszkiw, Ariel Javellana, Gary Jahn, Mark Bell, Eugene Hettel, Devlin Kuyek, Roopa Mathew, Diane Young, Ivor Greer, John Heard, Mike Meaney, Vicki Parsons, Brain Taylor, Terry Whittaker, Peter Schrock, Kit Whitney, James Skaptason, Grant Singleton, Frank Spangler, Bruce Sharp, Mike Hooper, Pierre Mineau, Brad Scholz**.

Special thanks go to **Dr Yang Saing Koma** and the staff of **CEDAC** whose pioneering studies' findings on Cambodia's pesticide problems and sustainable alternatives have been central to this report.

In thanking these individuals, we in no way imply that they or their organisations fully endorse the report's content.

Environmental Justice Foundation is a London-based non-governmental organisation. More information about EJF's work and pdf versions of this report can be found at **www.ejfoundation.org**. Comments on the report, requests for further copies or specific queries about EJF should be directed to **info@ejfoundation.org.**

This document should be cited as: EJF. 2002. *Death in Small Doses: Cambodia's Pesticides Problems and Solutions*. Environmental Justice Foundation, London, UK.

PESTICIDE TOXICITY CLASSIFICATION

The World Health Organisation classifies pesticides according to acute toxicity, using the LD50 (Lethal Dose 50%) benchmark. LD50 denotes the amount of a chemical required to kill 50% of an exposed population of laboratory rats. There are two measures for each product, oral LD50 (the product is given orally) and dermal LD50 (the product is given through the skin).

	Oral LD50		Dermal LD50	
	mg per kg body weight required to kill 50% of rat population			
WHO category	**solids**	**liquids**	**solids**	**liquids**
Ia Extremely hazardous	5 or below	20 or below	10 or below	40 or below
Ib Highly hazardous	5-50	20-200	10-100	40-400
II Moderately hazardous	50-500	200-2000	100-1000	400-4000
III Slightly hazardous	Over 500	Over 2000	Over 1000	Over 4000

N.B. The terms "solids" and "liquids" refer to the physical state of the active ingredient being classified

executive summary

- Pesticides have played a role in increasing crop yields and food security but, in contrast to modern products marketed in the developed world, many pesticides used in developing countries like Cambodia fail to meet international quality standards.
- Agriculture, rice production in particular, is of major importance to Cambodian food security and society, and pesticide use in this sector has accelerated in recent years. Unregulated imports have resulted in many chemicals banned by the Cambodian Government being readily available on the domestic market.
- Cambodia faces human and environmental pesticide-related problems. Farmers and their families are being poisoned and food, water supplies and ecosystems are being polluted. 88% of 210 pesticide-using farmers interviewed recently had experienced symptoms of poisoning. The ultimate consequences of the inappropriate use of such dangerous chemicals include human mortalities and illness, and long-term damage to natural ecosystems and their productivity.
- Inappropriate pesticide use, including the timing, frequency, concentration and type of products used, is widespread. Safety measures are often ignored or misunderstood. This situation is exacerbated by a lack of appreciation of risks associated with pesticides and inadequate labelling that is usually in Thai or Vietnamese and is incomprehensible to even the minority of rural users who are literate.
- The direct cost of Cambodian pesticide use has been estimated at US$7-20 million per year.
- Indirect costs of Cambodians' inappropriate pesticide use include negative impacts on food security, on public health, on the export market, and on the burgeoning tourism industry.
- Current practice can encourage pests' resistance to pesticides. Cambodian farmers are becoming trapped on the 'pesticide treadmill', using increasing volumes in order to control perceived threats.
- Western agrochemical companies' product stewardship programmes fall short of pledges to promote safe use. The continued supply of chemicals severely restricted in the West to countries unable to ensure safe use is ethically questionable.
- Much of Cambodian pesticide use is non-essential, especially in rice cultivation for which experts conclude that insecticides are frequently not needed. Safer alternatives include Integrated Pest Management (IPM), rice-fish culture and organic farming. Elsewhere in Asia, IPM has realised 50-100% reductions in pesticide use without impacting yield. Cambodian interest in organic farming was recently measured at 70% of interviewed farmers.
- The Royal Government of Cambodia's demonstration of political will to tackle the pesticide issue by banning hazardous compounds, and the findings of this report, show that genuine solutions and alternatives are available.
- This report recommends the adoption of the precautionary principle based on reduced use, reduced risk and reduced dependence. Central requirements are increased education and research into alternatives and stronger enforcement of Cambodian law. The Cambodian Government, donor community, NGOs, agrochemical industry and Cambodia's neighbours, Thailand and Vietnam, all have roles to play in ameliorating the current situation.
- Cambodia's economy, environment and food security would benefit in the long-term from the development of large-scale active programmes to promote alternatives to current pesticide uses.

Dangerous pesticides, unwanted by the rest of the world, are posing serious threats to Cambodian development targets.

© EJF

A small price to pay for environmental justice

£5 / $6 per month could help kids get out of the cotton fields, end pirate fishing, protect farmers from deadly pesticide exposure, guarantee a place for climate refugees

This report has been researched, written and published by the Environmental Justice Foundation (EJF), a UK Registered charity working internationally to protect the natural environment and human rights.

Our campaigns include action to resolve abuses and create ethical practice and environmental sustainability in cotton production, shrimp farming & aquaculture. We work to stop the devastating impacts of pirate fishing operators, prevent the use of unnecessary and dangerous pesticides and to secure vital international support for climate refugees.

EJF have provided training to grassroots groups in Cambodia, Vietnam, Guatemala, Indonesia and Brazil to help them stop the exploitation of their natural environment. Through our work EJF has learnt that even a small amount of training can make a massive difference to the capacity and attitudes of local campaigners and thus the effectiveness of their campaigns for change.

If you have found this free report valuable we ask you to make a donation to support our work. For less than the price of a cup of coffee you can make a real difference helping us to continue our work investigating, documenting and peacefully exposing environmental injustices and developing real solutions to the problems.

It's simple to make your donation today:

www.ejfoundation.org/donate

and we and our partners around the world will be very grateful.

EJF ENVIRONMENTAL JUSTICE FOUNDATION

Protecting People and Planet

introduction

Developing countries spend US$3 billion annually on pesticides[1]. However, approximately one-third of these pesticides (US$900 million in value) do not meet internationally accepted quality standards[1]. Poor countries lacking in infrastructure and human resources are being used as dumping grounds for such hazardous pesticides, many of which are banned throughout much of the rest of the world because of the serious threats they pose to human health and the natural environment. Cambodia is one such country.

Cambodia has emerged from decades of war and internal turmoil as one of the world's poorest countries and remains heavily reliant on agriculture. The largely rural population has embraced pesticide use, yet the chemicals available are among the most dangerous in the world and are being applied with little regard for suitability or safety. Rather than contributing to Cambodia's development, current patterns of pesticide use have grave implications for the country's future, posing risks to public health, ecosystem functioning, food security, small and large-scale economies, export markets, and the tourism industry. Perhaps the greatest tragedy is that Cambodia does not even need to use such great volumes of these pesticides.

In this report we provide a background to global pesticide production and Cambodian agriculture. We highlight the extent of dangerous pesticide use in Cambodia and summarise the detrimental effects this practice has on humans and wildlife. We demonstrate that pesticides are often an unnecessary component of agricultural production and that safer alternatives exist. Finally, we make recommendations for the Cambodian Government, NGOs, the donor community and the agrochemical industry. We propose reductions in pesticide use, dependence and risk centred on the adoption of sustainable alternatives (such as Integrated Pest Management) in collaboration with increased enforcement of existing legislation and a wide-reaching education programme. Thus, we suggest a strategic framework by which Cambodia and other relevant parties can work to safeguard the population and natural environment without compromising agricultural output, food security or development targets.

Cambodia remains heavily reliant on rice production for food security. Pesticide use has increased rapidly in the past two decades endangering the sustainability of rice production itself as well as threatening public health, the environment, and, indirectly, the future of Cambodian rice export markets and the burgeoning tourism industry.


CAMBODIA
THAILAND
LAO P.D.R.
VIET NAM
GULF OF THAILAND
ODDAR MEANCHEY
BANTEAY MEANCHEY
SIEM REAP
PREAH VIHEAR
STUNG TRENG
RATANAKIRI
KRONG PAILIN
BATTAMBANG
KAMPONG THOM
MONDOL KIRI
PURSAT
KAMPONG CHHNANG
KAMPONG CHAM
KRATIE
KOH KONG
KAMPONG SPEU
KANDAL
PREY VENG
SVAY RIENG
KAMPOT
TAKEO
SIHANOUKVILLE
Sisophon
Siem Reap
Phnom Thbeng Meanchey
Stung Treng
Boung Long
Battambang
Kampong Thom
Pursat
Kratie
Senmonorom
Kampong Chhnang
Kampong Cham
Krong Koh Kong
PHNOM PENH
Prey Veng
Ta Khmau
Kampong Speu
Takeo
Svay Rieng
Kampot
Sihanoukville
Tonle Sap
Mekong
Bassak
Chhak Kampong Saom
104°
106°
14°
12°
International boundary
Province boundary
National capital
Province capital
0 10 20 30 40 mi
0 20 40 60 km

global pesticide production and use

Natural products to synthetic organic compounds: the evolution of insect control

● The most traditional method of protecting crops from insect pests was – and remains – hand picking. Being labour intensive and tedious, farmers sought alternatives from a very early date.

● The first recorded pesticide use is the Sumerians' use of sulphur compounds to protect their crops from mites and ticks around 2500 BC[8].

● By 1200 BC, botanical insecticides were used in China[8].

● Regular insecticide use began c.1850 with the USA and Western Europe's 'first agricultural revolution'. International trade of mineral or botanical insecticides (e.g. arsenic, fluor compounds, nicotine and rotenone) began and commercial spraying machines appeared in 1880[8].

● In 1939, with the recognition of DDT's insecticidal qualities, the first synthetic organic insecticides were marketed and have since become the most commonly used. Currently, four classes of synthetic organic pesticides are used:

Organochlorines (OCs) dominated Western markets from the 1950s to 1965. The most famous, DDT, was first produced in 1873, though its insecticide properties were not discovered until 1939[9]. Most OCs have moderate acute toxicity to mammals[10] and are highly persistent in the environment. They concentrate in fat tissues, accumulating and becoming more toxic as they move up the food chain, thus posing a threat to species, including humans, at the top[11].

Organophosphates (OPs) were discovered during World War II by German scientists researching new toxic gases[12]. This diverse group (less persistent in the environment than OCs) includes compounds ranging in toxicity from highly hazardous to mammals to some of the least toxic pesticides known[10]. Examples include parathion and malathion.

Carbamates are more recently developed products (discovered in 1955), including aldicarb and pyrimicarb. Together with organophosphates they are potential endocrine disruptors (they affect the hormonal system – see pages 21-22)[13].

Pyrethroids are synthesised by copying a natural molecule (a Chrysanthemum pyrethrin), are active at very small doses and usually have broad-spectrum effects. Also termed 'fourth-generation' insecticides, pyrethroids are usually less toxic than earlier insecticides and are allegedly more biodegradable[14].

● The latest products are Insect Growth Regulators, few of which are presently available. These mimic insect hormones active in moulting and are specific (active on some insects, e.g. caterpillars, but not others), so present reduced risk to non-target species[10].

Pesticides are poisonous substances used to kill animals or plants considered pests by humans. Classes of pesticides and their targets include: insecticides (insects), herbicides (weeds), fungicides (fungi) and rodenticides (rodents). Since the early 1950s, pesticides have been an important component of agriculture in industrialised countries, increasing yields and contributing to food security.

Today, pesticides are increasingly used in developing nations hoping to achieve their own 'green revolution' to feed growing populations and produce surpluses for export. Although industrialised countries dominate the global pesticide market, sales in developing countries have tended to increase year by year. By some estimates, developing countries' pesticide use doubled each decade from 1945 to 1995[1].

In 2000, global pesticide consumption reached 2.5 million tonnes in several hundred chemical formulations and with estimated annual sales in agriculture of US$30 billion[2,3]. Despite sales downturns in 1999 and 2000, the value of trade is expected to reach US$31.4 billion by 2005[4]. Crop prices, weather conditions, exchange rates and pest outbreaks govern regional variations in demand. In 2000, sales rose 2-3% in North and Latin America, whilst the Asia-Pacific region experienced an increase of 10.5%, with total sales amounting to US$7.6 billion[4].

Global pesticide market share in 2000[5].

Region	*Share of Market*
N. America	29.6%
Asia-Pacific	25.4%
Western Europe	21.9%
Latin America	12.8%
Rest of the World	10.3%

WHERE ARE PESTICIDES PRODUCED?

Synthetic organic pesticides are largely made by transnational agrochemical companies. An unprecedented period of merger and corporate consolidation during the last decade has reduced their number and, by 2000, 75% of pesticides sales were being made by only seven companies (see table)[6,7]. All are based in the USA or Europe and operate through local subsidiaries elsewhere.

As well as pesticides, these companies produce fertilisers and seeds and are increasingly involved in biotechnology, e.g. genetic modification of crops. For example, Monsanto's sales increase in 2000 was primarily due to its herbicide Roundup (active ingredient: glyphosate), which accounted for 67% of total sales[6]. Roundup sales rose 20% in the US and Argentina and 16% worldwide due to increased sales of 'Roundup Ready' (glyphosate-tolerant) genetically engineered crops and glyphosate-based no-till farming practices[6].

Monsanto reports that Roundup Ready soybean sales rose by 12%, to comprise 60% of US soybean acreage whilst in Argentina the rise was 3%, with 90% of the country's soy genetically modified to be glyphosate tolerant. Roundup Ready corn is currently grown in 1.2 million

© EJF

By some estimates developing countries' pesticide use doubled every ten years from 1945 to 1995. In 2000, global pesticide consumption reached 2.5 million tonnes in several hundred chemical formulations.

Sales of the top seven agrochemical companies in 2000[6,7]

Company (HQ base)	*2000 sales (US$ millions)*	*% change from 1999*
Syngenta (Switzerland)	5,888	-2.6%
Monsanto (USA)	3,885	+8.3%
Aventis (France)	3,701	-0.6%
DuPont (USA)	2,511	-3.1%
Dow AgroSciences (USA)	2,271	-0.1%
Bayer (Germany)	2,252	+12.8%
BASF (Germany)	2,228	+39.1%

N.B. Aventis sold Aventis CropScience to Bayer in October 2001

hectares (3 million acres), but Monsanto envisages a potential global market of 281 million hectares (200 million acres)[6].

In an increasingly globalised economy, agrochemical companies have been able to access and develop markets world-wide. Market saturation and increased regulation of chemical manufacture and use in the developed world have both factored in the expansion of new developing world markets.

As well as increasing exports (US pesticides exports alone rose by 40% between 1992 and 1996[21]), agrochemical companies have developed networks of local subsidiaries that manufacture or import agrochemicals. In the Asia-Pacific region alone, Monsanto has offices in China, Malaysia, Singapore, India, Indonesia, Japan, South Korea, Thailand, Vietnam, Taiwan and the Philippines[22]. Several chemicals are seemingly ubiquitous. Since its introduction by Monsanto in 1974, glyphosate has been registered for use in 130 countries[22].

Case study: banana production in Latin America

Bananas are the fifth most valuable agricultural commodity in world trade after cereals, sugar, coffee and cocoa[15]. Most of the world's bananas are grown for local consumption with little external inputs (e.g. pesticides). However, 14% of world production is traded on the global market and utilises increasing levels of inputs in order to meet the high quality standards of this competitive market[15].

Banana exports represent an important source of income for many Latin American countries[16]. Ecuador, Costa Rica and Colombia alone account for 64% of world exports[15]. In these countries bananas are grown in large monoculture plantations of up to 2000 hectares[16].

Thanks to intensive production methods and massive use of external inputs (pesticides and fertilisers), these banana plantations achieve high yields (50-80 tonnes/ha)[16]. In particular, these crops require increased amounts of fungicide to combat *Mycosphaerella fijiensis*, a fungal disease that has become resistant to some fungicides[17].

The expansion of Costa Rican banana production caused an increase in pesticide import cost of 50% between 1990 and 1994 (from US$56.2 million to $84.3 million)[17]. In 1993, the banana sector accounted for 57% of all pesticide sales in Costa Rica, despite occupying under 10% of the agricultural area[17]. In 1995, IUCN calculated the average amount of pesticides used on bananas annually to be 44kg per hectare[18].

In large plantations, pesticides are sometimes sprayed by plane, an imprecise method capable of affecting neighbouring interests (the Escuela de Agricultura de la Region Tropical Humeda estimates that up to 15% of plane-sprayed fungicide is lost to wind drift and falls outside of plantations[15]).

High pesticide concentrations used are also harmful to workers handling the fruit[19]. Between 1980 and 1994, the number of poisoning cases due to pesticides registered by Costa Rica's National Centre for Poisoning Control steadily increased from 593 to 1144. In 1994, 34% of registered cases were classified as 'occupational', 43% 'accidental' and 19% 'suicide attempts'[17]. Studies by the National University of Heredia reveal that rates of pesticide poisoning are three times higher in banana regions than in the rest of the country[16].

Instead of improving work conditions or reducing the use of pesticides, the international companies that own plantations usually circulate the labour force, hiring sprayers on 3 or 6 month contracts[15,20].

Case study: the Indian pesticide market

Pesticide production in India began in 1952 with production of BHC, an organochlorine insecticide.

India is now the second largest pesticide manufacturer in Asia (after China), ranking 12th globally[33].

The Pesticide Manufacturers and Formulators Association of India states that India has "*one of the most dynamic generic pesticides industries in the world*", which has formed the basis of an export sector that grew 20-25% in two to three years[3,34].

Importers of Indian pesticides include the USA, UK, France, Germany, Netherlands, and Middle Eastern, Latin American and African countries[35].

Until recently, lacking finances to develop and market new chemicals, Indian companies waited for patents to expire. They now produce more than 30 generic compounds including (with WHO hazard classifications in parentheses): **monocrotophos** (Ib), **endosulfan** (II), **dichlorvos** (Ib), **zinc phosphide** (Ib), **aluminium phosphide** (Ia), **paraquat** (II), **permethrin** (II) and **glyphosate** (U)[3]. According to Greenpeace, India is also one of four countries still manufacturing DDT (with Italy, Mexico and China)[36].

Currently, many companies, encouraged by the Indian Government, have begun developing infrastructure and establishing laboratories and research and development centres. The Indian pesticides industry predicts the development of new molecules within the next decade[34].

Over 30 years since this Cambodian stamp was produced, pesticides are still applied in a dangerous manner, without protective gloves or masks. Although DDT use is presently prohibited or severely restricted in most countries, it is still easily available in some developing countries with weak law enforcement. Worryingly, in Cambodia, DDT is illegally sprayed on crops.

THE LIFE-SPAN OF A PESTICIDE

Like most innovations, new pesticides are protected in most countries by patents. Patents have two consequences. Firstly, they protect inventions by legally excluding unauthorised manufacture, use or sale. Secondly, patents are technical documents fully describing how to make and use the invention, thus stimulating further innovation. Patents have limited 20 year life-spans (which, for pesticides, can be extended by 5 years), after which the invention becomes public property. Products whose patents have expired can be made and sold by any company and are termed 'generic products'[23].

The agrochemical business demands long-term, very high investments; to bring a new agricultural product to market costs US$40-100 million and takes 8-10 years[7,23]. Thus, it is in the companies' interests to maximise a product's sales before its patent expires, and to continue selling it for as long as possible afterwards.

In developing countries, patent protection does not always exist and demand is higher for cheaper generic products. So, new pesticides are usually developed for Western markets whilst older, broad-spectrum products are targeted towards the developing world. By 2005, off-patent pesticides are expected to account for 69% of the global market, with countries such as China, India and Brazil (with technical capacity and cheap labour) becoming centres of production[7].

THE ASIAN PESTICIDES MARKET

Recently, production of restricted substances has shifted to the developing world. Currently, about 50 companies make or supply agrochemicals in South-East Asia[24]. These are transnational companies with branded products or generic producers of patent expired chemicals. Among the former, 10-12 companies dominate and, in 1999, just three – Bayer, Aventis and Novartis (now part of Syngenta) – had a 47% market share[24]. Revenues are expected to rise 39% between 2000 and 2006 to US$877.2 million[24].

