ENVIRONMENTAL HEALTH CONCERNS RELATED TO AGRO-CHEMICAL USE IN THE MEKONG RIVER DELTA

PURPOSE

This case study examines environmental concerns related to the widespread use of pesticides and fertilizers in agriculture in the Mekong River Delta. Course participants will learn about: (i) increasing use of agro-chemicals in Vietnam; (ii) the relationship between agricultural productivity and agro-chemical use; (iii) unforeseen consequences of high rates of nitrogen use in agriculture; (iv) evidence that agro-chemical residues are persisting and accumulating in the environment resulting in adverse impacts; (v) chronic health impairments in farmers frequently exposed to pesticides; and (vi) potential risks to consumers from chemical residues in foods. Emphasis is given to the challenges faced by policy makers in balancing between achieving agricultural self-sufficiency and environmental and human health protection.

ETP1 COURSE TOPIC COVERAGE:

- SUSTAINABLE DEVELOPMENT AND ENVIRONMENTAL AWARENESS
- ENVIRONMENTAL SCIENCE IN THE MRB
- DISTURBANCES TO AQUATIC ECOSYSTEMS IN THE MRB
- INTEGRATED RESOURCE AND ENVIRONMENTAL MANAGEMENT (IREM) PRACTICAL TOOLS FOR IMPLEMENTATION
- ECOLOGICAL RISK ASSESSMENT
- CUMULATIVE EFFECTS ASSESSMENT (CEA)
- STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA)
- ENVIRONMENTAL ECONOMICS

ISSUES

Specific issues highlighted by this case study are:

1. Unintended consequences of policy choices in the absence of full understanding of potential environmental impacts
2. The importance of assessing the potential environmental impacts of proposed policies prior to implementation
3. Poor environmental awareness among farmers leading to inappropriate use of agro-chemicals
4. The need for cradle-to-grave management of chemicals to minimize environmental and human health impacts related to their manufacture and use

LEARNING OBJECTIVES

On completion of this case study, participants will be able to:

- Discuss environmental and human health concerns relating to agro-chemical use
- Detail the expected benefits of increased agro-chemical use

- Specify potential significant environment issues (SEI) relating to agro-chemical use in the Mekong River Delta
- Identify valued environmental components (VEC) at risk from overuse of agro-chemicals
- Conceptualize pathways and fate and effects of agro-chemical residues in the receiving environment
- Provide examples of both direct and indirect environmental and human health concerns
- Discuss the concept of significance and explain how the significance of potential environmental impacts is determined
- Critique the effectiveness of existing mitigation measures in reducing, eliminating, offsetting or controlling adverse effects related to agro-chemical use
- Suggest additional mitigative measures which might prove more effective
- Assess the adequacy of current knowledge about the pros and cons of agro-chemical use
- Summarize considerations in completing a cost-benefit analysis of agro-chemical use in the Mekong River Delta

PROJECT SUMMARY

Introduction and Background

The Mekong River Delta is located in southern Vietnam, encompassing the twelve provinces of Longan, Tiengiang, Bentre, Vinhlong, Cantho, Travinh, Dongthap, Angiang, Soctrang, Baclieu, Kiengiang and Camau. The total area of Delta is about 39,574,500 hectares, accounting for approximately 12% of the country's total area, three times larger than the Red River Delta in northern Vietnam.

The Mekong River with a length of 4,200 km and a combined delivery of 4.66 billion m^3 per year, is the tenth largest river in the world. The Mekong River flows into southern Vietnam via the Tien and Hau rivers with a total length of 1,708 km and through 137 major irrigation ditches and canals with a total length of 2,780 km. The Mekong River receives approximately 90 billion m^3 of rainwater annually, of which 90% is received during the rainy season. Unfortunately, the rainy months and high water flow of Mekong River occur at the same time, often resulting in serious flooding during the rainy season followed by drought conditions in the dry season.

The Mekong Delta of Vietnam is the country's biggest food growing area, accounting for 37% of cultivated area and providing more than half of the total food output, 50% of fishery and 60% of fruit. At present, approximately 2.6 million ha of land in the Delta is used for farming and aquaculture, representing two-thirds of the

total area of 3.9 million ha. Single and double rice cropping are dominant cropping systems in the Delta, being applied on up to 70% of the agricultural land. Approximately 20% of the land base is used for upland crops and perennials.

The Mekong Delta has long been considered as Vietnam's rice basket with the gross output of paddy farming having increased rapidly since 1985. More recently, aquaculture (mainly shrimp) has been expanding rapidly throughout the delta, especially in i.e., coastal freshwater and marine environments due to the higher revenue returns compared to paddy farming. For example, the area devoted to aquaculture in Vinh Long province is projected to increase from 18,000 ha in 2000 to 31,000 ha by 2010. The gross output of aquacultural products in the Delta was 266,982 tonnes in 1995, increasing to 284,926 tonnes in 1996.