Since 1990, China has become the world's second largest agrochemical producer[25,26], with an estimated total production that nearly doubled between 1995 and 1999 from 230,000 to 424,000 tonnes[27]. The Shandong Huayang Pesticide Group, for instance, claims to be the leading manufacturer of methyl-parathion in China and to be the only producer of aldicarb in Asia[28]. This reflects a general trend of increased production of pesticides (especially generics) in Asia.

In order to maintain some degree of control over the burgeoning generics trade, transnational agrochemical companies have obtained interests in local businesses. For example, Aventis (with a 14% market share in India) recently obtained a 51% stake in the Indian joint venture, Bilag Industries[29], one of the leading producers and exporters of pyrethroids in India[7].

CHEMICAL DUMPING GROUNDS?

The FAO and WHO recently warned that 30% of pesticides marketed in developing countries do not meet internationally accepted quality standards and "*frequently contain hazardous substances and impurities that have already been banned or severely restricted elsewhere*"[30]. As legislation concerning hazardous products and pollutants is becoming increasingly restrictive in developed countries, many pesticides used in the past are now prohibited or severely restricted. In developing countries, however, such laws are absent or more permissive, and dangerous pesticides can persist on the market. For example, in 2000, the Indian Government noted that the import and use of 33 pesticides banned in some other countries are permitted[31]. Consequently, concerns have been raised that the developing world is becoming a 'dumping ground' for obsolete or hazardous products[21,32].

In March 1994, the US Environmental Protection Agency issued a conditional registration aimed at reducing use of the pesticide – and suspected carcinogen – alachlor. In the subsequent months US exports of alachlor almost trebled[21].

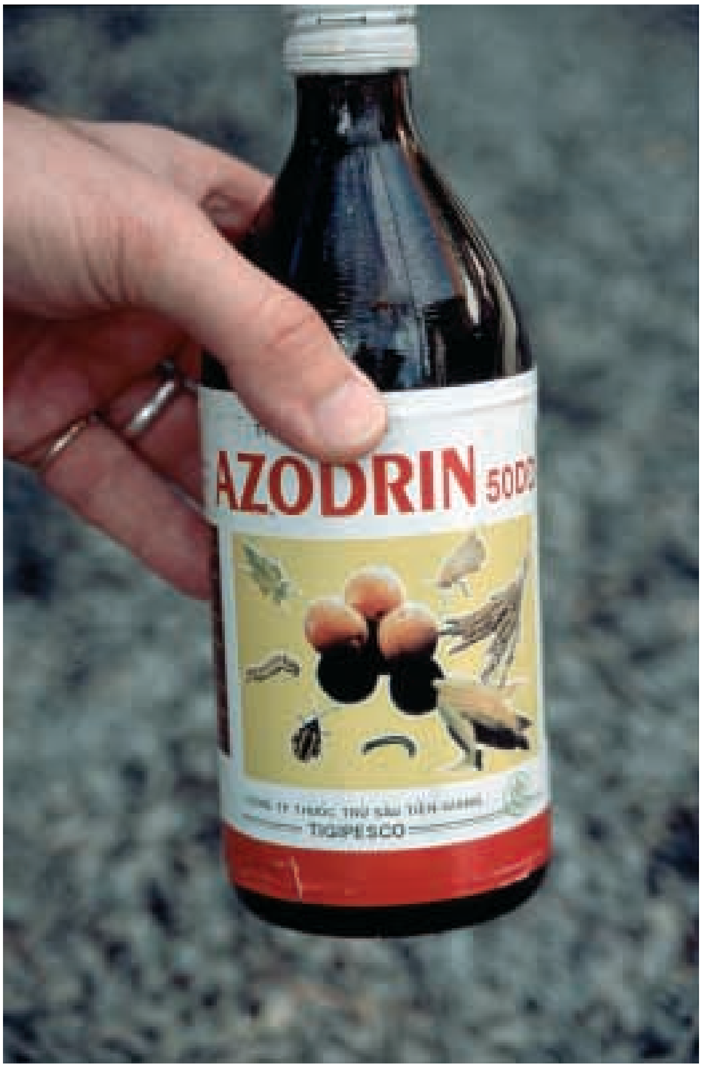
Legal loopholes facilitate Western companies' exploitation of developing world markets. For example, European legislation prohibits the export of end products banned in Europe but permits export of active ingredients, which can then be formulated into end products in developing countries[37].

Alternatively, corporate acquisitions enable patterns of pesticide production and export that are unfeasible from bases in the West. For example, the Indian RPG Life Science (formerly Searle (India) Ltd) recently sold its agrochemical business to Italian giant ISAGRO, itself a subsidiary of Isagro Sp.A[38], a partial partner of both Dow AgroSciences and Aventis CropScience. Industry observers noted that ISAGRO "*may consider using the Indian unit as a manufacturing base for certain products and to service the Far Eastern and South Asian markets*"[38]. RPG's existing portfolio includes the widely-restricted monocrotophos and flucythrinate, both WHO Class Ib chemicals, and fenvalerate, a Class II chemical whose authorisation has been withdrawn in the EU[39].

In 1996, Novartis (now Syngenta) was congratulated upon announcing that it was phasing out production of monocrotophos in response to mass poisoning of hawks in Argentina (see page 24)[40]. The motivation for this move is unclear in light of the subsequently reported opening of a plant in China capable of producing 5000 tonnes of monocrotophos per year[7]. In June 2000, it was reported that all of the largest transnational corporations had opened or bought major facilities for production of hazardous chemicals in developing nations in the previous decade[7].

Trade in restricted and banned pesticides is difficult to track[32] but US shipments of monocrotophos alone (most shipped under the trade name Azodrin[41]) totalled over 500 tonnes in 1995 and 1996[21]. Use of monocrotophos, an organophospate classified by the WHO as 'highly hazardous', is prohibited in the USA.

Close ties with importing purchasers, which may indeed be subsidiaries, can allow exporters to bypass the commercial offices of consulates and embassies – as reflected by this comment from the commercial consul in Sao Paolo, Brazil, the largest importer of pesticides in Latin America: "*I've never had a request for assistance from a US exporter of pesticides in the three years I've been here*"[42].



© EJF

Use of Azodrin, (active ingredient: monocrotophos), is prohibited in the USA; however exports from US ports totalled over 500 tonnes in 1995 and 1996. Although banned, Azodrin is commonly found in Cambodian markets, labelled in Vietnamese.

an overview of cambodian agriculture

Cambodia has emerged from decades of war and internal conflict and now faces the challenge of rebuilding. However, the country remains one of the poorest in the world, ranked in 2000 by the Human Development Index as 136th of 174 countries[4] and with a per capita GDP of US$270[2]. Over one-third of the population lives below the poverty line, 90% of them in rural areas, and 32% have no access to safe drinking water[5,6]. Food security is of prime importance and rice, in particular, sustains the country. For these reasons, although pesticides are also used in Cambodia to combat vectors of human disease (e.g. malarial mosquitoes), agricultural applications of pesticides are of special interest in this report. This section, therefore, serves as an overview of current agricultural practices in Cambodia.

Agriculture is a mainstay of Cambodia's economy, contributing c.43% of the GDP (1998 estimate) and employing 80% of the labour force in 1999[2], when there were an estimated 1.2-1.3 million farming households among a 12 million population[2,7]. Other growth areas are tourism (in 2000, the service sector employed 16% of the labour force and contributed 45% of the GDP[8]) and the garment industry (employing 3% of the labour force yet accounting for 70% of exports in 2000)[8,9]. Key agricultural products are rice, livestock, rubber, corn and vegetables[2], with rice and livestock alone accounting for 27% of Cambodia's GDP[10].

Indeed, rice is the cornerstone of Cambodian food security, utilising 90% of arable land in its production and providing 75% of daily calorie intake[11-12]. The remainder of typical Cambodian diets is comprised of fish, meat, tubers, vegetables and fruit[12].

Rice production, together with political stability, is central to the country's recovery from the Khmer Rouge period. Agriculture is a priority in national development policy, aimed at increasing food security, economic growth, rural incomes, and developing export industries[7]. However, agricultural development is constrained by Cambodia's poor infrastructure and the presence of an estimated 4 to 6 million landmines[13], which limit access to approximately 40% of arable land[7]. Cambodia has benefited from economic stimulation since joining ASEAN in 1999.

Before 1970, Cambodia was self-sufficient for food and wood, and exported rice, rubber, fish and wood[15]. In 1979, when the Vietnamese army entered Cambodia, the country's rice production had shrunk to barely 20% of the 3.8 million tonnes harvested in 1970[11]. The Khmer Rouge regime had left the country with badly-damaged infrastructure, a drastically reduced labour force, and seed stocks of traditional rice varieties had

© SAO-UK

Rice is the cornerstone of Cambodian food security, utilising 90% of arable land in its production and providing 75% of daily calorie intake.

been eaten by starving people. The re-building of agricultural activities was hindered by the absence of researchers and technicians, who had fled the country or been killed. Consequently, Cambodia was forced in 1980 to import 300,000 tonnes of rice to help feed the six million survivors[16].

Between 1981 and 1990, the International Rice Research Institute (IRRI) re-introduced 766 traditional Cambodian rice varieties to Cambodia[17]. Rice production steadily increased from the early 1990s due to increases in cultivated area (in part through deforestation) and use of high yielding IRRI varieties and methods[17]. Food security remained a serious problem until 1995, when the country achieved self-sufficiency for the first time in 25 years, even producing a surplus 139,000 tonnes of milled rice[11]. In 1999, a record 4.04 million tonnes of paddy rice were produced (with a surplus of 220,000 tonnes)[16].

Rice is cultivated largely in the central Mekong basin and delta and in the Tonle Sap floodplain, with 15 of the 23 Cambodian provinces accounting for 97% of total production[24]. The main rice harvest consists of the wet season (May-December) paddy rice, which is entirely rain dependent and accounts for 80-85% of annual production[10]. Although occupying only 10% of the planted area, dry season irrigated rice accounts for the remaining 15-20%[10]. Irrigated dry season rice yields and cultivated areas depend on rainfall levels during the previous wet season and on floods in the Mekong basin.

In 2000, other crops accounted for about 12% of the total area harvested[25]. In areas with high population densities, farmers tend to grow crops more profitable than rice. Consequently, such provinces are deficient in rice. Conversely, surpluses are produced in lower density areas[12]. Typically, Kampong Cham province is the main

cambodian rice pests

Rice pests[18-23] vary depending on the nature of rice cultivation but include rats, birds, arthropods (mostly insects) and over 60 weed species. Although over 200 arthropod species occur in Cambodian rice fields, the majority, as in any agricultural system, do not eat plants and are not pests. On the contrary, some benefit crops through predation or parasitism of true pest species.

Weeds

Weeds are problematic and difficult to eradicate in rain-fed rice systems since field water levels cannot be controlled. Presently, removal by hand is the most efficient option. Competition between rice plants and weeds is especially strong in upland rice systems that regularly suffer dry conditions. Conversely, in irrigated rice, water control allows a large reduction of weed problems. In any case the levelling of fields could greatly improve weed-control and thus help increase yields.

Insects

The main pests of rain-fed rice are leaf-eating insects, the most common of which are green semilooper caterpillars (Noctuidae: *Naranga* spp.). Although abundant, they usually have little impact on rice yields – rice plants can lose 50% of their leaf area during the first month after transplanting without any consequence for yield. Moreover, predators of green semilooper exist in Cambodia: mainly semi-aquatic bugs (e.g *Microvelia douglasi;* Veliidae) and spiders.

Another well-known rice-pest is the brown planthopper (*Nilaparvata lugens*). However, natural control by its predators is usually enough to keep it at non-damaging levels. Outbreaks occur when this balance is disrupted by pesticide use or dry weather conditions (many predators are semi-aquatic). Slender rice bugs (*Leptocorisa* spp.) attack rice grains and in outbreak years damage can be substantial.

Similarly, grasshoppers become pests only after prolonged periods of dryness have prevailed in the fields.

Conversely, gall midge (*Orseolia oryzae*) populations build up under humid weather conditions, but natural control by wasp parasitism typically reaches 90% of a given population – if a previous pesticide spray has not killed the parasitoids. Some Cambodian rice varieties (*Kaun Trei* and *Changkom Kreal*) are more sensitive to gall midges; whereas new varieties IR36 and IR42 are resistant.

Below from top to bottom: **Green Leafhopper**, **Stemborer feeding**, ***Rattus argentiventer***

© IRRI

© IRRI

© G. Singleton / CSIRO

Varietal control is also a good option against stem borers (*Scirpophaga incertulas*, *Chilo auricilius*, *C. suppressalis*, *Sesamia inferens*) as some locally available varieties are partially resistant, e.g. IR36, IR42, IR66, IR72. No totally resistant variety is yet available.

Diseases

Tungro virus causes a rice disease the symptoms of which are commonly reported, but its vector, the green leafhopper (*Nephotettix* spp.), is rare, suggesting misdiagnosis of nutrient deficiencies, which also cause leaf yellowing. Green leafhopper is a potential pest itself but predation and parasitism (12-60%) keep populations at non-damaging levels.

Fungal diseases can occur but their frequency is very low, so it appears that no control method is necessary.

Rodents

Three main rat species have been identified in or near Cambodian rice-fields (*Rattus argentiventer*, *R. exulans* and *Bandicota indica*). Rat outbreaks occur in rain-fed as well as in irrigated rice systems and, in the 1990s, caused an average annual loss of 3000 tonnes, enough to feed 12,000 people each year. While 34% of farmers report rat problems, only 13% attempt control. A CIAP (Cambodia-IRRI-Australia Project) study in 1999 showed that traps and baits do not seem to provide adequate control (and baits are also poisonous for cattle). Plastic barriers tend not to be used as they are too expensive compared to the losses caused by rats. As a result, hunting and digging up burrows (especially when done during daytime) still remain the safest, cheapest and most effective rat-control method in common use.

A new pest: the Golden Apple Snail

Introduced to Asia from South America for food, the Golden Apple Snail (*Pomacea* spp.) escaped from cultivation and arrived in Cambodia in 1995. It is now a pest of both dry season irrigation and wet season rain-fed rice, feeding on seedlings. Control is by hand-picking or rearing of fish or ducks to feed on snail eggs – the snails can be used as pig or duck food, or for human consumption when cooked. Pesticide (molluscicide) applications are also used in some provinces.

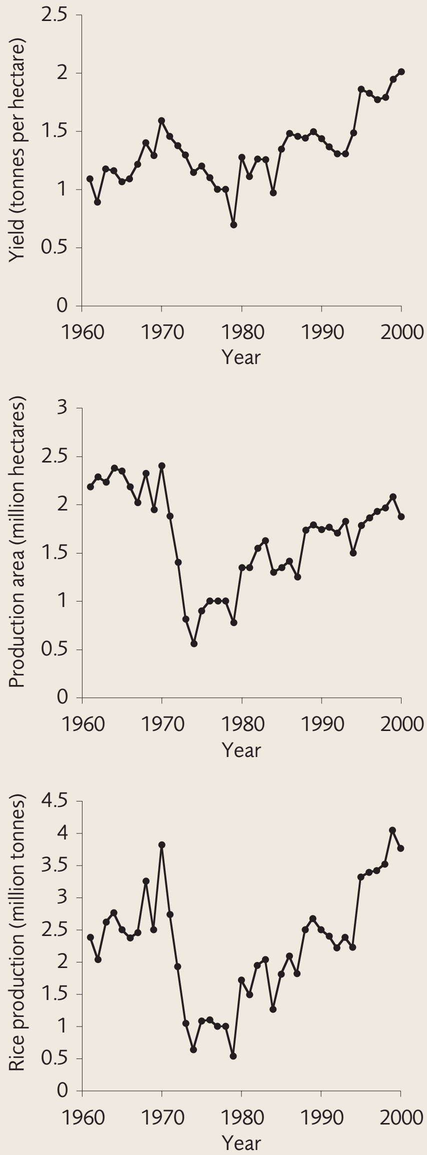
Right: Four to six million landmines limit access to approximately 40% of Cambodian arable land. They are also responsible for further depleting a labour force already drastically reduced by Khmer Rouge regime: one in 236 Cambodians has been seriously disabled by landmines.

Far right: Agricultural development is constrained by Cambodia's poor infrastructure. After the wet season in particular many roads are unusable, preventing farmers from selling rice outside their commune.

© Bruce Sharp

© Bruce Sharp

Cambodian rice production trends (data from FAOSTAT)[25]



producer of soybean, maize, vegetables, mung bean, groundnut and sesame, accounting for 40% of the non-rice cultivated area, while being deficient in rice by around 24,800 tonnes[24].

PROBLEMS IN CAMBODIAN AGRICULTURE

Since most rice production (80-85%) is rain-fed, yields are highly dependent on rainfall, which, in Cambodia, can vary widely year to year. The FAO/WFP estimates that major crop losses (of rice and other crops) occur every 3-4 years due to droughts or floods[24], the latter being exacerbated by soil erosion associated with deforestation[15]. In 2000, one of the worst floods in recent history hit Cambodia first in July and again, more significantly, in September, causing an estimated 400 deaths (largely of children) and destroying crops and infrastructure – an estimated 400,000 hectares of wet season rice were affected[10].

In recent years, crop destruction due to adverse weather or pest outbreaks occurred early in the season, allowing replanting with early maturing rice varieties or recovery of the late maturing varieties during the end of the season (September-December)[24]. However, at a time when most families' income from the previous harvest has already been spent, replanting is only an option for farmers wealthy enough to buy new seeds or those receiving international aid[26].

Poverty and indebtedness compel farmers to sell large parts of their rice production as soon as harvests are finished, inducing a reduction of national rice prices at this time of year and preventing them from keeping staple stocks[24]. Debts accrue as farmers borrow to hire labour or buy agricultural inputs, as well as clothes, tools, etc[27]. Debt may even force farmers to sell their land – their only source of income – thus contributing further to rural landlessness and poverty[8].

© G. Bizarri / FAO

Above: Despite having higher yields than wet-season rain-fed rice, irrigated rice accounts for only 15-20% of total production. Primitive irrigation methods and the limited extent of their implementation reduce food security in Cambodia.

Below: Half of Cambodian children under five are stunted and up to 20% suffer severe malnutrition.

© Frank Spangler / Panorama Productions

Despite recent success in reaching rice self-sufficiency according to recorded figures, food security is a serious issue in parts of the country, mainly due to variations in per capita production between provinces (or even communes); of 15 main rice-producing provinces, five are rice-deficient[24]. With less than 25% of the rice growing communes (just 15% of the population) producing 75% of the national rice surplus, food distribution is a major issue and is hampered by a transport infrastructure that remains rudimentary following years of strife[24]. Most rural roads are unusable during the wet season and, following the 2000 floods, food insecurity increased in spite of total rice production being on a par with that of 1999 (c. 4 million tonnes)[9]. The poor infrastructure means that mills in neighbouring countries may be more accessible than domestic ones (particularly during floods), and rather than channel surplus rice to deficit areas, it is often more profitable to sell rice across the border[24].

Although Cambodia's official rice exports are low (a few thousand tonnes of milled rice), it seems that smuggling of unmilled rice to Thailand and Vietnam is considerable[27]. Later in the year, as the need arises, the rice is then bought back from these neighbours[24].

The poor quality of Cambodian milling means that official exports realise low prices, further contributing to rural poverty. The recent building (in Kandal province) of a milling plant of international standards, should improve this situation[28].

In addition to food insecurity, malnutrition – caused by limited food supplies and low dietary diversity – is prevalent, especially among women and children under five[24]. The UN estimates that 50% of children under five are stunted and up to 20% suffer severe malnutrition[10]. For example, according to a survey by the Royal Government of Cambodia (RGC) and NGOs in 2001, Vitamin A deficiency is a serious public health problem in rural areas[26]. Vitamin A deficiency increases susceptibility to infectious diseases (and, consequently, early death) in the under fives; it can also result in permanent blindness[26].

Although minor in terms of total production, staple crops other than rice (like green vegetables, a source of Vitamin A) and fishing, when possible, are very important for balancing households' diets. Most farming families keep livestock but, rather than being eaten, pigs, ducks, chickens and eggs are usually sold for cash to buy family goods[29]. Regardless, the main buyer of meat is the tourism industry[30]. Larger animals (e.g. buffalos and cows) are used for farm work and are rarely consumed[29]. The relative importance of livestock in agriculture does not therefore reflect a protein source for rural people. Rather, fish provide the majority (75%) of

© EJF

Left: Green vegetables and fish can contribute to Cambodian dietary diversification.

Below: Fish provides 75% of Cambodians' animal protein

Cambodian animal protein[31]. In particular, fermented fish paste is an important protein source[32]. Recent declines in fish catches due to intensive fishing and ecological disruption (deforestation causing silting of lakes and rivers and the loss of mangroves and flooded forests that are the reproductive sites of many fish species) does not contribute to improvement of the situation, but actively worsens it[15]. From 1995-1997, fishing lots around the Tonle Sap lake and river caught only half of the fish species and families, and one-third of the genera, recorded in earlier studies up to 1976[33].

Another advantage of diversification of agricultural activities is that it can help farmers cope with drops in rice production like those caused by the floods of September 2000. People living near rivers and the Tonle Sap lake suffered comparatively less than those in lowland rain-fed or scrub areas, thanks to the fishing activities and cash crop production in the former[10]. However, the inefficiency of the rice market leads to low capital for farmers, preventing them from investing towards diversification or equipment[34].

Lack of manpower is another difficulty faced by the Cambodian agricultural sector. Deaths caused by the civil war and Khmer Rouge regime were greater among men than women, seriously depleting the rural labour force. The number of disabled people is also high as a consequence of the war.

Many women have been left with the responsibility of farms as well as household management (21% of the population lived in female-headed households in 1994)[29].

© EJF

In 2000, as a consequence of floods, migration from rural areas toward the cities accelerated. The departure of young women to better-paid jobs in the garment industry, in particular, resulted in labour force shortage in agriculture[9] (about 90% of the garment industry's workers are young women, the majority of them recent immigrants from rural areas[35]). The garment sector has developed extremely rapidly since the mid-1990s, leading to the Government adopting a minimal legal wage for employees of this industrial sector (raised from US$40 to $45 per month in July 2001), as well as rules on labour conditions[36]. The minimum wage imposed is approximately double the average Cambodian income, making jobs in the garment industry very attractive.

pesticide use in cambodia

AGRICULTURE

PESTICIDE USE has recently intensified in Cambodian agricultural practice (see GRAPH). A CEDAC survey[1] conducted in 2000 showed that of 933 farmers surveyed, 67% used pesticides. Of these 44% began using them in the 1980s with the rest beginning in the 1990s[1].

Insecticides and rodenticides (rat poison) are, by far, the most commonly used pesticides in Cambodia. Herbicide use is not yet common but practices in other countries in the region suggest that usage is likely to increase[2]. Herbicides are already available on Cambodian markets – many of them with glyphosate or 2.4-D as active ingredients. Although fungicide use is extremely rare[3], products can easily be found.

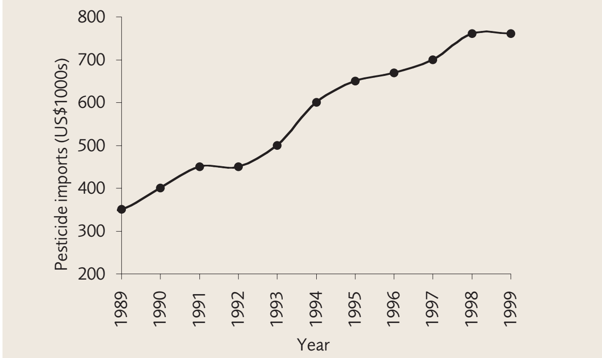
Pesticides are used in greater volumes on vegetables (e.g. 72 litres or kg per hectare per year) than rice (1 litre or kg per hectare per year)[1]. However, because rice production dominates (using 90% of productive land[4]), pesticide use in rice culture is greatest in terms of total volume. An IRRI report showed that, depending on the province, 40-100% of dry season and 8-50% of wet season rice farmers use pesticides[3].

In 1994, 30 different pesticides (active compounds) were available in Cambodia[5] and within six years this had grown to at least 76 compounds in 241 different products, a significant proportion (33%) of which are classified by WHO as Class I: highly or extremely hazardous to human health[6]. In most provinces, the most commonly used pesticides are all Class I chemicals: mevinphos, monocrotophos, dichlorvos and, especially, methyl-parathion, produced in Thailand by Bayer with the trade name Folidol[7]. Persistent organic pesticides including DDT and chlordane are also available[1].

Since Cambodia does not produce pesticides, all products available are imports, which steadily increased and doubled in value between 1989 and 1999[8]. Data are not easy to obtain but as insecticides accounted for 100% of official pesticide imports in 1996[8], it is likely that they were also predominant in other years.

Surveys of Cambodian markets reveal that most pesticides come from Vietnam and Thailand (c.21% and c.69% respectively in Kandal Province[9]). Product labels indicate manufacture in these two countries by local companies or by production facilities of international companies – for instance, Bayer has a production site in Thailand and a joint venture in Vietnam[10]. Other products are manufactured elsewhere (China, Japan, India, United Kingdom), but formulated and packaged in Thailand or Vietnam. Some products, labelled in Vietnamese, for example, bear the logo of Makhteshim Agan, a company claiming to be the "*largest and most geographically diverse generic manufacturer of agrochemical products*" and that has manufacturing plants in Israel and Brazil[11].

Some pesticides on sale in Cambodia are banned in their country of origin. 42 of 241 products available in 2000 were banned in Vietnam, whilst another 16 are banned in Thailand[6]. This has led to fears that Cambodia is becoming a dumping ground for unwanted and dangerous pesticides[6,12].



Pesticides imports to Cambodia 1989-1999 (data from FAOSTAT[8])

© EJF

The most commonly used pesticides in Cambodia are all WHO Class 1 chemicals, including methyl-parathion, much of which is produced in Thailand by Bayer with the trade name Folidol[7].

Methyl-parathion: ten facts[13-16]

- A non-systemic organophosphate insecticide and acaricide (kills parasitic mites).
- Kills insects by contact or via digestive or respiratory action.
- WHO acute hazard classification: Ia (extremely hazardous). Acute toxicity: oral LD50 (rats) = 3 mg/kg.
- Highly toxic if inhaled or ingested, moderate toxicity by skin adsorption. Human acute toxicity symptoms: sweating, nausea, vomiting, dizziness, diarrhoea, pupil constriction, muscle cramps, excessive salivation, laboured breathing, convulsions, and unconsciousness.
- Death may be caused by respiratory failure or cardiac arrest.
- Repeated / long-term exposure affects human nervous system. Cholinesterase inhibition and cumulative effects are possible.
- Very highly toxic to birds and mammals.
- Moderately to very highly toxic to amphibians, fishes, crustaceans and molluscs.
- Degrades in lakes, rivers and sea but degradation rate data vary from 100% degradation within two weeks to a half-life of 175 days.
- Banned or severely restricted in the USA, Tanzania, Indonesia, Sri Lanka, Malaysia, Bangladesh, Korea, Japan, China and Cambodia. Included in the Rotterdam Convention on Prior Informed Consent due to concerns about its impact on human health under conditions of use in developing countries.

"When I was in the field I felt dizzy and then I couldn't walk. When I returned home I vomited... I have to use pesticides. There is no other alternative. I am a farmer".
Pech Savoeun, Cambodian farmer[7]

© SAO-UK

Pesticides have the psychological attraction of "modernity"; and are believed capable of solving any problems farmers might face.

OTHER USES OF PESTICIDES

Tens of thousands of malaria cases, and hundreds of deaths, occur each year in Cambodia[17]. In 1998, 475 died from dengue fever[18]. The World Health Organisation still endorses the use of DDT to control these diseases' mosquito vectors but, in recognition of evidence linking DDT to cancer, changed its policy to one of recommending indoor use only in 1993[19]. DDT is a persistent organic pollutant covered by the United Nations Environment Programme sponsored Stockholm Convention (POPs). As such, it is now illegal in Cambodia (see page 16) yet remains available on the market. Safer synthetic pesticides (e.g. Temephos and new pyrethroids) are used to impregnate mosquito nets and in standing water containers.

Illegal fishing using pesticides including Folidol (methyl-parathion)[20] and Thodat (endosulfan)[21] also occurs.

Finally, the use of pesticides (e.g. mevinphos and dichlorvos) to keep insects away from dried fish has been reported[22].

WHY ARE PESTICIDES USED?

The relatively recent increase in pesticide use in Cambodian agriculture is attributable to a number of factors.

Loss of Culture: The flow of information from generation to generation was severely disrupted by the upheavals of recent decades. Thus, farmers active today do not necessarily know traditional methods of pest control.

Many farmers have relatively little experience and have not had the time to develop knowledge of the need for pesticides, or their impact on health and non-target species[23]. Indeed, the FAO found that those

Some highly (Ib) and extremely hazardous (Ia) pesticides available in Cambodia[1,6,9]

Active compound	WHO class	Trade names	Chemical type	Producer country#
brodifacoum	Ia	Brodifa	Organobromine	Vietnam
carbofuran	Ib	Furadan	Carbamate	Vietnam
dichlorvos	Ib	DDVP, Dichlorvos, VP 50EC	Organophosphate	Thailand, Vietnam
endrin	O	Endrin	Organochlorine	Thailand
methadathion	Ib	Supracide 40ND	Organophosphate	Vietnam
methamidophos*	Ib	Fillitox, Giant, Methaphos, Monitor, Ovansu, Thom, U-T 70, Vindo	Organophosphate	Germany, Thailand, Vietnam,China
methomyl	Ib	Lannate, Methomyl	Carbamate	Thailand
methyl-parathion*	Ia	Ankun-V, Folidol, Fosintol-phodetol, Foxentol, Isodol D, Methaphos, Methylparathion, Parathet, Parathion-methyl, Suthon-M	Organophosphate	Thailand, Vietnam
mevinphos	Ia	Bosdin, Fitor, Kvinphos, Lockphos, Mevinphos, Phosdrin, Sudrin, Triphos,	Organophosphate	Thailand
monocrotophos*	Ib	Azodrin, Mobile 600, Tanchrodin, Worldcron, Apadrin	Organophosphate	Thailand, Vietnam
omethoate	Ib	Zony	Organophosphate	China
phosphamidon*	Ia	XK-35EC	Organophosphate	Vietnam
pirimiphos-ethyl	Ib	Actellic 50EC	Organophosphate	France
zinc phosphide	Ib	USA tra-cantal, Zawa, Bek kham, Razor, Osotspa, Zinphos, Fobeka	Inorganic	Thailand, China Vietnam

#note: these are countries of final formulation. Constituent chemicals may be manufactured elsewhere.
*Also listed on Rotterdam Convention Prior Informed Consent
O = previously class I, now considered obsolete by WHO

farmers who had reduced pesticide usage in 2000 were the older, most experienced ones[23].

Demographic Factors: Rural manpower shortages resulting from migration to urban centres have resulted in increased farm labour costs. This, together with the low market price of (often illegally imported) pesticides, encourages pesticide use over traditional, labour-intensive methods (e.g. rat hunting or hand-picking of Golden Apple Snail). The situation is compounded by the high proportion (1 in 236) of Cambodians seriously disabled by landmines[24].

Perception of pesticides: Pesticide consumption is encouraged by agrochemical companies' burgeoning advertisement campaigns (it is estimated that the industry spends US$1 billion annually on advertising and marketing in Asia[7]). The radical and rapid pesticide action portrayed in adverts makes a very strong impression on farmers, especially as the Khmer translation of "pesticide" includes the word "medicine"[25]. Some farmers increase product concentrations used in the belief that pesticides not only control pests but also stimulate vegetative growth[12].

Overall, pesticides are seen as status symbols with the psychological attraction of "modernity", and are believed to be able to solve many problems farmers might face[7,26].

Foreign Aid: Cambodian pesticide use has been encouraged by international aid supplying free pesticides to stimulate modernisation and increase productivity. Between 1979 and 1982 the FAO and several NGOs provided 2,100 metric tonnes of pesticides[27]. In 1993, a Japanese project provided 35,000 litres of free broad-spectrum pesticides – an action roundly criticised by environmentalists, the IRRI, and the FAO, under suspicion that the 'gift' primarily served to establish the Japanese chemical industry rather than assist poor Cambodian farmers[28]. Regardless of whether or not pesticides were required or used effectively, such influxes have contributed to a culture of pesticide-dependence in Cambodia.

Previous Pesticide Use: Paradoxically, pesticide use itself encourages further chemical applications. As shall be shown when detailing negative impacts of pesticide use (pages 21-26), such chemicals can kill natural predators (fish, frogs, insects) of pest species, and can encourage pest resistance and pest resurgence leading to outbreaks, to which farmers respond with further spraying.

The impact of wildlife trade

Recent outbreaks of insects and rats in rice fields have been attributed by Cambodian authorities to "*the dwindling number of sparrows, which eat insects, and snakes, which eat rats*"[29]. Snakes are hunted and sold to restaurants and snake blood mixed with rice wine is a popular – and expensive – beverage. Roasted sparrows are a cheap, popular meal among Cambodians, requiring 10-15 birds per person. Snake and sparrow hunters are increasing in number each year, since the activity is more lucrative than farming[29]. At the peak of the wet season, 8500 snakes per day are removed from the Tonle Sap for domestic consumption (by humans and farmed crocodiles) or export to Thailand, Vietnam and China[30]. Other natural predators of rats targeted by wildlife poachers include wild cats and owls[31]. Besides impoverishing Cambodian wildlife, diminishing predator numbers encourage pest outbreaks, to which farmers respond with the use of pesticides.

"I never see any snakes or sparrows in the fields or the jungle, but I see many of them in cages at Neak Leung or in front of the Royal Palace"[29]
—Hean Van Horn, Crop Protection Office, Cambodian Ministry of Agriculture

© Mike Meaney / mikemeaney.com

Many snake species help control rat populations. At the peak of Cambodia's wet season, 8500 snakes per day are removed from the Tonle Sap for domestic consumption or export to Thailand, Vietnam and China.

© The Traveladdicts / www.traveladdicts.connectfree.co.uk

In Cambodia, sparrows help control insect pest populations but are caught and roasted to create a cheap, popular meal, requiring 10-15 birds per person.

pesticides and cambodian law

domestic law

Until 1998, Cambodia had no legislation specifically concerning pesticides, although the 1996 Law of Environmental Protection and Natural Resource Management (Article 12) covered the need to inventory pollutants being produced, imported, stored or released[1]. Monitoring, record-keeping, pollution prevention and control are to be covered by sub-decrees, represented to date by the April 1999 sub-decree on Water Pollution Control, which also provides water quality standards in Annex 5 for concentrations of pesticide pollutants.

The 1998 sub-decree on Standards and Management of Agricultural Materials was the first legal instrument mentioning pesticides, and is concerned with "the import, sale, labelling, packaging, quality, storage, disposal and marketing of pesticides in Cambodia"[2]. The sub-decree prohibits the use and sale of pesticides classified by WHO as 'extremely or highly hazardous to human health' (Class Ia or Ib). As shown on pages 13-14, many of these proscribed chemicals are still in use in Cambodia.

international law

Cambodia is a signatory to the Stockholm Convention banning Persistent Organic Pollutants (POPs). Mostly pesticides, POPs pose special threats to human health and the environment through their ability to persist and biomagnify, increasing in concentration up the food chain and capable of transmission to offspring via the placenta or milk[3]. Two of the nine POP pesticides are available in Cambodian markets: DDT and chlordane[4]. Under the Stockholm Convention, a health-related exemption has been granted for DDT, which is still needed in many countries to control malarial mosquitoes. This will permit governments to protect their citizens from malaria – a major killer in many tropical regions – until they are able to replace DDT with chemical and non-chemical alternatives that are cost-effective and environmentally friendly. To date, Cambodia has not applied such exemptions.

A second relevant international instrument is the Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade. Cambodia has yet to sign the agreement but is participating in the voluntary interim procedure, which is aimed at reducing use of dangerous pesticides imported from other countries, and assisting developing countries to develop strategies to deal with the issues surrounding hazardous pesticides.

Through the procedure Cambodia can publicise decisions on whether or not it desires imports of the PIC chemicals (those banned or severely restricted in member countries), passing the onus to control trade to exporting countries.

the challenge

Having established their dedication to environmental protection, the greatest challenge facing the Royal Government of Cambodia (RGC) is the enforcement of its laws. Given the permeability of Cambodia's borders, the route via which many hazardous pesticides enter the country, it seems likely that a situation will develop akin to that in Indonesia, where there is "*…a flawless approvals system for pesticides, but no monitoring program to police their use. Therefore, there is no way of checking that government legislation is being obeyed*"[5]. Indeed, of 168 pesticides found in CEDAC's 2000 Cambodian market survey, the Ministry of Agriculture bans eight and places 43 in the 'restricted use' category[6].

The RGC appears to be dedicated to tackling the pesticide problem and official institutions such as the Bureau of Agricultural Material Standards were established in 1999 to enforce the law[7]. They are currently working on how to implement the sub-decree but lack of human and financial resources, in this area as in others, impede the Government's actions despite its political will[7]. Clearly, both financial and technical support from donor countries and agencies would be valuable and cost-effective.

Although Cambodian law prohibits use and sale of pesticides classified by WHO as Class 1 (extremely or highly hazardous to human health), they are widely available in pesticides shops and markets. Despite its political will, the Royal Government of Cambodia is impeded by a lack of human and financial resources.

cambodia's pesticide problem: causes

CAMBODIA'S pesticide problem arises not only because of the presence of chemicals banned by the Government and regarded globally as hazardous to human and environmental health, but also because of a suite of contributory factors.

LACK OF EDUCATION

Limited education and little access to relevant information has led to a culture of ignorance in Cambodia regarding the dangers of pesticides and means to minimise these. Typically, farmers lack even the most basic information such as which pesticides are appropriate for specific pests, what doses to use, which pesticide mixes are safe, and what the correct re-entry and pre-harvest periods are. An FAO survey showed that only 1% of vegetable farmers had received training from a technical field officer[1]. 95% of 1000 farmers in a CEDAC survey learned to use pesticides from neighbours or traders[2], who themselves are unaware of pesticide risks, have not been trained and are often unable to read labels. Nevertheless, traders are perceived to be knowledgeable, "*similar to a doctor*"[1].

The paucity of Cambodian farmers' education extends to lack of awareness about the necessity of (and alternatives to) pesticide use and ignorance of whether insects on crops are genuine pests, are benign or even beneficial.

PRODUCTS AVAILABLE

Western companies continue to produce pesticides regarded by the international community to be of sufficient risk to human health and the environment to be included on the Prior Informed Consent procedure or in WHO categories Ia and Ib. Although many of these pesticides are banned or restricted in the Western world, stockpiles remain and continue to be exported to developing countries, a process of questionable ethics, given the inability of many such recipient countries to ensure safe and effective use.

Intrinsic consequences of corporate marketing strategies are the increased use of and increased dependence upon pesticides. Whilst such market expansion is naturally the aim of any commercial interest, it may run counter to the aims of Integrated Pest Management strategies (see pages 28-30), which emphasise the use of a suite of methods (including chemicals when necessary) to increase agricultural productivity in an ecologically sound and sustainable manner.

Whilst the agrochemical industry voices support for IPM efforts in South-East Asia[3], it has been suggested that their marketing strategies hinder attempts to develop and implement safe and sustainable alternatives[4].

© G. Bizarri / FAO

50% of Cambodia's population is under 15 and many are active in agriculture. 48% of farmers recently asked allowed children to apply pesticides. The heat discourages the use of overalls, boots, gloves and masks and such protection is too expensive for most farmers. Pesticides are thus often in contact with the applicants' skin, eyes or mouth, leading to serious risks of poisoning.

Regent (a Rhône-Poulenc fipronil product) and Zeneca's lambda-cyhalothrin are promoted as IPM-compatible pesticides but have been criticised for their negative impacts on natural control and potential for promotion of severe pest outbreaks in Vietnam[5]. Furthermore, fipronil is harmful to crustaceans – a major concern as floodwater links paddy fields with shrimp farms[5].

That Western agrochemical companies continue to market older more dangerous chemicals in Asia but not in the West is tacitly acknowledged in the APCPA statement that: "*The lack of adequate data protection in several economically important Asian countries is without doubt a serious barrier to introducing new, safer, more effective IPM-compatible molecules*"[6].