By 1995 the population of the Mekong delta of Vietnam had reached 15.9 million people with an average density of 403 persons/km^2, nearly double compared with the rest of the country. Based on the current population growth rate in the delta of 2.1% per year, the population is expected to reach 23.7 million people by the year 2015. The rapidly increasing population represents a serious concern as the land area is already approaching its limit in terms of the number of people it can support (i.e., the current land per capita is only 0.16 ha/person).

The population in the Mekong Delta is generally poorly educated. The number of persons having received a higher education (i.e., high school, college, university and post graduate) is only 1/3 of the Vietnam's overall level. Moreover, due to high cost of education, more and more people do not attend school, or go to school late in their lives.

Utilization of Fertilizer in the Mekong River Delta

Agro-chemicals play an important role in intensive agriculture. They offer an attractive low-cost method of increasing output per hectare of land, providing farmers with a high economic return on their labor and investment. The application of agro-chemicals has increased considerably in recent years, most notably in developing countries attempting to achieve food security through increased yields is extremely important. This has been true for Vietnam where the quantity of agro-chemical used in agriculture had increased threefold by 1994 as compared to the 1980's. Inorganic fertilizers are the most commonly used agro-chemical in Vietnam with current usage having reaching the level of 3 million tonnes/year of which 2 million tonnes are imported. Nitrogen was introduced into Vietnam earlier than phosphorous and potassium because of its yield effect – modern rice varieties are nitrogen responsive. The Vietnamese government has actively promoted use of nitrogen by farmers through price incentives. The combination of these factors has led to the overuse of nitrogen by farmers.

Farmers in the Mekong Delta explain that the use of fertilizers has increased remarkably in recent years due to increasing intensification of cropping. In the past, there was only one crop planted each year and the farmers did not pay much attention to fertilizer application because every year the alluvium replenished

nutrients. This has changed now that farmers have increased the number of crops to two or three per year - resulting in severe depletion of soil quality. Consequently, to maintain or increase productivity, a large amount of chemical fertilizer now must be applied.

In the Mekong Delta, fertilizer use is considered to be at an optimum level except possibly for a slight over-use of nitrogen in the wet season. This suggests that, even from an economic optimum standpoint, opportunities exist to reduce some fertilizer application rates (i.e., especially nitrogenous fertilizers). This is easier said that done. Working with farmers to reduce fertilizer use is complicated by the lack of awareness of the need for balanced fertilizer application. Many farmers tend to use urea heavily but under-utilize potassium and phosphorous. Such unbalanced use of fertilizers is not considered sustainable in the long run and could lead to unexpected problems. For example, too much nitrogen also enhances plant growth thereby making it attractive to some insect pests thus necessitating increased pesticide use.

Utilization of Pesticides in the Mekong River Delta

While other pest management practices have been declining, chemical pesticide use has been steadily increasing in Vietnam. The quantity of pesticides used in agriculture increased by 140% between 1991 and 1994 as shown in the following table.

TYPE	1991		1992		1993		1994	
	TONNES	%	TONNES	%	TONNES	%	TONNES	%
Insecticides	17,590	82.2	18,100	74.1	17,700	69.2	23,500	68.3
Fungicides	2,770	12.6	2,800	11.5	3,800	24.8	4,650	15.5
Herbicides	500	3.3	2,600	10.6	3,050	11.9	3,500	11.7
Others	410	1.9	915	3.8	1,050	4.1	1,350	4.5
Total	24,400		24,415		25,600		30,000	

Pesticide use in rice cultivation accounted for 65.5% of the total market value of pesticides in 1996. Insecticides were the most widely used pesticide (85%) for rice cultivation. Fungicide use by value was relatively low as was herbicide use at only about 4%.

Studies of pesticide use in Vietnam suggest that pesticides are relatively over-used in the South as compared to North. As a result, expenditures on pesticides by farmers in the Mekong Delta had been significantly higher than in the Red River Delta in northern Vietnam. The frequency of application is also greater in the Mekong Delta (i.e., pesticides are typically applied 5.3 times per season), although high applications of pesticides are common in most rice farming regions of the country. Compared to other countries in Southeast Asia, expenditures on pesticides and frequency of application in Vietnam is high as shown in the following table compiled from 1990-1991 data.