"The labelling often written in improper language fails to provide data on the active ingredient, application, date of manufacture and safe handling of the chemical"
FAO/WHO press release[10]

THE PROBLEM OF LABELLING

A large proportion of pesticides on sale in Cambodia is imported from Vietnam and Thailand[7] and is thus labelled in a language and script incomprehensible to even the minority of farmers who are literate. A CEDAC study revealed that only 8 of 77 pesticide traders said they could read foreign labels on pesticides they sold, whilst 97.5% of the pesticides were labelled in a foreign language[8]. This exacerbates the problems outlined above and leaves users ignorant of which chemicals they are using, what application regime is recommended and what the dangers are. This is exemplified by farmers' treatment of fungal attacks on coffee with monocrotophos and mevinphos, both insecticides and thus ineffectual[9].

"SPC's (Saigon Pesticides Company) products are characterized by their high quality and consistency, good in appearance and safe in use, and to be widely used throughout country"[11]
—*Corporate information of the Saigon Pesticide Company, whose WHO Class Ib products DDVP (dichlorvos), Azodrin (monocrotophos) and Monitor (methamidophos) are widely available in Cambodia – with only Vietnamese labelling.*

Bad labelling: This WHO Class Ia pesticides is labelled in English, not Khmer, lacks an expiry date and uses symbols that are difficult to interpret.

© CEDAC

Good labelling: Although methamidophos is also banned, these bottles are labelled in Khmer, illustrate target crops and use clearer safety symbols.

© CEDAC

Producers of some pesticides sold in Cambodia without Khmer labelling[12]

Product	WHO class	Company	Instructions language
Folidol (methyl-parathion)	Ia	Bayer	Thai
Mevinphos (mevinphos)	Ia	Cyanamid	Thai
Phosdrin (mevinphos)	Ia	Shell	Thai
DDVP (dichlorvos)	Ib	TIGIPESCO (Vietnam)	Vietnamese
DDVP (dichlorvos)	Ib	Saigon Pesticide Company (Vietnam)	Vietnamese
DDVP (dichlorvos)	Ib	VIPESCO (Vietnam)	Vietnamese
Furadan (carbofuran)	Ib	VIPESCO (Vietnam)	Vietnamese
Ovansu (methamidophos)	Ib	Bayer	Thai
Giant (methamidophos)	Ib	Sanonda (China)	English, Vietnamese
Monitor (methamidophos)	Ib	Saigon Pesticide Company (Vietnam)	Vietnamese
Azodrin (monocrotophos)	Ib	VIPESCO (Vietnam)	Vietnamese
Azodrin (monocrotophos)	Ib	Saigon Pesticide Company (Vietnam)	Vietnamese
Lannate (methomyl)	Ib	DuPont	Thai
Regent (fipronil)	II	Rhone-Poulenc (now Aventis)	Chinese, Vietnamese
Thiodan (endosulfan)	II	Hoechst (now Aventis)	Vietnamese
Thiodan (endosulfan)	II	Techno Agricultural Supplying Co.	Vietnamese
Padan (cartap)	II	Takeda (Japan)	Vietnamese
Sumicidin (fenvalerate)	II	Sumitomo Chemical Co. Ltd	Vietnamese
Diazinon (deltamethrin)	II	Asiatic Agricultural Industries Pte Ltd (Singapore)	English
Decise (deltamethrin)	II	AgroEvo (Hoechst) (now Aventis)	Vietnamese
Cyrin (cypermethrin)	II	Searle (India) Ltd (now ISAGRO, Italy)	Vietnamese
Pegasus (diafenthiuron)	III	Novartis (now Syngenta)	Vietnamese
Glyphosate	U	Monsanto	Vietnamese

"Since I began to use pesticides I notice that my health has deteriorated."
Mrs Srey Ya, vegetable farmer, Kien Svay district, Kandal Province

'GOOD PRACTICE' AVOIDED

If evidence from Cambodia's neighbours is indicative, it would appear that even if instructions are printed in Khmer, and can be read, they will not necessarily be understood or respected. A study by German technical aid agency GTZ and the University of Hannover revealed that, "*Thai farmers apply higher than recommended concentrations, do not pay attention to labels, wear no protective clothing and do not respect recommended intervals between spraying and harvest*"[13]. Similarly, in Vietnam, whilst 65% of farmers were able to read pesticide instructions, only 39% understood and followed them[14].

Instructions targeted to temperate zone consumers are simply not realistic in the Cambodian context. The heat discourages the use of overalls, boots, gloves and masks and such protection is too expensive for most farmers[9]. Only 7% of farmers interviewed in a 2000 FAO study changed their clothes after spraying and one-half did not wash their hands[1]. Lockable storage (beyond reach of children and animals) is uncommon and pesticides are often kept near cooking areas[1,9]. Used pesticide containers are disposed of without caution, frequently discarded in fields, ponds or near houses[1]. Furthermore, tools used are often old and in poor condition. In Indonesia – a country with similar problems – it was found that nearly half the spray equipment (tanks, valves, lances) leaked onto the sprayers' hands and down their necks and backs[15].

Ignorance or disrespect of good practice is reflected by a CIAP survey conducted in 2000, which demonstrated that 51% of farmers mixed pesticides in the same containers used for drinking water[16]. Even at the traders' level, risk awareness is minimal. Of 123 pesticide shops visited by CEDAC in 1999, over half did not separate pesticides from cosmetics, food, drinks, and medicine[8]; the situation remained a year later[17].

"*During one season I spray 20-25 times, which is 4 tanks of pesticide in one go. I mix three different types of pesticide. This makes the crop grow better and look more attractive. I can read but cannot understand the labels on the bottles and packages of pesticides. Since I began to use pesticides I notice that my health has deteriorated.*"[1]
Mrs Srey Ya, vegetable farmer,
Kien Svay district, Kandal Province

IGNORANCE OF HEALTH RISKS

According to a 1994 Government report, 82% of Cambodian farmers believed that pesticides had no effect on human health, 14% thought that sickness was possible and none envisaged a risk of death[18]. Even when health risks are accepted, many believe that danger only exists if pesticides are ingested orally, rather than via the skin or inhalation. Said farmer Keo Chouk, 19, "*If you don't drink* [the pesticide] *you will never die. If you are careful, you will never have a problem*"[17].

Even when signs of pesticide poisoning are shown, farmers do not always make the

The Magnificent Seven?
The seven companies (**Aventis CropScience**, **BASF**, **Bayer**, **DowAgroSciences**, **DuPont**, **Monsanto** and **Syngenta**) dominating agrochemical production are all based in Europe or the USA, where some of the strictest chemical control legislation exists.

The seven companies dominating agrochemical production are all based in Europe or the USA, where some of the strictest chemical control legislation exists. Among their products are chemicals banned or severely restricted in the West but which are marketed to developing countries where inappropriate use is rife.

Ascertaining which companies are producing which chemicals and where is difficult. Some of the companies' websites, for example, list only a selection of their agrochemical portfolio – generally the most modern, patented-protected products.

During the writing of this report, each of the big seven was approached with requests to provide lists of all of their agrochemical products and the sites of their manufacture and formulation. With the exception of DuPont, all declined to reply.

Lockable storage, beyond reach of children and animals, is uncommon in rural Cambodian houses. Pesticides are often kept near cooking areas, sometimes among food items.

© Rachel Rinaldo

"I can read but cannot understand the labels on the bottles and packages of pesticides." Mrs Srey Ya, vegetable farmer, Kien Svay district, Kandal Province

connection. Some have blamed "bad magic" for health problems that are symptoms of pesticide poisoning[9]. A child who collapsed whilst spraying insecticide on rice was said to have "*fell asleep immediately*" by his family, who expressed surprise that he was so exhausted from the work: applying insecticide directly from a bucket to the plant with the help of straws[9]. Such exposure of children to harmful chemicals is widespread. Indeed, 48% of farmers in a recent survey said that they allowed children to apply pesticides[1].

A recent FAO study suggested awareness is improving – 88% of vegetable farmers associated ill health with pesticide use[1]. However, bad practice persists and farmers aware of health risks may consider them minimal relative to the lost harvest they fear will follow a cessation of pesticide use. Vegetable farmers also believe pesticides make their crops look healthy and therefore increase their market value.

WEAK LAW ENFORCEMENT

Many dangerous pesticides (those in WHO Class Ia and 1b) are officially banned under Cambodian law (see page 16) but remain available. 52% of 210 vegetable farmers questioned by FAO researchers used Class 1a or 1b chemicals[1]. Weak law enforcement contributes to the continued market presence of these dangerous chemicals.

VARIABLE PESTICIDE QUALITY

Variable pesticide quality, encouraged by lack of controls over what is sold, confuses farmers and discourages good practice. For example, fake versions of well-known branded products are widely available. A 1998 CIAP survey of rat poison revealed that one product was completely fake and another was only 12% zinc phosphide, though labelled as 80%[12]. Safe use of such pesticides is almost impossible as farmers consider them 'weak' on the basis that they do not work as expected. During the next use of the same type of chemical, doses might be increased, but if the next product is more concentrated, over-application will result, increasing risks to humans and the environment.

Safe use?
The Asia-Pacific Crop Protection Association (APCPA), provides regional representation of the agrochemical industry (members include Aventis, BASF, Bayer, Dow AgroSciences, FMC, DuPont, Monsanto, Syngenta and Sumitomo). APCPA members endorse the Safe Use Initiative, a system of product stewardship in Asia[19].

According to the Bayer website "*Product stewardship does not end at the factory gate. At Bayer, environmental and safety aspects of a product are critically examined for the entire life of the product*"[20]. However, Bayer is the manufacturer of Folidol (methyl-parathion), the most commonly used pesticide in Cambodia, although banned by the Government. Much of Cambodia's Folidol is labelled in Thai and, as such, instructions for safe use are unintelligible to most users. This can hardly be considered safe for the product's "entire life" (see also page 22 on Peru). Although the industry highlights the fact that fake Folidol is on sale in Cambodia, independent sources question the significance of the counterfeits as a proportion of the total[15].

Japan's Takeda Chemical Industries Ltd boasts on its website that "*The safe, environment-friendly agrochemicals created at these laboratories are making a significant contribution to Japanese agriculture, and are also exported worldwide*"[21]. Indian workers report poisoning and death from handling Padan (a cartap pesticide) for Takeda[22]. Padan is available in Cambodia but all instructions are in Vietnamese.

Cambodian farmers, who are often unable to read the labels, do not know basic precautions related to the use of pesticides. Food containers are used for mixing pesticides. This can lead to confusion and serious domestic accidents, especially for children.

cambodia's pesticide problem: dangers

Cambodia faces both human and environmental pesticide-related problems, all of which are exacerbated by limited appreciation of the risks associated with pesticides.

impacts on human health

An estimated three million reported cases of pesticide-associated acute poisoning occur annually, resulting in 220,000 deaths, 99% of which occur in the developing world[1], although these countries account for only 20% of global pesticide use[2].

Contamination can occur via three main routes:

- oral (ingestion)
- inhalation
- through the skin (adsorption)

Oral contamination affects both sprayers and consumers, whereas the two other modes of contamination affect mainly farmers. Although ingesting pesticide is the most dangerous, breathing and adsorption through the skin are probably the major causes of occupational poisoning cases among farmers in Cambodia as they are usually unaware of these particular risks.

Direct drinking of large quantities of pesticides is very rare and usually happens in connection with suicide attempts. Accidental oral contamination usually results when farmers eat, drink or smoke while spraying or do so just after spraying without washing their hands (for some pesticides, like methyl-parathion, very small quantities can induce poisoning).

As many Cambodian farmers are unfamiliar with the concept of pre-harvest period, pesticides may be applied up to the day of harvest, resulting in high levels of residues in food products, and potentially causing consumer poisoning[3]. A growing concern is contamination of drinking water through use of the same containers to mix pesticides and to transport drinking water, or by direct pollution of water systems.

A major cause of farmers' poisoning is pesticide inhalation caused by spraying without protective masks (pieces of cloth are sometimes used but they usually have minimal protective effect)[3]. Adsorption of pesticides through the skin is the least acknowledged mode of contamination. It is not unusual for farmers to mix pesticides with bare hands, or to walk barefoot in fields[3]. These routes of contamination are very difficult to prevent as Cambodian conditions make wearing of protective clothes and masks impractical.

Pesticides can be dangerous for human health in two ways: acute

Why are pesticides dangerous for humans?

The diversity of pesticide compounds makes it difficult to generalise, but insecticides – with the exception of the most recent ones – all tend to act in the same way: targeting insects' nervous systems, specifically the 'synapses'. Synapses are spaces between nerve cells, across which chemical molecules transmit nervous information.

Each insecticide can affect different synaptic molecules, but a given insecticide does not affect all potential target molecules. What makes insecticides particularly toxic for humans is the fact that human and insect nerve cells work, at a basic level, in the same way. So the nerve cell targets of the insecticides are present – and can be affected – in the human body. Usually, however, insecticides must reach nerve cells and so undergo modifications – mainly in the digestive system, which differs greatly between insects and humans. Insecticide compounds thus tend to be activated specifically by insect metabolism, and neutralised by human metabolism. Despite this tendency, many pesticides are still dangerous for human health.

For example, parathion is activated in insect bodies to give paraoxon, a molecule 100 times more toxic to insects. Mammals cannot make this transformation, but parathion is still toxic to them through different reactions.

Such actions on the nervous system can result either in immediate toxic effects or on longer-term disruptions (delayed neuropathies).

Right: Many farmers believe that danger only exists if pesticides are ingested orally, rather than via the skin or inhalation. It is not unusual for farmers to mix pesticides with bare hands, or to walk barefoot in fields. This Cambodian farmer's hands show symptoms of direct pesticide exposure.

© CEDAC

A warning from Peru[9]
A scenario bearing striking similarities to that currently observed in Cambodia exists in Peru and serves as a stark warning of the potential for harm posed by pesticides. According to a recent press release from Pesticide Action Network[9], 24 Peruvian children died following ingestion of Bayer's Folidol (methyl-parathion), which had contaminated powered milk supplies. Although the pesticide was labelled in Spanish, it was marketed to Andean farmers, many of whom speak only Quechua and are illiterate. Furthermore, the packaging lacked pictograms warning of health hazards, instead showing images of healthy carrots.

poisoning and chronic effects. Acute poisoning has the most striking effects and can lead to immediate incapacitation and death. Chronic poisoning is usually less dramatic, appearing gradually, thus making the connection with pesticide more difficult to establish and to explain to the victim.

Pesticides' acute toxicity is measured by the Lethal Dose 50 (LD50), the amount of the product that would result in the death of half a population of laboratory rats. The most toxic pesticides have the lowest LD50 (very small doses can kill). For example, methyl-parathion has an oral LD50 of 3 mg per kg of body weight[4]; nicotine and DDT both have oral LD50 of 50 mg per kg; malathion has an oral LD50 of 2800 mg per kg.

Acute poisoning symptoms depend both on the toxicity of the product and on the quantity absorbed. They are numerous and range from dizziness and nausea to breathing difficulties, convulsions, increased blood pressure and changes in heart rate (that can lead to coma or death)[5,6]. The same symptoms can sometimes be observed after repeated exposure to pesticides (chronic toxicity). Delayed effects (including loss of feeling and needle-like pain in the extremities) can sometimes be observed 2 to 4 weeks after an important exposure (to methamidophos, for example[6]).

Long-term effects are harder to evaluate and data for a given pesticide vary between sources. One general concern is pesticides' effect on hormones. Since hormones are especially important in early stages of human development and in reproduction, such 'endocrine disruption' can affect humans as embryos or children. However, consequences may only appear later in life, and include learning difficulties, behavioural and reproductive affectations (e.g. accelerated puberty, infertility), and increased susceptibility to cancer[7].

One well-known effect of some pesticides is their disruption of cholinesterase, an enzyme functioning in the transmission of information across synapses between nerves. Cholinesterase disruptors prevent nerves from working correctly. In particular, this can affect brain nerves, responsible for the release of hormones, hence affecting the reproductive system. Cholinesterase disruption thus results in both immediate symptoms and longer-term effects. Immediate symptoms resemble the symptoms of acute toxicity. They can, however, be mistaken with symptoms of common illnesses in developing countries: heat prostration, exhaustion, hypoglycaemia, pneumonia, etc[8]. Many pesticides from the organophosphate and carbamate families are known cholinesterase disruptors[8].

Other long-term effects are teratogenic (inducing embryo malformation), mutagenic (inducing genetic or chromosomal mutations) and carcinogenic (inducing cancer). Pesticides are tested for these effects, but their slow emergence is hard to reveal in tests. If effects are found at small doses though, pesticides are not commercialised.

POISONING EVIDENCE FROM CAMBODIA

A recent (2000) report from the FAO Community IPM programme provided strong evidence of pesticide poisoning among Cambodian farmers, the majority of whom were using chemicals classed as moderately to extremely hazardous to human health (WHO classifications Ia, Ib, II)[10]. Of 210 pesticide-using farmers interviewed, 88% had experienced symptoms of poisoning (dizziness, headaches, night sweats, shortness of breath, chest pains, red eyes, unconsciousness) during or after spraying. 35% reported vomiting, a sign of moderate poisoning after spraying, whilst 5% had experienced unconsciousness, indicative of serious poisoning[10].

According to a CEDAC report, in 1999, at least one farmer died from pesticide poisoning and several became seriously ill[11]. In Siem Reap in 2000, seven Cambodians died and 79 became sick after eating normally non-toxic tetradontus fish[12]. Hong Sun Huot, Cambodian Minister of Health said, "*According to the results of our laboratory tests, there were high levels of pesticides in the fish*"[12]. This explanation was later disputed[12b], and the role of pesticides in this case remains unclear.

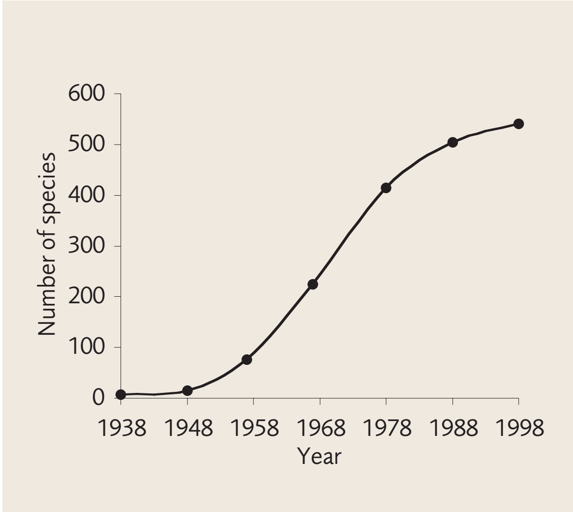
It is likely that pesticide poisoning is under-reported in Cambodia, where symptom recognition and association with pesticides have only recently developed. In Thailand, in the early 1990s, there were reported to be about 3500 cases of occupational pesticide poisoning annually[13].

"I have never seen such hazardous pesticides used in any country in such a hazardous fashion"
Helen Murphy, Medical Epidemiologist, speaking of Cambodia[36]


© Scott Bauer / USDA-ARS

Left: This parasitic wasp is laying its eggs in a pest caterpillar, which will die as a result. Such natural enemies are beneficial to farmers but are killed by broad-spectrum pesticides, making pest resurgence more likely.

Right: Arthropod species resistant to at least one pesticide (global data)[14,15]



PESTICIDE RESISTANCE

Another major environmental concern is pests' resistance to some pesticides. Far from being restricted to the developing world, this occurs virtually everywhere pesticides are used (an estimated 540 arthropod species are resistant to one or more pesticides)[14].

Pesticide resistance occurs by natural selection. Whilst pesticides kill most insects, individuals with random mutations conferring reduced sensitivity to insecticide molecules are more likely to survive spraying and reproduce. Some of their offspring will inherit this resistance and, as long as pesticide application continues, the proportion of resistant individuals will increase. Resistance can spread rapidly as insects have short generation times and large numbers of offspring.

For example, the brown plant-hopper (*Nilaparvata lugens*), a pest of rice, became resistant to methyl-parathion in Vietnam in 1974 and Taiwan in 1982[14]. Resistance to this insecticide elsewhere in Asia is suspected, but confirmatory surveys have yet to be conducted. In total, the brown plant-hopper is resistant to 19 pesticides across South-East Asia[14].

Cambodian farmers' responses to pesticide resistance include mixing several insecticides to obtain "*more powerful*" products[3]. This is a dangerous undertaking, as the toxicity of the mixtures may be greater than that of constituent chemicals – the so-called 'cocktail effect'. Farmers also react by increasing the quantity and frequency of pesticide application, misinterpreting increased insect prevalence as pesticides being "*not as strong as in the past*"[10]. This is termed the "pesticide treadmill", a classic vicious circle that leaves farmers in thrall to dangerous pesticides whilst promoting further resistance[16].

PEST RESURGENCE

Pesticides, particularly broad-spectrum insecticides widely used in Cambodia today, often fail to differentiate between target and non-target species. As well as killing pest species, other insects, including natural enemies of pest insects, are killed. However, differences in reproductive strategies often allow pests to recover faster than their predators. The absence of natural control agents can then lead to explosions of pest populations.

For example, insecticide sprays against brown plant-hoppers eliminate the adults – and their predators – but plant-hopper eggs are safely laid inside rice plants and hatch a few days later, giving rise to a second generation that, in the absence of predators, will proliferate even more than the first one[17]. Such pest resurgence has occurred on a range of Asian crops including fruit, rice, cotton, vegetables, cocoa and oil palm[18]. As long ago as 1993, FAO researchers presented data from Cambodia that showed that pesticide applications threatened rice crops by killing off natural enemies of pest insects, allowing the pests to proliferate in their absence[16].

The emergence, in tandem, of pesticide resistance amplifies the problem of reliance on chemicals for pest control. In Thailand it has been observed that brown plant-hopper outbreaks do not precede pesticide use – they follow it[19].

ENVIRONMENTAL IMPACTS

Negative pesticide effects are not limited to farmers and insects in the vicinity of their application, but are also manifested through the contamination of the wider environment, particularly of water systems and food chains. Consequently, environmental pesticide

Already endangered by wildlife trade, birds can be poisoned by pesticides through direct contamination or by feeding on contaminated insects in the fields.


© Peter Schrock

Case studies: effects of pesticides on wildlife

Research from Cambodia is lacking but data from elsewhere indicate the risks posed by chemical pesticides used today in Cambodia today.

endosulfan (WHO Class II) runoff from cotton fields killed over 240,000 fish in Alabama (USA) in 1995 – the pesticide was applied according to label instructions[27].

monocrotophos (Ib) is responsible for extensive mortality of Swainson's Hawk (*Buteo swainsonii*) in Argentina, with as many as 20,000 birds dying in winter 1995-6[28].

DDT (II) is one of a cocktail of organophosphates implicated in the deaths of hundreds of fish-eating birds, largely pelicans but also rare storks, in Lake Apopka, Florida (USA) in the late 1990s[29].

brodifacoum (Ia) has killed large predatory birds, including owls and hawks, that have eaten rats targeted by the poison[30]

cypermethrin (II) sprayed on Bangladeshi vegetables in 1999 caused over 5000 sparrows to die the following day, having eaten poisoned insects[31].

diazonin (II) is blamed for numerous cases of mass poisoning of geese (up to 700 in a single kill) in Canada and the USA, with death coming within minutes of swallowing sprayed grass[32].

carbofuran (Ib) used to control flea beetles caused the deaths of several thousand Lapland Longspurs in a single Canadian field in 1984[32].

phosphamidon (Ia), nicknamed 'purple death', resulted in heavy mortality and massive reductions of kinglets and several warbler species in Canada between 1963 and 1977[32].

Other specific compounds responsible for pesticide-related wildlife mortality include: **chlorpyrifos** (II), **dimethoate** (II), **methyl-parathion** (Ia), and **methamidophos** (Ib)[23].

All of these pesticides remain available on the Cambodian market

pollution further impacts humans by the contamination of water supplies and food products.

Water contamination can be direct, if spraying occurs near the water system, but more commonly occurs when pesticides are carried away from fields by rain or soil erosion. Contamination also results from the practice of abandoning pesticide packages, since they often retain some chemical that eventually enters the environment. Finally, washing of spraying equipment is a source of pollution.

Once in the environment, pesticides can be broken down by sunlight, water, or micro-organisms (e.g. bacteria)[20]. However, although pesticides usually break down into less harmful compounds, in some cases the newly formed compounds are more toxic than the initial pesticide[20]. Furthermore, not all pesticides degrade in the environment, and some (termed persistent organic pollutants, e.g. DDT, endrin) can remain unchanged for very long periods[20].

In Cambodia, higher levels of persistent organochlorines, including DDT, have been recorded in freshwater than marine species of fish and mussels, indicating that pollution originated in inland watersheds[21]. Concentrations of such pesticides in fish tissues, for instance, can be tens to hundreds of thousands times greater than in the surrounding water[20]. By concentrating in fat tissues these persistent pollutants 'escape' metabolic degradation and concentrate up the food chain. Meat-eaters, including humans, at the top of the food chain thus face increased risks[7]. The effects of persistent organic pesticides vary between species and concentrations, but include direct mortality through disruption of the nervous system. Less toxic effects, often observed in birds, include egg-shell thinning, feminisation of embryos and reduced levels of hormones concerned with egg-laying[22]. Although sub-lethal, these effects still contribute to population declines.

Although carbamates and organophosphates do not persist in the same manner as organochlorines, many are highly toxic to birds, mammals, fishes, reptiles, and insects, acting by interfering with neurological processes common to these disparate taxa. Again, effects vary between species, pesticides and concentrations but include rapid death (see box); in the USA, mammals and thousands of birds of over 50 species have died as a result of pesticide exposure[23]. Other less obvious neurological and hormonal effects of pesticides on wildlife include appetite suppression contributing to starvation, decreased cold tolerance, disruption of parental care and increased susceptibility to predation[22]. In the USA, methoprene, an insect growth regulator used to

Cambodian water-birds, like this globally threatened Painted Stork, are especially prone to pesticide exposure because of contaminated food and water.

© EJF

Left: Pesticide packages abandoned near fields are an important source of environmental contamination.

Right: A major problem is that farmers spray crops a few days before harvests. Thus, pesticide concentrations on produce (especially fruit and vegetables) are still very high when they are sold at market and eaten.

© EJF

control fleas and mosquitoes has been linked to frog deformities (extra legs)[24]. Birth defects noted in birds include crossed bills, missing eyes and clubbed feet[25]. As with persistent organochlorines, these sublethal effects nonetheless contribute to population declines.

By disrupting the natural ecosystem balance, pesticides can have further indirect effects on wild species. For example, in the UK, sharp declines in UK bird populations have been linked to pesticide use, not through direct poisoning, but through elimination of plant and insect food sources[26]. Similarly, as stressed earlier, pesticide poisoning of natural enemies of pest species can allow them to proliferate and cause greater problems for agriculture.

Dr Yang Saing Koma, Executive Director of CEDAC, believes that declines in numbers of some bird species from around the Tonle Sap are partly due to pesticide poisoning[33]. In recent years, mung bean farmers in Siem Reap province are estimated to have applied 10 tonnes (active ingredient) of a pesticide cocktail of DDT, Thiodan (endosulfan) and Folidol (methyl-parathion) on fields that, in the wet season, are submerged and thus capable of polluting the Tonle Sap[34].

Besides accidental contamination of the environment from pesticides used on farmland, pesticides are purposely used around Tonle Sap to kill fish and game for human consumption[33]. Animals thus contaminated usually contain high levels of pesticides in their tissues. They can cause serious food poisoning when, in turn, they are consumed by humans.

SOCIO-ECONOMIC IMPACTS

As well as public health concerns related to direct and indirect pesticide poisoning, continued pesticide use in Cambodia will have other socio-economic impacts.

Current agricultural pesticide use is a costly approach, not reflected by increases in yield. As such, it impoverishes farmers and leaves them dependent on external inputs. According to CEDAC, methyl-parathion retails at US$4-9 per litre[35] and FAO states that rice farmers use 1-2 litres per hectare, depending on the type of cultivation[10]. Thus, for some farmers, pesticide costs equate to almost 7% the per capita GDP. An IRRI study showed that there is no net economic benefit of pesticide use in tropical rice cultivation. In vegetable farming, higher pesticide concentrations (up to 72 litres / ha) are used. Although most family-level vegetable farmers have only about 0.2 hectares in production, such concentrations are extremely expensive especially since it has been shown that pesticide use can be reduced by over 80% from current practice in vegetables without loss in yield[36].

Beyond direct costs, pesticide presence in paddy fields prohibits traditional rice-fish culture (see page 31), a potential means of increased income for rice farmers. Each year, Cambodian floodplain rice fields fill with fish that, along with crabs, shrimps, edible insects and frogs, represent a valuable protein source for rural people. The use of pesticides kills these animals and denies rice farmers access to the dietary supplement.

Fish constitutes an integral component of typical Cambodian diets, providing around 75% of animal protein[37]. In an environment already destabilised by fishing and logging practices, water pollution by pesticides is one more element that could lead to dramatic disruption of the Cambodian ecosystem and contribute to increased imbalance in rural diets.

Pesticide residues limit the potential for export to countries with strict controls on food safety. This concern is said to have triggered the Indonesian decision to improve its residues monitoring programme, whilst providing an incentive to increase control of domestic pesticide use[38]. Similarly, Thailand has recently developed a pesticide residue monitoring system for market produce destined for human consumption[36]. In Cambodia, local consumers are also expressing concern about pesticide ingestion through food consumption[39]. A major problem is that farmers spray crops a few days before harvests. Thus, pesticide concentrations on produce (especially fruit and vegetables) are still very high when they are sold at market and eaten.

Pesticide residues therefore have the potential not only to endanger the future of Cambodian exports but also to impact the domestic market, thus affecting the urban population and potentially tarnishing the image of the burgeoning tourism industry.

tonle sap: a disaster waiting to happen?

The Tonle Sap lake, the largest in SE Asia, is the dominant geographical feature of the Cambodian landscape, expanding to cover 13,000 km^2 in the wet season[40]. The lake and its 80,000 km^2 catchment are of considerable cultural and economic importance to the communities that live close to its shore, and to those more distant who benefit from its abundant fisheries and agricultural output – in total, half of Cambodia's population are thought to draw gain from the catchment[40]. However, dangers posed by pesticides loom on the horizon. The potential for severe human and environmental impacts in the Tonle Sap area reflect wider pesticide-related problems facing Cambodia as a whole. Tonle Sap's unique hydrology (wet season reverse flow of the river) and connection with the Mekong basin may contribute to pollutants being distributed far from their source[41].

Pesticide input

- 1.3 million litres of pesticides used in Tonle Sap catchment in 2000[35].
- Most chemicals used are illegal and classed as highly or extremely hazardous to human health (WHO class I)[35].
- An estimated 10 tonnes of DDT & methyl-parathion have run-off from 2000 ha of mung bean crops in recent years[34].
- Pesticides including endosulfan and methyl-parathion are illegally used to kill fish[16,43].
- Pesticides are used to protect dried fish from insects[44].
- Most users remain ignorant of potential for harm.

Human uses

- Rural population of 3.4 million[40], 38% of whom live below the poverty line[42].
- Many subsistence fishers and 60% of Cambodia's commercial catch[37].
- Centuries old rice production and other agriculture.
- Burgeoning tourist industry visiting nearby Angkor Wat and bird-watching sites.

© EJF

Natural riches

- 500 fish species (179 endemic to the lake)[40,45].
- 225 bird species. Internationally significant breeding grounds for rare birds, e.g Bengal Florican (*Houbaropsis bengalensis*), Greater Adjutant (*Leptoptilos dubius*)[46].
- 190 plant species in flooded forest[40].
- Rare turtles and endemic Tonle Sap water snake Enhydris longicauda[47,48].
- UNESCO Man and Biosphere Reserve[40].

© EJF

Dangers posed by pesticides

- Acute and chronic poisoning of farmers.
- Wildlife poisoning and death.
- Pest outbreaks caused by absence of predators inadvertently targeted by pesticides.
- Poisoning of human food supply of rice and fish.
- Impacts on domestic and export food markets, and on the tourist industry.
- Long-term and long-distance impacts due to bioaccumulation of toxins, considerable water flow and transport of polluted food.

alternatives and solutions in cambodian agriculture

ARE PESTICIDES REALLY NECESSARY?

It is now known that pests of rice do not affect yield to the extent previously thought and experts conclude that "*insecticides are usually not needed in rice*"[1]. Reflecting this, elsewhere in the region, increases in pesticide application have not been matched by proportionate increases in productivity[2].

Furthermore, it seems that many insecticide applications are inappropriate, targeting the wrong insect or being applied at the wrong time. This is the case for up to 80% of pesticides sprayed in the Philippines, for instance[3]. In Thailand, most rice farmers spray their crop in the first month after planting, yet these applications are unnecessary[3]. On the contrary, they can kill pests' predators, thus allowing subsequent pest outbreaks.

Studies in Vietnam and the Philippines revealed that leaf-feeding insects were commonly targeted, accounting for 42% and 28% of insecticide use in each country, but that spraying was out of proportion to pest abundance[4]. Although, leaf-feeding insects are conspicuous to farmers, rice can tolerate losing up to 50% of leaf area without compromising yield[5]. A joint IRRI / Cantho University (Vietnam) study conducted in 1995 in Vietnam's Mekong Delta convinced rice farmers that spraying insecticides against leaf-folders is unnecessary[6]. Consequently, half the region's farmers stopped using pesticides against this pest and some were even testing whether they also really needed other pesticides.

An IRRI study of rice production in the Philippines concluded that, when health costs are included in an economic analysis, pesticide use is detrimental to both rice productivity and farmers' health[7]. Given the similarities between rice production in the above countries and Cambodia, it is likely that a large proportion of insecticide used in Cambodian rice production is unnecessary.

Indeed, recommending against the introduction of insecticides to Cambodia in the early 1990s, staff of the Japan International Volunteer Center, FAO and IRRI warned that: "*in most Cambodian rice paddies the pest population is not high enough to seriously affect harvests*"[8].

© IRRI

Although targeted by Cambodian farmers' pesticides, research from Vietnam has shown that spraying against rice leaf-folders is unnecessary

After insects, the major pests targeted by pesticides in Cambodia are rats. In contrast to insects, rat damage seems to be of real importance, "*one of the biggest threats to a growing rice crop*", according to CSIRO expert Dr Grant Singleton[9].

Alternatives to chemical control are being developed and include CSIRO's Community Trap Barrier System (CTBS), which uses a small, early crop to lure rats into a central trapping area and is cost-effective in situations where losses are expected to exceed 10%[9]. CTBS is only effective when used at the community level and although initial costs are relatively high (US$20-25 per unit in Indonesia and Vietnam), materials can be re-used and shared[9]. Other non-chemical approaches include avoiding staggered harvests in cropping areas, use of extended fallow periods, and ensuring field bunds are low to deter nesting[9].

In non-rice agriculture, conclusions about the need for pesticides are less easy to draw. This is in part because, compared to rice, considerably less research has been conducted into crop pests and protection. Furthermore, the diversity of non-rice products means that a more diversified approach to crop protection is required. This is of concern given the agrochemical industries' recent prediction that vegetable production will increase by 7% per annum in all South-East Asian countries[10].

In some circumstances, pesticide use is an attractive means of pest control for farmers. However, the direct and indirect costs of using pesticides should always be compared to the benefit they bring. As mentioned earlier, another hidden cost of pesticide use is the residual effect on food products and their subsequent loss in value, particularly for products destined for export. Such costs are major incentives for farmers and government to turn to Integrated Pest Management or organic farming (see below). Without suggesting that pesticides should be abandoned, their use should always remain a last resort, when the cost of loss induced by pests' outbreaks justify it.

© SAO-UK

“Insecticides are usually not needed in rice”
Dr P. Matteson, FAO[1]

IPM: Indonesia's success story[20,21]
In 1986, in response to pesticide-induced resurgence of brown plant-hopper, President Suharto banned 28 pesticides in 57 products and IPM became national policy for rice production.

Indonesia saved over US$100 million a year by phasing out an 85% pesticide subsidy between 1986 and 1989.

IPM Farmer Field Schools (FFS) were initiated – nearly 1 million farmers have been trained in Indonesia.

Nearly every village in rice-growing areas has a FFS graduate.

IPM-trained farmers use significantly less pesticide.

IPM farmers achieve equal or higher yields, and greater profits.

Across the country, pesticide use has halved and yields have risen by 10%.

Health costs of pesticide poisoning have fallen since IPM's introduction.

INTEGRATED PEST MANAGEMENT

Integrated Pest Management (IPM) is defined in the FAO Code of Conduct as “*the careful integration of a number of available pest control techniques that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce/minimise risks to human health and the environment. IPM emphasises the growth of a healthy crop with the least possible disruption of agro-ecosystems, thereby encouraging natural pest control mechanisms*”[11].

Essentially, IPM is a system of pest control using a suite of biological, chemical, cultural, and temporal methods in concert and in an environmentally sound and sustainable manner.

In order that farmers learn these techniques, FAO and the Cambodian Department of Agronomy initiated “Farmer Field Schools”. In FFS, farmers meet weekly and learn to recognise pests, predators and parasites, to decide when pesticide use is necessary, and to use pesticides safely[12]. In addition they learn about seed selection, soil fertility, water management and other aspects of crop production.

Importantly, teaching occurs in the field, through a participatory process, and is often conducted by farmers who have previously received such training (Trainers' Training Scheme). Thus, farmers can gain the confidence required to make their own decisions back on their own farms.

To date, over 30,000 farmers (1/3 female) have attended rice IPM FFS and over 300 have completed further training and now organise FFS in their own areas[13].

This is a self-sustaining system, and farmers can pass on the knowledge without any external help. Paradoxically, the fact that farmers learn from each other is the main reason that misconceptions about pesticides exist, as there has been no previous access to reliable information sources. Now, once the basics of safe, environmentally-friendly pest control have been gained by some farmers, they can be passed on to others in the same way. Farmers have more faith in their neighbours who share their problems than in outsiders who are not part of their community[15].

For IPM to work farmers must *“be able to identify problems, have access to appropriate control measures and have the confidence to make appropriate choices”*[16]. Field schools help solving the first and last points, but government and NGOs play a central part in providing appropriate control measures, by conducting field experiments.

Focuses of IPM methods in rice production include:

In Farmer Field Schools, farmers learn to recognise pests, predators and parasites and that most pesticide use indiscriminately kills all of these species.


© G. Bizarri / FAO

“The FAO Inter-country Programme for the Development and Application of IPM in Rice in South and South-East Asia has achieved a significant reduction in pesticide use and has led to 50-100% reductions of insecticide use, without reductions in yield; cropping has become more sustainable and more profitable."
—FAO. Summary of FAO Capacity Building Efforts in Pesticide Management[14]

Rice-field ecology: Farmers learn that respect of wildlife living in or nearby the fields helps control pests – that frogs, toads, fishes, birds, and especially spiders and certain insects feed on insect pests, and that snakes feed on rats. Farmers learn to identify different species, understand their feeding habits and life cycles, be aware of factors affecting population dynamics, and appreciate crops' ability to recover from damage. Thus, they learn that predators such as lady beetles, wolf spiders and mirid bugs can control herbivorous insect pests.

There is, of course, a conflict of interest for the rural population between hunting larger animals that can represent a very valuable source of cash income when sold on Cambodian markets, and protecting them to help control rice pests and thus improve their staple food harvest. Often in such situations, farmers prefer the short-term solution. Arguably, if Cambodian farmers were more aware of the relations between rice pests and their predators, the unsustainable trade in wildlife might decrease.

Weed control: Farmers learn that attention should be given to weed problems as soon as possible to give farmers alternative tools before the temptation of herbicide becomes a reality and results in the same problems as insecticides and rodenticides pose today. It is easier to teach farmers how to fight weeds without chemicals than to have to convince them later to give up herbicides.

Weeds cause an estimated yield loss of 20-30% in Cambodian rice fields[17]. Water management in irrigated rice is a very efficient way of controlling weeds[18]. Many Cambodian farmers do not have this option as most rice production is rain-dependent and even in irrigated systems water resources are limited. However, a better preparation of the field, particularly a good levelling of the soil could lead to great improvements in weed-control. It has been estimated that 90% of Cambodian rain-fed rice fields are uneven, with an average difference in height between highest and lowest parts of 160 mm (range: 70-330 mm)[19]. A CIAP three-year trial showed that yields can more than double when fields are levelled (average yields obtained were 3.2 tonnes per hectare versus 2.3 tonnes per hectare in uneven fields, though in some levelling trials, yields of 5.4 tonnes per hectare were attained)[19].

Seed quality: Farmers should pay attention to the cleanliness of their seeds. Many seed stocks contain weed seeds (either in seeds set aside by farmers from previous years or in commercial seeds). Clean seeds could increase yield by up to 10%[18].

Pesticide timing: Kenneth Fisher, deputy director-general for research at IRRI in 1994, advised that simplicity in the implementation of Integrated Pest Management techniques is of great importance. For example, simple, but very effective, advice that can be given to farmers is to wait at least 40 days after sowing before spraying any insecticides: most insects disappear on their own within this period[18]. Not using pesticides early in the season allows the establishment in rice fields of predatory spiders, crickets and beetles, and also, depending on rice system, fishes and frogs that also eat pests, and are potential protein sources[6].

Biological control: The use of natural enemies of pest species can partially obviate the need for chemical pesticides. Predators and parasites including *Trichogramma* wasps, lacewings and nematodes can be reared in low-tech insectaries near to the fields in which they are to be deployed[22]. Release of bio-control agents may be more applicable in vegetable than rice cultivation since the long history of the latter means that a rich complement of natural predators or parasites usually exists already.

Resistant varieties: New high-yielding rice varieties (IR) have been developed and some show resistance to pest species (see page 9). However, in Cambodia, consumers and producers prefer traditional varieties for their texture and flavour and retailers interviewed in Phnom Penh and Battambang stated that customers would avoid IR rice unless it is heavily discounted[23].

Case study: IPM of diamondback moth

Larvae of the diamondback moth (*Plutella xylostella*) are major pests of cabbages and their relatives.

They are resistant to all pesticides in Thailand, Malaysia, and the Philippines[26].

Parasitic wasps (*Cotesia plutellae*) have been used as biocontrol agents in conjuction with Bt (biological insecticide) sprays in Cambodia's Kien Svay district, Kandal Province. Little damage appeared in fields without chemical insecticides whereas those sprayed with pesticides were heavily damaged by the moth[27].

In another study, net barriers over cabbage plants reduced peak larvae densities from 80.9 to just 3.4 per plant, and doubled yield[25].

© G. Bizarri / FAO

Above: Using insect zoos, IPM farmers learn the life cycles of pest and beneficial insects.

Below: In terms of quantity per hectare vegetable production uses considerably more pesticides than rice. The FAO has recently shifted its IPM focus away from rice and towards vegetable production.

© EJF

VEGETABLE IPM

IPM has also been used in Cambodian vegetable production, although on a smaller scale compared to rice – the obvious reason being that rice is by far the major Cambodian crop. However, in terms of quantity per hectare, vegetable production uses considerably more pesticides than rice. FAO has recently shifted its IPM focus away from rice and towards vegetable production. To date, 2500 farmers (half female) have been trained in vegetable IPM and 60 government staff have been trained to continue providing further FFS teaching[13].

In the 1998/99 dry season, the National IPM Programme in Cambodia conducted a pilot FFS for 30 mung bean farmers on the Tonle Sap shore[24]. Crops grew well without the use of hard pesticides (two applications of Bt were used, rather than five applications of a cocktail of methyl-parathion, DDT and endosulfan), and yields were slighter higher than those of non-IPM farmers. The project's success led to the extension of FFS to all 2000 mung bean farmers with a planned local bio-pesticide industry using native pathogens as an alternative to chemicals[24].

Other IPM methods used in vegetable production include use of early trap crops (which lure egg-laying insect pests and are then destroyed), biological control using natural enemies, use of biological insecticide (Bt) and use of barrier nets to exclude low flying insects[25]. In Sri Lanka, IPM programmes have resulted in the drop in the number of pesticides applications on cabbage fields from 6 to 1[16].

BIOLOGICAL PESTICIDES

Alternatives to the use of synthetic pesticides are "natural" pesticides, like inorganic or botanical pesticides (the only ones allowed for organic farming in Europe). Although some are as poisonous as synthetic pesticides, most are much less dangerous and are cheaper.

Furthermore, as almost all synthetic insecticides target insect nervous systems, when a pest population builds up resistance to one insecticide (through changes in its nervous system), it often becomes resistant to all other insecticides with the same target molecule. Some plants, having co-evolved with insect pests for a very long time, have developed other forms of defence. For example, in the Philippines, the makabuhay vine (*Tinospora rumphii*) burns insects using a chemical that concentrates sunlight[28]. In rice cultivation, makabuhay can be ground up and applied directly or in solution to control stemborers and leafhoppers[29].

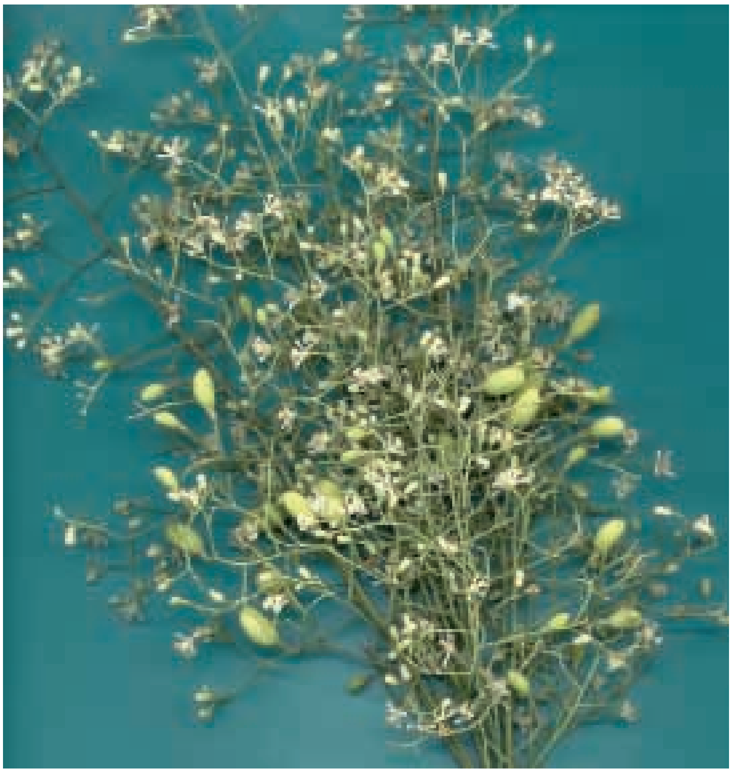
The neem tree (*Azadirachta indica*) is another source of botanical pesticide[26], and has been used in India since 1930. Neem use declined with the advent of DDT, but has experienced a modern resurgence in response to the need for ecologically sound, ethical pest management products, which are biodegradable and not harmful to humans and the environment.

Neem's insecticide properties have been well studied and its components are even found in commercial formulations in India[26]. Rather than killing insects outright, neem kernels affect insects' behaviour and physiology in various ways including as a repellent, feeding and oviposition deterrent, growth regulator, sterilant and impairer of egg hatching[26]. Multiple modes of action reduce the likelihood of insects developing resistance to neem extracts. As well as 400-500 insect species, neem extracts have been demonstrated to reduce impacts of pest nematodes, snails and fungi[26].

In the Cambodian context, neem is effective against field pests of paddy rice (e.g. stem borers and leaf hoppers) and vegetables (e.g. diamondback moth) as well as pests of stored produce, for which 10% is lost to pests worldwide[26].

Further biological pesticides utilise natural insect diseases caused by viruses, bacteria, fungi and protozoa. The most widely used is 'Bt', a toxin produced from the bacterium *Bacillus thuringiensis* and applied as an insecticide spray. Although the chemical is less toxic and environmentally harmful than most synthetic products, there are still doubts about the long-term safety of Bt[30].

The neem tree (*Azadirachta indica*) is a source of botanical pesticide, used in India since 1930. Rather than killing insects outright, neem products affect insect behaviour and physiology in various ways to deter damaging effects.



"My father never used chemical pesticides, and he never lost a crop."
Hem Savoeun, Cambodian organic farmer[34]

RICE-FISH CULTURE

Fish tend to colonise rice fields naturally, representing an important source of protein for the rural population. Under certain conditions, an alternative to non-sustainable capture methods is the 'cultivation' of fish together with rice. This 'rice-fish culture', is a 2000 year old South-East Asian tradition, which has declined following increased populations, dwindling fish stocks, and use of pesticides, which are toxic to fish[31].

Besides pesticide absence, rice-fish culture requires certain field conditions, and is therefore not possible throughout Cambodia. However, CIAP has successfully advocated this system in Svay Rieng province, where rice-fish culture is possible in both wet and dry season rice[32].

In rice-fish culture, refuge areas are created in or adjacent to fields for fish to move into in case fields dry up. Fingerlings are purchased as soon as the ponds are flooded and are nursed in nearby ponds before introduction into fields (usually about 10 days after rice has has been transplanted)[32]. Predators like snakehead fish (*Channa striatus*) and rats are reported to prey on reared fish and may increase costs by requiring greater fingerling numbers[32].

Besides helping balance rural diets and providing a potential source of income, fish cultivation benefits rice production, constituting a natural component of the field ecosystem. Fish feed on worms, snails, insects, algae and soft weeds, although some farmers supplement this diet with insects or rice bran[32]. Among the naturally occurring prey are rice pests (including leaf-hoppers, stem-borers and aphids). Predation by fish can play an important role in controlling Golden Apple Snails. Common carp, *Cyprinus carpio*, eat large numbers of juvenile snails[32].

Although fish predation does not appear to provide as immediate a control of insect pests as insecticides do, the effect comes without further disturbing the ecosystem and the resulting fish production largely compensates for the pest damage.

The drying out and re-flooding of rice fields stimulates some weeds' germination. As rice-fish culture requires farmers to regulate fields' water levels[32], a degree of weed control is achieved, reducing the need for removal by hand.

Fish not only feed on the pests and weeds, but they turn them into natural fertiliser through the deposition of faeces[31]. This increases the uptake of nutrients such as phosphorus and nitrogen by the rice.

In some instances, rice yields have improved up to 25-30% after implementation of rice-fish culture[33]. Arguably, this is due to better water management and increased focus on the rice field, but even if rice-fish culture's only benefit is to promote Integrated Pest Management techniques, it is a very promising sustainable system. Its cost is lower than the equivalent price for pesticides and fertilisers[33] and it has the advantage of providing a protein source to rice farmers. Since rice-fish culture is not applicable throughout Cambodia, research programmes on where, and under what conditions, it can be used should be undertaken.

ORGANIC FARMING

Organic farming requires exclusive use of botanical and inorganic, rather than synthetic, pesticides. Like IPM, organic farming requires good knowledge of the field ecosystem, particularly the relationships between pests and other species present (e.g. fish, frogs, spiders, non-pest insects) and natural contributions to soil fertility (manure and compost, but also faeces from animals, like fish, living in the fields). In a CEDAC survey of nearly one thousand farmers, 70% of interviewees expressed interest in organic farming because it was cheaper than buying chemicals whilst 20% cited health reasons[34].

A further advantage of the organic approach is that organic produce commands higher prices on international markets. Organic rice sells for up to three times the price of non-organic Vietnamese or Thai rice[35]. This means a better-paid crop for farmers of 500 riel/kg (US$0.13) instead of 300 riel/kg (US$0.08)[36]. Individual initiatives in this direction have recently been backed by the Ministry of Commerce, which exempted organic products from export licence charges[35].

Organic farming avoids the problems caused by chemical pesticides. Interest in this alternative was recently measured at 70% of Cambodian farmers.

© EJF

conclusions and recommendations

Current pesticide practice leaves the people and environment of Cambodia in a parlous state. Outdated chemicals, unwanted by the rest of the world are being imported and used by farmers, almost wholly unaware of their potential for harm. The results of recent studies highlight the deleterious effects of pesticide misuse on human health and ecosystem stability. These early indicators presage long-term effects, yet to be revealed by the limited research conducted in this nascent democracy.

The Royal Government of Cambodia's recognition of the pesticide issues detailed in this document, and its moves to make legal provisions to rectify them, are laudable. It is essential that the international community and the industrial concerns active in South-East Asia support these moves and further action required to safeguard Cambodian interests.

Whilst recognising that pesticides can be of great benefit during major pest outbreaks, and that safe, modern chemicals can contribute to IPM schemes, they are not being used appropriately at the current time. Thus, we favour the adoption of the precautionary principle based on:

- reduced use
- reduced risk
- reduced dependence

This will rely primarily upon increased education, research, financial support and stronger governance. In short, the Cambodian Government, with the assistance of bi- and multi-lateral donors, NGOs, and the agrochemical industry, should strive to encourage the same standards as are accepted in the West. To this end, we make the following general and specific recommendations.

© CDRI

The production of rice itself – the major staple food – is jeopardised by current pesticide practice in Cambodia. Residues in food products are also of great concern for human health and can have long-term effects.

General Recommendations

In light of the information presented in this report, all relevant parties should:

- Acknowledge the valuable uses, limitations and dangers pesticides have to play in Cambodian crop protection.
- Recognise that current patterns of pesticide use in Cambodia pose threats to human health and the natural environment, and that there exists both the need and the potential means to rectify this situation.
- Oppose and combat the presence in Cambodia of pesticide formulations banned by a Government presently unable to control illegal imports.
- Recognise that rats, rather than insects, currently pose the greatest threat to rice production and, consequently, food security and that resources should be targeted towards addressing this problem.
- Support Cambodian efforts to enforce relevant legislation.
- Endorse a massive farmer training programme aimed at raising risk awareness and inspiring good practice.
- Acknowledge indirect costs of Cambodian pesticide use such as impacts on domestic food security, on public health, on the export market and on the burgeoning tourism industry.
- Participate in the establishment of a Pesticides Working Group to coordinate efforts to address the issues described herein.

The Cambodian Government

Profligate use of dangerous pesticides has the potential to seriously impact Cambodian food security, public health and development targets. The Royal Government of Cambodia should:

- Fully accede to the Rotterdam Convention's Prior Informed Consent (PIC) procedure, thereby officially identifying to the international community those chemicals not desired in Cambodia, and placing the onus on exporter countries to behave more responsibly with chemicals they themselves may have banned or restricted.

- Join the intergovernmental Asian Productivity Organisation in order to benefit from its human resource development, technical assistance and information dissemination programmes.
- Further restrict use of pesticide chemicals not covered by the existing domestic sub-decree controlling WHO Class I pesticides. In particular, chemicals such as endosulfan need to be better controlled.
- Ensure that the 'farmer first' principle is applied by facilitating the availability of all relevant information on pesticide issues to agricultural workers.
- Take steps to collect and dispose of all obsolete pesticide stock safely.
- Introduce economic measures to discourage misuse of pesticides (e.g. taxation of pesticides, subsidies for conversion to rice-fish culture, bounties for captured rats).
- Introduce a system of market inspection for pesticide residues in produce for human consumption, as occurs in Thailand.
- Improve enforcement of domestic legislation banning WHO class I pesticides. Central to this are inspections at borders and markets, and action against those infringing the new law.
- Officially encourage Integrated Pest Management in rice and vegetable cultivation.
- Establish a central office (or designate an existing one) under the Ministry of Agriculture, Fisheries and Forestry to co-ordinate all efforts to tackle the pesticide problem described herein, including organisation of the various Integrated Pest Management and educational schemes already established.
- Facilitate regular public health and environmental research to quantify and monitor pesticide levels and their effects on humans and the environment.
- Establish a national poison surveillance centre to monitor incidences of illness related to pesticide exposure.
- Prohibit use of the word *thnam* [medicine] to describe pesticides, in reflection of their potential to harm human health.
- Require that individuals and organisations involved in pesticide trade be licensed, and encourage farmers to buy pesticides only from licensed vendors.
- Build capacity and inter-ministerial cooperation in all relevant ministries and departments in order to better enforce present legislation and to have a greater role in future monitoring, education and management of pesticides issues.
- Develop mass media (especially radio and television) campaigns to deter farmers from unnecessary pesticide practices, such as very early and very late season spraying.
- Impose a moratorium on pesticide advertisements, particularly on television. This is especially relevant for as long as banned chemicals remain widely available and until farmers' awareness of threats posed by pesticides improves.
- Increase training of medical staff in the recognition of pesticide-induced symptoms and in the ability to inform victims of the risks associated with pesticide misuse.
- Increase education about the importance of wild species in maintaining ecosystem functioning, and follow this up with greater control of the trade in wild-caught species.

Education programmes highlighting the natural balance between pests and their natural enemies, and offering other alternatives to the use of pesticides – like sound water management or the rice-fishing system – can result in high yields of healthy crops.

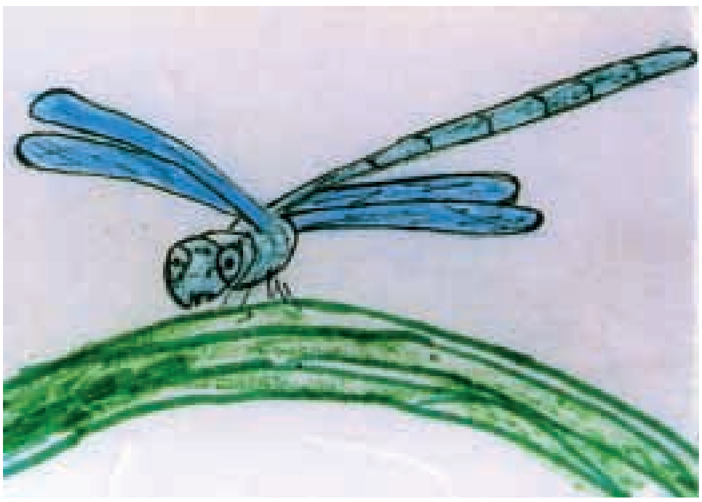
© Peter Schrock

The Donor Community & NGOs

The scale of Cambodia's pesticide problem requires that solutions facilitate the further spread of better practice across the whole country, rather than simply providing site-specific solutions. Approaches taken must be sustainable and undertaken with long-term vision. Thus considerable applied research will be a necessary component of genuinely valuable projects. Two priorities are education and capacity building. The donor community and NGOs should:

- Recognise that like Cambodia's HIV, malaria and tuberculosis crises, pesticide-related problems are widespread, directly or indirectly affecting a large proportion of the workforce, and present serious public health concerns that urgently need to be addressed.
- Ensure commitment to long-term, sustainable projects and to co-ordination between projects initiated by different agencies.
- Support central and local government and NGOs, with a view to strengthening the role of civil society in pesticide control.
- Increase funding for rural education programmes following the model of IPM Farmer Field Schools in order to educate farmers about pests, beneficial insects, good practice when using pesticides, and alternatives to pesticide use.
- Support capacity building within the relevant Ministries, e.g. in training pesticides monitoring and law enforcement staff.
- Promote education about the impact of pesticides on the natural environment and about threats to human health posed by consuming pesticide-tainted food or by direct contact.

Drawing insects and learning their ecology in Farmer Field Schools helps farmers appreciate which species are pests, and which are beneficial.



- Support alternative livelihood schemes such as the move to rice-fish culture and organic farming.
- Direct funding towards research into and support of biological control insectaries and eco-labelling schemes for organic produce.
- Target additional funding towards landmine clearance in order to increase the area of land available for agricultural production.
- Research the benefits of irrigation projects aimed at increasing dry season lowland rice production.
- Conduct and support further research on the extent of pesticide pollution, the source of Cambodian pesticides, and the impacts of pesticide use on human health and the environment. All such research should involve full sharing of information with the Royal Government of Cambodia and should include capacity-building components such that training and equipment are provided to allow relevant ministries and local organisations (NGOs and university) to continue a research programme in the long-term.
- Facilitate the transfer of relevant technologies to support increased productivity.

The Agrochemical Industry

The decision of some larger concerns to phase out production of old organophosphates is to be congratulated. It is in the interests of the agrochemical industry to protect its market and to back up its commitment to product stewardship with increased efforts to ensure customer safety. The agrochemical companies should:

- Ensure that pesticide packaging has clear, concise instructions, using obvious symbols for the illiterate and images of the target species. In view of the cross-border movement of chemicals, the addition of basic Khmer instructions would be a low cost gesture that would assist in informing users of risks and good practice as well as strengthening product stewardship.
- Increase efforts to make safer new chemicals available at affordable prices. In parallel, companies should begin to phase out production of the most dangerous chemicals, reducing their pesticide portfolios to those products permitted for use in their headquarter countries.
- Increase efforts to reduce quantities of fake chemicals being produced in Thailand and Vietnam. The onus is on the transnational companies to protect their brand image and

they should cooperate with the RGC to determine the source of fake pesticides with a view to ending their supply to Cambodia.

- Increase transparency and accountability by identifying all subsidiaries and all chemical products in public, readily accessible lists (i.e. on the internet).

Cambodia's Neighbours

Many of the pesticides Cambodia has identified as being undesirable continue to arrive in the country from adjacent countries, in spite of some being banned there. The governments of Thailand and Vietnam should:

- Be prepared to control pesticide exports that Cambodia decides to state, under the Prior Informed Consents procedure, are not desired.
- Realise that as Cambodia's economy matures, so will its agricultural export market. Thus it is in the interest of its neighbours to be aware of the 'circle of poison', the danger of chemicals formulated in Thailand and Vietnam but banned for use there returning to these countries in agricultural produce imported from Cambodia. The Thai and Vietnamese governments should be prepared to limit which chemicals can be produced in their countries.
- Under the requirements of the Rotterdam Convention PIC procedure, and in acceptance of the fact that pesticides formulated in Thailand and Vietnam reach Cambodian markets, ensure adequate labelling of all products containing PIC chemicals, regardless of whether or not Cambodia consents to their import. This includes insisting that domestic producers include instructions in Khmer.

© EJF

Cambodia is going through a re-building period. The international community has a responsibility in helping this young country develop its agricultural sector in an efficient, safe and environmentally sound way.

The USA & EU Member States

The European Union and United States of America, through their highly developed legislation and as centres of operation of market leaders in the agrochemical industry, set the global standards for safe use of pesticides. These Western nations should:

- Contribute substantial further development aid targeted toward the development of sustainable agricultural practices aimed at improving long-term food security an agricultural productivity.
- Eliminate the hypocrisy of banning exports of end products not permitted for use in member states, whilst permitting start products (active ingredients) to be exported for formulation within developing countries, where they are often used in a dangerous manner.
- Increase efforts to monitor exports and enforce existing legislation on the movement of restricted pesticides.

glossary

Acaricide: Pesticide used to control pest mites.

Active ingredient: Pesticides comprise two types of ingredients: the active ingredient is the chemical that affects the targeted pest. Other ingredients' make the active ingredient work more efficiently, by improving contact with the plant or the pest, for example.

Arthropods: Biological classification grouping crustaceans, insects, spiders, etc (literally: animals with 'articulated limbs').

Good practice: Includes the officially recommended or nationally authorized uses of pesticides under conditions necessary for effective and reliable pest control. It encompasses a range of levels of pesticide applications up to the highest authorized use, applied in a manner that leaves a residue, which is the smallest amount practicable. The 1988 FAO's "Guidelines on good practice for ground and aerial application of pesticides" gives some recommendations on pesticide use, with particular regards to each step of the process: "what to use", "before applying the pesticide", "while mixing the pesticide and during application", "after application", etc. At each step, they describe what action should be taken to ensure the safest possible use of the chemical.

Bio-pesticides: Pesticides whose active ingredients are biological agents. The most famous ones are 'Bt'-based products. Bt stands for *Bacillus thuringiensis*, a bacterium that induces disease in insects through toxin synthesis. Bt products contain either whole bacteria or just their toxins.

Botanical pesticides: Botanical pesticides are extracted from plants containing active compounds that have poisonous properties against a pest. Some of the most famous botanical insecticides are nicotine, rotenone, pyrethrins and neem extracts.

Broad-spectrum action: describes the action of a pesticide that acts upon a wide range of organisms as opposed to specific or selective products or narrow-spectrum action pesticides that only affect very specific organisms (e.g. broad-spectrum insecticides may kill very different insects, like aphids and beetles).

Cholinesterase: An enzyme of the nervous system. Its role is to eliminate the acetylcholine that accumulates in synapses when nervous information passes between nerve cells. Information travels along nerve cells as electrical signals, but between cells is a gap (the synapse) where electrical information is transformed into chemical information. Here, molecules including acetylcholine are the vectors of nervous information, released from the first cell and then recaptured on receptors in the second. If acetylcholine accumulates in the synapse, there is a "jamming" of information. The role of a destructive enzyme like cholinesterase is therefore central to functioning of the nervous system.

Endocrine disrupting effect: Pesticide's effect on hormone release or action, usually via actions on nerve cells located in the brain that control the release of hormones. Such effects can have long-term consequences.

Fungicide: Pesticide used to control fungal diseases.

Generic product: Product whose patent has expired that can thus be manufactured by companies other than the one that first discovered it.

Half-life: Length of time after which half of the quantity of a product has degraded. It indicates the time a substance will remain in the environment.

Herbicide: Pesticide used to control weeds.

Human Development Index: A measure of a country's average achievements in three basic dimensions of human development: longevity, knowledge and standard of living. The variables used to calculate the index are life expectancy, educational attainment and real gross domestic product per capita (United Nations Development Programme).

Inorganic pesticides: Inorganic pesticides are typically derived from minerals that occur as natural deposits. Examples of inorganic pesticides (many of them forbidden in most countries) are: sulphur, boric acid, fluoride or arsenic compounds.

Insecticide: Pesticide used against insects.

Integrated Pest Management (IPM): Defined by FAO as "the careful integration of a number of available pest control techniques that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce/minimise risks to human health and the environment. IPM emphasises the growth of a healthy crop with the least possible disruption of agro-ecosystems, thereby encouraging natural pest control mechanisms".

Lethal Dose 50: Pesticides' acute toxicity is measured by the Lethal Dose 50 (LD50), the amount of the product that would result in the death of half a population (50%) of lab-rats. There are two measures for each product, oral LD50 (the product is given orally) and dermal LD50 (the product is given through the skin). The most toxic pesticides have the lowest LD50 (very small doses can kill).

Molluscicide: Pesticide used to control molluscs (snails, slugs, etc.).

Natural enemies: The natural enemies of a given animal are all organisms that harm it in one way or another. They include predators and parasites.

Neem: *Azadirachta indicia* (Meliaceae), an Asian tree species with insect repelling properties that is becoming increasingly popular as a source of 'botanical pesticides'.

Nicotine: An extract of tobacco, *Nicotiana tabacum*. As a botanical insecticide it is authorised in organic farming by European legislation, but its high acute toxicity leads to restrictions in use and it may soon be outlawed in European agriculture.

Organic farming: Farming system that, in the case of arable production, excludes the use of any synthetic organic pesticide. As a consequence only botanical or biological pesticides are authorised, but preference is usually given to non-chemical pest control techniques.

Oviposition: Laying of eggs (by insects).

Parasitoid: Insects whose larva develops inside a host-insect, feeding on its tissues and resulting in its death. This last characteristic makes the behaviour of parasitoids closer to that of a predator than of a parasite *per se*. Many parasitoids are wasps (Hymenoptera).

Pest: Organism considered harmful to human activities. Agricultural pests include insects, mites, fungi, etc. living at the detriment of crops and resulting in reduced yields.

Poverty line: Definitions vary but, in the Cambodian context, the World Bank definition of US$1 per person per day serves as the level of income below which a state of poverty exists.

Precautionary principle: Essentially, the avoidance of factors promoting risk, before damage can be done. Following the 1992 Rio Conference on the Environment and Development, the principle was adopted in the Rio Declaration, which states "in order to protect the environment, the precautionary approach shall be widely applied by States according to their capability. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation". The European Commission states that the principle "covers those specific circumstances where scientific evidence is insufficient, inconclusive or uncertain and there are indications through preliminary objective scientific evaluation that there are reasonable grounds for concern that the potentially dangerous effects on the environment, human, animal or plant health may be inconsistent with the chosen level of protection".

Pre-harvest period: Period of time it is recommended to observe between the last spraying of a pesticide and harvest. It ensures that the harvest will contain as little pesticide residue as possible, so it can be consumed without danger.

Re-entry period: Period of time necessary for a pesticide to decompose, so that its concentration becomes low enough to allow people to re-enter the field without risk of contamination.

Resistance (Pest resistance to pesticides): When a pesticide is used repeatedly against a pest, this pest can become resistant to this type of pesticide. Such resistance occurs by natural selection. Whilst pesticides kill most insects, individuals with random mutations conferring reduced sensitivity to insecticide molecules are more likely to survive spraying and reproduce. Some of their offspring will inherit this resistance (for some pests, that produce clones it can even be all offspring) and, as long as pesticide application continues, the proportion of resistant individuals will increase. Resistance can spread rapidly as insects have short generation times and large numbers of offspring.

Resistance (varietal resistance to a pest): As a plant and its natural enemies (diseases, fungi, insect) have evolved together, some plant varieties have acquired partial or total resistance to these pests. The process involved is natural selection through a selective pressure from the natural enemies on the less sensitive plant types. As a result many local rice varieties, for example, are resistant to local diseases or insects, whereas imported varieties usually lack these defence mechanisms.

Rice-fish culture: 2000-year old traditional SE Asian agricultural system combining aquaculture and rice production. It gradually declined, but is currently regaining interest from Asian countries as a complete, sustainable production system.

Rodenticide: Pesticide used to control rodents (rats, mice, etc.).

Rotenone: A botanical insecticide allowed under restriction in European organic farming. It is extracted from *Derris* spp., *Loncho-carpus* spp., *Cude* spp., or *Terphrosia* spp.

Synapse: Gap between two nerve cells, where nervous information from the first cell is translated from an electrical signal into a chemical signal to cross the gap and be passed on to the second cell.

Synthetic organic insecticides: Do not exist in the nature but are man-made. They are referred to as "organic" since they are carbon-based chemicals.

Systemic / non-systemic insecticide: A systemic insecticide is a chemical that is first absorbed by the plant, and then kills organisms that feed on its tissues. Conversely, non-systemic insecticides require direct contact with the insect (insects living inside plant tissues like rice stem borer larvae are not affected by this type of product).

Transplanting (of rice): A common practice in Asian rice culture is to sow the rice first in nursery beds. The partly-grown seedlings are transplanted later into paddy fields.

Variety: A group of organisms within a species, which differs slightly from the remainder of the species. Varieties are the result of selective breeding (natural or artificial). Crop varieties are also referred to as cultivars.

Weed: Any unwanted plants that grow in a field. They can be wild plants as well as previous or neighbouring crops. Weeds reduce yields by competing with crops for resources (water, sunlight, and nutrients).

references

N.B. Unless otherwise stated, all internet pages cited were viewed on 15 November 2001.

Introduction

1 FAO/WHO. 2001. *Amount of poor-quality pesticides sold in developing countries alarmingly high*. Press release. 1 February 2001.

Global pesticide production and use

1 Fengsheng He & Shuyang Chen. 1999. Health impacts of pesticide exposure and approaches to prevention. *Asian-Pacific Newsletter of Occupational Health and Safety*. ILO/FINNIDA. March 1999.
2 Worldwatch. 2000. *Stepping off the Toxic Treadmill*. Press Release. 18 November 2000.
3 Pradeep P. Dave. 2000. *Agrochemical scenario on global and national levels.* http://www.pmfai.org
4 Agrow. 2001. Global agrochemical market down again. *Agrow World Crop Protection News*: 2 March 2001
5 Pesticides Action Network Updates Service. 2001. *Global agrochemical sales down*. 16 March 2001. http://www.panna.org
6 Agrow. 2001. *World Crop Protection News*. 5 January, 2 March and 13 April 2001. In: PANUPS. 2001. *Top seven agrochemical companies in 2000*. 23 May 2001. http://www.panna.org
7 Devlin Kuyek. 2000. Lords of poison: the pesticide cartel. *Seedling*. June 2000. http://www.grain.org/publications
8 Dent, D. *History of pest management*. Pest Management Resource Center. http://www.pestmanagement.co.uk/culture/histrory.html
9 *POPs producers –POPs pesticides*. http://www.greenpeace.org
10 Koehler, P.G. & Belmont, R.A. 1998. *What are pesticides?*. Technical information – Pesticides. School IPM. http://schoolipm.ifas.ufl.edu
11 Extension Toxicology Network (EXTOXNET). 1993. Bioaccumulation. *Toxicology Information Briefs*. September 1993
12 Hough, P. 1998. *The global politics of pesticides*. Earthscan Publications Ltd. London. p. 4
13 Lyons, G. 1999. *Endocrine disrupting pesticides*. PAN-UK. http://www.pan-uk.org
14 Hoechst AG. 1999. *Joint venture of agreement of AgrEvo and Bilakhia finalised*. Press Release. 13 July 1999.
15 Chambron, A-C. 1999. *Bananas: The "green gold" of the TNCs*. UK Food Group. http://www.bananalink.org.uk
16 Banananlink. *Regions supplying the banana trade, Latin America*. http://www.bananalink.org.uk/trade/for_exp.htm
17 Agne, S. & Waibel, H. 1997. Pesticide policy in Costa Rica. *Pesticide News:* 36. June 1997.
18 International Union for the Conservation of Nature. 1995. *Evaluation of the Social and Environmental Impact of the Banana Expansion in Sarapiqui, Tortuguero, and Talamanca*. In: Chambron, A-C. 1999. *Bananas: The "Green Gold" of the TNCs*. UK food group. http://www.bananalink.org.uk
19 Dufumier, M., Labrousse, R. & Losh, B. 1997. Les plantations des zones tropicales humides: caracteristiques et perspectives. *Plantations, recherche, developpement:* Volume 4, Numero 2. March-April 1997
20 Dinham, B. 1992. Paraquat and occupational hazards, *Pesticides News:* 16. June 1992
21 Foundation for Advancements in Science and Education (FASE). 1998. Exporting risk – US hazardous trade 1995-1996. *Pesticides News:* 40. June 1998
22 http://www.monsanto.com
23 Begemann, B., Deaton, R., Dow, A., Fischhoff, D., Fuchs, R., Hoerner, D., Mullins, W. & Perlak, F. The Importance of Intellectual Property to Product Development. *The business of Agriculture*. http://www.farmsource.com
24 Frost & Sullivan. 2001. SEA Agrochemicals Market. *Agrolinks*: 8-10. September 2001
25 Thiers, P. 1994. Pesticides in China. *Global pesticide campaigner*: Volume 4, Number 1. March 1994. http://www.panna.org
26 Grimes, A. 1998. Insight on booming Chinese market. *Pesticides News:* 39. March 1998
27 Pesticides Action Network Updates Service (PAN-UPS). 2000. *Pesticides on the rise in China*. 26 May 2000. http://www.panna.org
28 http://huayang.ebigchina.com
29 Anju Ghangurde. 2000. Aventis CropScience vice-chairman Unni joins Hikal Chemicals board. *The financial express*. 17 May 2000. http://www.financialexpress.com
30 FAO/WHO. 2001. *Amount of poor-quality pesticides sold in developing countries alarmingly high*. Press release. 1 February 2001.
31 Pesticides – banned elsewhere, used in India. *The Financial Express*, Mumbai, India. 10 December 2000
32 World Resource Institute (WRI). 1999. *Intensification of agriculture – Chemical Inputs*. http://www.igc.org/wri/wr-98-99/agrichem.htm
33 Saiyed, H.N., Bhatnagar, V.K. & Kashyap, R. 1999. Impact of pesticide use in India. *Asian-Pacific Newsletter*. March 1999
34 Pradeep P. Dave. 1997. *India – a generic pesticides giant*. Chemical Engineering World. http://www.exicom.org/cew/mar97/dave.htm
35 Santillo, D., Johnston, P., Stringer, R. & Edwards, B. 1997. A catalogue of gross contamination; Organochlorine production and exposure in India. *Pesticides News:* 36. June 1997
36 http://www.greenpeace.org
37 Television Trust for the Environment (TVE). 2001. *Toxic Trail documentary*. TVE. http://toxictrail.org
38 RPG Life sells agrochem business to Italy's ISAGRO. *The Financial Express*, Mumbai, India. 28 July 2001.
39 http://www.rpglifesciences.com/aproduct.htm
40 Mineau, P. 1998. Praise for Novartis' Decision. Pesticide Impacts on Wildlife. (http://www.pmac.net/wildimp.htm).
41 http://www.pesticideinfo.org
42 Thurston, C. 1999. Making the world safe for pesticides. *Foreign Service Journal*: November 1999.

An overview of Cambodian agriculture

1 Mougin, T., Fontaine, D. & Brun, J-M. 1995. Vietnam, Cambodge – L'espoir apres la tourmente. *Peuples en marche, mensuel de la solidarite internationale : Numero 103. March 1995. Ed. Peuples solidaires et Terre des hommes France.*
2 CIA. 2000. *The World Factbook 2000 – Cambodia.* http://www.cia.gov
3 http://www.Mekong.net/Cambodia/facts.htm
4 UNDP. *Cambodia Key Facts*. http://www.un.org.kh/undp/cambodia.html
5 The World Bank Group. 2000. *The World Bank and Cambodia*. May 2000. http://www.worldbank.org/eap
6 UNDP. 2000. *UNDP Cambodia – Poverty Reduction*. http://www.un.org.kh/undp
7 O'Brien, N. 1999. *Agricultural resources*. In: MOE/UNDP/ETAP. 1999. *Environment: concepts and issues – A focus on Cambodia*. UNDP/ETAP reference guide book. Edited by Noelle O'Brien
8 Sarthi Acharya. 2001. Poverty reduction in Cambodia – Some reflections. *Cambodia development review:* Volume 5, Issue 2. April-June 2001
9 Chea Huot, Pon Dorina and Sok Hach. 2001. Economy watch – Domestic performance. *Cambodia development review*: Volume 5, Issue 2. April-June 2001
10 FAO/WFP crop and food supply assessment mission to Cambodia. 2000. *Special report on Cambodia*. 29 December 2000
11 IRRI. *Cambodia's long journey back*. http://www.irri.org/hunger/cambodia.htm
12 FAO/WFP crop and food supply assessment mission to Cambodia. 1997. *Special report on Cambodia*. 17 February 1997
13 http://www.landmines.org
14 Services d'Expansion Economique de Phnom Penh. 2000. *Presentation macro-economique du Cambodge et perspectives*. 28 April 2000. Ambassade de France au Cambodge. http://www.dree.org/cambodge
15 Boun Suy Tan. 1996. *Le Cambodge au parlement francais – Developpement – Agriculture*. Agence Universitaire de la Francophonie. http://www.bibliotheque.refer.org/collcbdg/agri.htm
16 IRRI. *A few case history*. http://www.irri.org
17 Cambodia-IRRI-Australia Project. http://www.bigpond.com.kh/users/CIAP/
18 Jahn, G.C., Bunnarith, K., Sophea, P. & Chanty, P. 1997. *Pest management in Rice*. In: CIAP. 1997. *Rice production in Cambodia*. Edited by H. J. Nesbitt
19 Professor Merle Sheperd, Clemson University: personal communication.
20 Holmes, B. 1994. A natural way with weeds. *New Scientist*: Volume 142, Issue 1924. 7 May 1994
21 CIAP IPM Program. 1998. Working with farmers to manage rats. *CIAP bulletin*. September 1998
22 http://www.ipmnet.org/IPMnet_NEWS/news56.html
23 ACIAR. 2001. *Non-chemical control of rodents in lowland irrigated rice crops*. ACIAR research notes: 26. September 2001. http://www.aciar.gov.au
24 FAO/WFP crop and food supply assessment mission to Cambodia. 1999. *Special report on Cambodia*. 17 February 1999
25 FAOSTAT. http://www.fao.org
26 Pen Chantra. 2001. *Cambodian children deficient in Vitamin A, at risk of serious illness*. Archive News Vision Articles – Asia. 2 May 2001. http://www.wvi.org/wvi/archives/asia.htm#Cambodia
27 Sik Boreac. 2001. Constraints on the rice marketing system. *Cambodia development review*: Volume 5, Issue 2. April-June 2001
28 McKinney, M. 2001. Rice milling plant may help farmers reach world markets. *The Cambodia Daily*. 22 May 2001
29 FAO. *Fact Sheet Cambodia – Women in agriculture, environment and rural development*. FAO Regional Office for Asia and the Pacific. Thailand.
30 Services d'Expansion Economique de Phnom Penh. 2000. *Le marche des produits carnes au Cambodge*. Ambassade de France au Cambodge. http://www.dree.org/cambodge
31 Ahmed & al. 1998. *Socio-economic Assessment of Freshwater Capture Fisheries of Cambodia*. MRC.
32 The Library of Congress. 1987. *Cambodia – Diet*. http://memory.loc.gov/frd/cs/cshome.html
33 Monirith et al. 2000. Organochlorine contamination in fish and mussels from Cambodia and other Asian countries. *Water Science and Technology* 42: 241-252.
34 Calvert, B. 2001. New market could change the way farmers do business. *The Cambodia Daily*. 22 May 2001
35 NGO statement to the 2001 consultative group meeting on Cambodia – Gender. http://www.bigpond.com.kh
36 Grosbois, C. 2001. *L'industrie de la confection au Cambodge*. Services d'Expansion Economique de Phnom Penh. Ambassade de France au Cambodge. http://www.dree.org/cambodge

Pesticide use in Cambodia

1 CEDAC. 2000. *Pesticide pollution in the Tonle Sap catchment*. Project progress report (September 1999-August 2000). September 2000. CEDAC, Phnom Penh.
2 Holmes, B. 1994. A natural way with weeds. *New Scientist*: Volume 142, Issue 1924. 7 May 1994
3 Jahn, G.C., Bunnarith, K., Sophea, P. & Chanty, P. 1997. *Pest management in Rice*. In: CIAP. 1997. *Rice production in Cambodia*. Edited by H. J. Nesbitt
4 FAO/WFP crop and food supply assessment mission to Cambodia. 1997. *Special report on Cambodia*. 17 February 1997
5 Bal, P. & Polo, Y. 1994. *Study on pesticide use in Cambodia and use habit of Cambodian farmers*. Royal University of Cambodia, Phnom Penh and GRET.
6 Yang Saing Koma et al. 2001. *The Situation of Pesticide Use in the Tonle Sap Catchment*. CEDAC, Phnom Penh.
7 Television Trust for the Environment (TVE). 2001. *Toxic Trail documentary*. TVE. http://toxictrail.org
8 FAOSTAT, http://www.fao.org
9 Yang Saing Koma, Keam Makarady & Lang Seng Horng. *Pesticide Market in Cambodia*. Market Survey in Kandal Province. CEDAC / Oxfam-America internal document.
10 http://www.bayer.com
11 http://www.main.co.il
12 Bou Sarouen. 2000. The greening of Cambodian farming begins. *Phnom Penh Post:* Issue 9/20. 29 September - 12 October 2000.
13 Extension Toxicology Network (EXTOXNET). 1996. *Pesticide Information Profiles*. Oregon State University
14 FAO. 1997. *Methyl parathion*. http://www.fao.org
15 Pesticide Action Network UK (PAN UK). *–Methyl parathion*, http://www.pan-uk.org
16 WHO/ IPCS/ ILO. 1993. *International Chemical Safety Cards – Methyl Parathion*
17 Webster, J. 2000. *Malaria control in complex emergencies*. Malaria Consortium, July 2000.
18 World Health Organisation. http://www.wpro.who.int/themes_focuses/theme1/focus2/themes1_focus2dengue2.asp
19 http://www.chem.unep.ch/pops/indxhtms/ifcsall.html#4
20 Loring, D. 1995. Struggling to keep Cambodia off the pesticide treadmill. *Global Pesticide Campaigner*: Volume 5, Number 4. December 1995.
21 *Review of the Fishery Conflict in Stung Treng*. NGO Forum.
22 Insecticides on foods in market. *Charet Khmer:* Volume 3. # 34. 11-12 October 2001
23 Sodavy, P., Sitha, M., Nugent, R. & Murphy, H. 2000. *Farmers' awareness and perceptions of the effect of pesticides on their health*. Field Document, FAO Community IPM Programme. April 2000
24 http://www.landmines.org
25 Specht, J. 1996. *Pesticides in Cambodia – A Compilation for Agriculturists, Local and Expatriate Staff Working for Agriculture in Cambodia.* Lutheran World Service and Integrated Rural Development Project Kandal/Takeo. Phnom Penh, Cambodia.
26 Dr Yang Saing Koma. Centre d'Etudes et de Developpement Agricole Cambodgien. pers. comm.
27 Scoville, O.J. 1990. *Rebuilding Kampuchea's Food Supply*
28 Mallet, V. 1993. Poisoned chalice. *The Financial Times*. 24 March 1993
29 Kay Kimsong. 2000. Predator drop means pest, pesticide trouble. *The Cambodia Daily*. 24 March 2000.
30 Stuart et al. 2000. Homalopsine watersnakes: the harvest and trade from Tonle Sap, Cambodia. *Traffic Bulletin* 18:3. http://www.traffic.org/bulletin/watersnakes.html
31 Global Witness. 1998. *Going Places: Cambodia's Future on the Move*. Briefing Document. March 1998.

Pesticides & the Cambodian law

1 http://www.camnet.com.kh/moe/index.htm
2 CIAP. 1999. Cambodia's first pesticide law. *CIAP Bulletin:* Volume 4, Issue 5. May 1999.
3 UNEP. 2000. *Governments Give Green Light to Phase Out of World's Most Hazardous Chemicals*. Press Release. 9 May 2001
4 CEDAC. 2000. List of Pesticides Available in Kandal and Phnom Penh (by Trade Name). Centre d'Etude et de Developpement Agricole Cambodgien, Phnom Penh.
5 Shaw, I. 1999. Regulation and monitoring of pesticides in Indonesia. *Pesticides News:* 44. June 1994.
6 Kay Kimsong. 2000. Predator drop means pest, pesticide trouble. *The Cambodia Daily*. 24 March 2000.
7 Dr Yang Saing Koma. Centre d'Etude et de Developpement Agricole Cambodgien. Pers. comm.

Cambodian pesticide problem: causes

1 Sodavy, P., Sitha, M., Nugent, R. & Murphy, H. 2000. *Farmers' awareness and perceptions of the effect of pesticides on their health*. Field Document, FAO Community IPM Programme. April 2000
2 Bou Saroeun. 2000. The greening of Cambodian farming begins. *Phnom Penh Post* Issue 9/20. 29 September – 12 October 2000.
3 http://www.apcpa.org/IPM.asp
4 http://www.pan-international.org/campaignsEn.html
5 Johnson, S. & al. 1997. *Some Ecological Effects of Fipronil and Lambda-cyhalothrin in Vietnamese Rice Fields*. Impact of Integrated Pest Management Programs in Rice Growing regions of Tropical Asia, 1994-1997, DANIDA, Denmark.
6 Asia-Pacific Crop Protection Association. *Intellectual Property Rights and Regulatory Affairs*. http://www.apcpa.org/IPR.asp
7 Yang Saing Koma, Keam Makarady & Lang Seng Horng. *Pesticide Market in Cambodia*. Market Survey in Kandal Province. CEDAC / Oxfam-America internal document.
8 CEDAC. 2000. *Pesticide pollution in the Tonle Sap catchment*. Project progress report (September 1999-August 2000). September 2000, CEDAC, Phnom Penh.
9 Specht, J. 1996. *Pesticides in Cambodia – A Compilation for Agriculturists, Local and Expatriate Staff Working for Agriculture in Cambodia.* Lutheran World Service and Integrated Rural Development Project Kandal/Takeo. Phnom Penh, Cambodia.
10 FAO/WHO. 2001. *Amount of poor-quality pesticides sold in developing countries alarmingly high*. Press release. 1 February 2001.
11 http://www.vietfarm.com/cooperate.htm
12 Yang Saing Koma, Keam Makarady, Lang Seng Horng & Ly Bun Thai. 2000. *Profile of selected pesticides available in Cambodia*. CEDAC / Oxfam America
13 Jungbluth, F. 1997. Pesticide facts in Thailand. *Pesticide News*: 35. March 1997
14 Wheeler, C. 1998. Investigating the impacts of pesticide use in the Mekong Delta. *IDRC Reports*. International Development Research Center. 20 February 1998.
15 Television Trust for the Environment (TVE), 2001. *Toxic Trail documentary*, TVE, http://toxictrail.org
16 CIAP. 2000. Upland and deepwater rice practices. *CIAP Bulletin*: Volume 5, Issue 6. June 2000.
17 Kay Kimsong. 2000. Predator drop means pest, pesticide problem. *The Cambodia Daily*. 24 March 2000.
18 Proceedings of the 1994 PAC Meeting, April 19-23, 1994. Davao, The Philippines.
19 http://www.apcpa.org/SafeUs.asp
20 http://www.bayer.com/en/unternehmen/unternehmenspolitik/umwelt/produkte.html
21 http://www.takeda.com
22 http://www.getipm.com/articles/letters/india-workers.htm
23 CIAP IPM Program. 1998. Working with farmers to manage rats. *CIAP Bulletin*. September 1998

Cambodia's pesticide problem: dangers

1 WHO/UNEP Working Group. 1990. *Public Health Impact of Pesticides Used in Agriculture*. World Health Organization. Geneva.
2 PAN AP. 1999. *Annual Report* (http://www.poptel.org.uk/panap/).
3 Specht, J. 1996. *Pesticides in Cambodia – A Compilation for Agriculturists, Local and Expatriate Staff Working for Agriculture in Cambodia.* Lutheran World Service and Integrated Rural Development Project Kandal/Takeo. Phnom Penh, Cambodia.
4 PAN-UK. 1995. *Methyl parathion*. http://www.pan-uk.org
5 Extension Toxicology Network (EXTOXNET). 1996. *Carbofuran*. Oregon State University
6 Extension Toxicology Network (EXTOXNET). Methamidophos. Oregon State University
7 Lyons, G. 1999. *Endocrine disrupting pesticides*. PAN-UK. http://www.pan-uk.org
8 Extension Toxicology Network (EXTOXNET). 1993. *Cholinesterase inhibition*, Oregon State University
9 PAN-UK. 2001. *Legal action filed against Bayer in the pesticide poisoning deaths of 24 children in the Peruvian Andes*. Press Release. 30 October 2001.
10 Sodavy, P., Sitha, M., Nugent, R. & Murphy, H. 2000. *Farmers' awareness and perceptions of the effects of pesticides on their health*. FAO Community IPM Programme Field Document. April 2000
11 Kay Kimsong. 2000. Predator drop means pest, pesticide trouble. *The Cambodia Daily*. 24 March 2000.
12 Reuters, Phnom Penh. 13 July 2001.
12b Phelim Kyne & Bou Saroeun. 2000. Tracing the toxin: rumors, fear and puffer fish. *Phnom Penh Post*. 16 September 2000.
13 Girard, D. 1994. In the tangerine grove. *IDRC Reports:* Volume 22. International Development Research Council.
14 Michigan State University. 2000. *The database of arthropods resistant to pesticides*. http://www.cips.msu.edu/resistance/rmdb/index.html
15 Georghiou, G. & Lagunes-Tejeda, A. 1991. *The Occurrence of Resistance to Pesticides in Arthropods: An Index of Cases Reported through 1989*. Food and Agriculture Organization of the United Nations. Rome.
16 Loring, D. 1995. Struggling to keep Cambodia off the pesticide treadmill. *Global Pesticide Campaigner*: Volume 5, Number 4. December 1995.
17 Mallet, V. 1993. Poisoned chalice. *The Financial Times*. 24 March 1993.
18 Williamson, S. 1995. Pesticide effects on natural enemies. *Pesticides News:* 28. June 1995.
19 Jungbluth, F. 1997. Pesticide facts in Thailand. *Pesticide News*: 35. March 1997.
20 Extension Toxicology Network (EXTOXNET). 1993. *Movement of pesticides in the environment*. Oregon State University
21 Monirith, I. & al. 2000. Organochlorine contamination in fish and mussels from Cambodia and other Asian countries. *Water, Science and Technology* 42: 12.
22 Cox, C. 1991. Pesticides and birds: from DDT to today's poisons. *Journal of Pesticide Reform* 11: 2-6.
23 Glaser, L.C. *Wildlife mortality attributed to organo-phosphate and carmabate pesticides*. http://biology.usgs.gov/stt/noframe/u216.htm
24 Mezquieda, M. 2000. *Larvicide linked to frog deformities*. The Wilton Villager, Connecticut, USA. 21 September 2000.
25 Van der Gaag, N. 2000. Crossed bills and broken eggs. *New Internationalist:* 323. May 2000.
26 PAN-UPS. 1997. *Sharp decline in UK bird populations*. Sept 15 1997. http://www.pmac.net/ukbirds.htm
27 PAN-UPS. 1996. *Endosulfan responsible for Alabama fish kill*. Pesticide Action Network North America Updates Service. 23 February 1996.
28 http://www.hawk-conservancy.org/priors/swainson.htm
29 CNN. 1999. *Chemicals killing Florida birds, fish*. 19 February 1999. http://www11.cnn.com
30 http://www.fbbfs.org/poisoning.html
31 UBINIG. 2000. *Sparrows massacred by pesticide in Bangladesh*. http://www.TWN.org.sg
32 Canadian Wildlife Service. 1998. *Pesticides and Wild Birds*. http://www.cws-scf.ec.gc.ca/hww-fap/pesticides/pest.html
33 Bou Saroeun. 1999. Pesticides killing great lake. *Phnom Penh Post*: Issue 8/10. 14-27 May 1999.
34 Whitten, M. 1999. A role for small-scale farmers and rural communities in reducing the entry of persistent organic pollutants (POPs) into the environment. *Proceedings of Regional Workshop on the Management of Persistent Organic Pollutants (POPs), Hanoi, Vietnam*. UNEP. 19 March 1999.
35 Yang Saing Koma & al. 2001. *The Situation of Pesticide Use in the Tonle Sap Catchment*. CEDAC, Phnom Penh.
36 Television Trust for the Environment (TVE), 2001. *Toxic Trail documentary*. TVE. http://toxictrail.org
37 Ahmed & al. 1998. *Socio-economic Assessment of Freshwater Capture Fisheries of Cambodia*. MRC.
38 Shaw, I. 1999. Regulation and monitoring of pesticides in Indonesia. *Pesticides News*: 44. June 1999
39 Bou Saroeun, 2000. The greening of Cambodian farming begins. *Phnom Penh Post*: Issue 9/20. 29 September – 12 October 2000.
40 Nou Bonheur. 2001. *Tonle Sap Ecosystem and Value*. Technical Coordination Unit. Ministry of Environment. Cambodia.
41 Chea Sina. 1997. Today's Tonle Sap water quality status and its tendency in future. *Kumnit Khmer Journal*: 7. July-September 1997.
42 CSES. 1997. *Cambodia Socio-Economic Survey*, Phnom Penh and UNDP, Cambodian Human Resource Development Report 1999.
43 Review of the Fishery Conflict in Stung Treng. NGO Forum.
44 Insecticides on foods in market. *Charet Khmer*: Volume 3 # 34. 11-12 October 2001.
45 Rainboth. 1996. *Fishes of the Cambodian Mekong*. FAO, Rome, Italy.
46 UNDP-GEF. 2001. *Tonle Sap Conservation Project Draft Inception Report.*
47 Seang Tana & al. 2000. *Overview of turtle trade in Cambodia*. In: *Asian Turtle Trade: Proceedings of a Workshop on Conservation and Trade of Freshwater Turtles and Tortoises in Asia*. Chelonian Research Foundation.
48 Stuart & al. 2000. Homalopsine watersnakes: the harvest and trade from Tonle Sap, Cambodia. *Traffic Bulletin* 18:3. http://www.traffic.org/bulletin/watersnakes.html

Alternatives and solutions in Cambodian agriculture

1 Matteson, P.C. 2001. Insect Pest Management in Tropical Asian Irrigated Rice. *Annual Review of Entomology* 45: 549-574.
2 Date from FAOSTAT (http://www.fao.org) use at: http://www.geocities.com/kmp_ph/reso/polpest/polpest.html#figure2
3 Pearce, F. 1996. Deadly sprays worse than useless. *New Scientist*: Volume 152, Issue 2057. 23 November 1996.
4 Heong, K.L., Escalada, M..M. & Mai, V. 1994. An analysis of insecticide use in rice – case studies in the Philippines and Vietnam. *International Journal of Pest Management* 40: 173-178.
5 Jahn, G.C., Bunnarith, K., Sophea, P. & Chanty, P. 1997. *Pest management in Rice*. In: CIAP. 1997. *Rice production in Cambodia*. Edited by H. J. Nesbitt
6 Mackenzie, D. 1995. Seeing is believing for Asia's rice farmers. *New Scientist*: Volume 147, Issue 1992. 26 August 1995
7 Rola, A.C. & Pingali, P.L. 1993. *Pesticides, Rice Productivity and Farmers' Health: An Economic Assessment*. IRRI/WRI, Washington DC.
8 Challenging Japan's pesticide aid. *Global Pesticide Campaigner*. Volume 3, Number 2. 1993
9 ACIAR. 2001. *Non-chemical control of rodents in lowland irrigated rice crops*. ACIAR research notes: 26. September 2001. http://www.aciar.gov.au
10 Frost & Sullivan. 2001. SEA Agrochemicals Market. *Agrolinks*: 8-10. September 2001
11 FAO. In prep. International Code of Conduct on the Distribution and Use of Pesticides (revised version). FAO, Rome, Italy.
12 Specht, J. 1996. *Pesticides in Cambodia – A Compilation for Agriculturists, Local and Expatriate Staff Working for Agriculture in Cambodia.* Lutheran World Service and Integrated Rural Development Project Kandal/Takeo. Phnom Penh, Cambodia.
13 http://www.communityipm.org/countries/Cambodia.htm
14 FAO. 1999. Summary of FAO Capacity building efforts in pesticide management. (http://www.fao.org/waicent/faoinfo/agricult/agp/agpp/pesticid/Manage/Capacit.htm)
15 Bou Saroeun. 1999. Getting farmers to teach each other. *Phnom Penh Post*: Issue 8/4. 19 February– 4 March 1999
16 Jones, K. 1996. IPM in developing countries – The Sri Lanka experience. *Pesticides News*: 31. March 1996
17 IRRI. *Cambodia's long journey back*. http://www.irri.org/hunger/cambodia.htm
18 Holmes, B. 1994. A natural way with weeds. *New Scientist*: Volume 142, Issue 1924. 7 May 1994
19 CGIAR. 1999. *New rice techniques promise up to 25 percent less water usage*. Consultative Group on International Agricultural Research Press release. 17 May 1999
20 FAO. 1998. *IPM-trained farmers in Indonesia escape pest outbreaks*. Press Release. 27 November 98. ww.fao.org
21 Bellamy, R. 2000. *EEPSEA Case Study: Integrated Pest Management in Indonesia: The cost of chemicals*. International Development Research Center (IDRC)
22 Loring, D. 1995. Struggling to keep Cambodia off the pesticide treadmill. *Global Pesticide Campaigner*, Volume 5, Number 4, December 1995.
23 Cambodian Development Resource Institute. 2001. Constraints on the rice marketing system. *Cambodian Development Review* 5 (2). April-June 2001.
24 Whitten, M. 1999. A role for small-scale farmers and rural communities in reducing the entry of persistent organic pollutants (POPs) into the environment. *Proceedings of Regional Workshop on the Management of Persistent Organic Pollutants (POPs), Hanoi, Vietnam*. UNEP, 19 March 1999.
25 AVRDC. 2000. *Annual Report 1999*. Asian Vegetable Research and Development Center, Tainan, Taiwan.
26 http://www.neemfoundation.org
27 Professor Merle Sheperd. Clemson University. pers. comm.
28 Eberlee, J. 1997. *A natural path to pesticide: botanical pesticides in Thailand*. IDRC Reports, International Development Research Center, http://www.idrc.ca/books/reports/index.html
29 http://www.stii.dost.gov.ph/tekno/Book3_35_5.htm
30 Swadener, C. 1994. *Bacillus thuringiensis* (B.T.). *Journal of Pesticide Reform* 14(3): 13-20.
31 http://www.IRDC.ca
32 Gregory R. & Guttman H. 1997. *Capture and culture rice-field fisheries in Cambodia*. In: CIAP. 1997. *Rice production in Cambodia*. Edited by H. J. Nesbitt
33 Peter Newton. 1993. *Fishing in the rice paddy*. International Development Research Center, Ottawa, Canada. July 1993. http://www.IDRC.ca
34 Bou Saroeun, 2000. The greening of Cambodian farming begins. *Phnom Penh Post*: Issue 9/20. 29 September – 12 October 2000.
35 Bou Saroeun. 2001. Hi-tech rice mill eyes export market. *Phnom Penh Post*: Issue 10/9. 27 April – 10 May 2001.
36 McKinney, M. 2001. Rice milling plant may help farmers reach world markets. *The Cambodia Daily*. 22 May 2001.

Environmental

Justice

Foundation

5 St Peter's St

London N1 8JD

UK

tel: 44 (0) 20 7359 0440

fax: 44 (0) 20 7359 7123

info@ejfoundation.org

www.ejfoundation.org

non-profit company no. 03853159