REGION/COUNTRY	EXPENDITURE (US$/ HECTARE)	NUMBER OF APPLICATIONS
China	25.6	3.5
India	24.9	2.4
Philippines	26.1	2.0
Indonesia	7.7	2.2
Northern Vietnam	22.3	1.0
Southern Vietnam	39.3	5.3

In total, approximately 2,000 to 3,000 tonnes of pesticides are used every year in the Mekong Delta. In 1990, the southern Vietnamese provinces used 5,615 tonnes of a total of 77 different pesticides, of which 4,848 tonnes were insecticides and 392 tonnes were fungicides. Many of the commonly used pesticides (e.g., organic phosphates, carbamates, pyrethroids) decompose easily and do not persist in the environment. Other pesticides, although less commonly used, are of more concern due to their persistence and are routinely detected in water quality monitoring program. Results for representative sampling stations in the Mekong delta are summarized in the following table (Note: all results are expressed as mg/L x 10^{-6}).

STATION	HEPTACHLOR	ALDRIN	DDE	ENDRINE	DIELDRINE	TDE	DDT
1	< 0.1	< 0.1	< 0.1	0.2	0.4	73	217
2	< 0.1	0.2	< 0.1	0.2	0.3	67	321
3	< 0.1	0.1	< 0.1	< 0.1	< 0.1	59	248
4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	67	309
5	< 0.1	< 0.1	< 0.1	0.3	< 0.1	42	226
6	< 0.1	0.3	< 0.1	< 0.1	< 0.1	40	240
7	< 0.1	< 0.1	< 0.1	< 0.1	0.3	111	275
8	< 0.1	< 0.1	< 0.1	< 0.1	0.2	122	310
9	< 0.1	0.3	< 0.1	< 0.1	< 0.1	86	279
10	< 0.1	< 0.1	1.2	0.4	< 0.1	120	386
11	< 0.1	< 0.1	0.6	< 0.1	< 0.1	95	345
12	< 0.1	< 0.1	0.3	< 0.1	< 0.1	60	281
13	< 0.1	< 0.1	0.4	< 0.1	< 0.1	75	238

According to the Vietnamese Water Quality standards (TCVN 5942, 1995), total concentrations of plant protection chemicals in surface waters (i.e., suitable for domestic use) should not exceed 0.15 mg/L. Concerns have been raised that this standard is too high, citing evidence that people's health can be negatively affected by exposure and uptake of organic chloride and phosphorous chemicals at the concentration allowed under the Standard. By comparison, the World Health Organization (WHO) has recommended lower maximum allowable concentrations for plant protection chemicals (e.g., DDT $\leq 2.10^{-3}$ mg/L, aldrin + dieldrin $\leq 3.10^{-5}$ mg/L, lindane $\leq 2.10^{-3}$ mg/L, 2,4D $\leq 30.10^{-5}$ mg/L). The advantage of the WHO

standards is that they are more conservative, providing greater protection for different water uses, and are specified for individual chemicals rather than just for total chemical concentrations.

Agro-chemicals have been measured in all environmental compartments of the Mekong Delta (i.e., soils and sediments in addition to receiving waters). Of particular concern are monitoring results which show the presence of banned or restricted chemicals such as DDT, lindane, captan, monocrotophos, methyl parathion, azodrin, and methamidophos.

Effect Of Agro-Chemicals in the Environment

Rice production in Vietnam's Mekong Delta contributes significantly to national economic prosperity in terms of food procurement and security for the nation, and provides revenues through export of the rice surplus. However, it is important not to isolate economic benefits from potential environmental concerns relating to the rapid intensification of rice cultivation in Vietnam. Intensification of agriculture, enabled by increasing usage of agro-chemicals in the Delta, has a price in terms of adverse impacts such as human health problems and environmental damage. These adverse effects of agro-chemical use are briefly examined in the following sections.

Environmental Issues Relating to Fertilizer Use

Potential environmental effects of fertilizer use in agriculture, particularly if large quantities are applied or if they are applied incorrectly, include:

- Nitrogen (N) and phosphorus (P) in run-off can contribute to eutrophication in receiving waters with a risk of oxygen depletion and fish kills
- Ammonia (NH_3) gas can cause haze and contribute to the acidification of soils
- Nitrogen oxide (NO_x) can contribute to regional acid precipitation and locally reduced air quality
- Sulphur dioxide (SO_2) reacts with other gases and contributes to haze formation and also to regional acid precipitation
- Dust can be a local nuisance and contribute to visible haze
- Fluoride (F), in high concentrations, is dangerous to plants and animals

Although the above-listed effects are normally imperceptible, cumulatively they can lead to serious degradation of receiving water bodies, the soil, and the environment in general unless preventative measures are taken. In developed countries, the levels of fertilizer application are based on regular soil analyses in order to prevent high concentrations of fertilizers in soil and consequent negative effects to the environment. This is not generally done in developing countries like Vietnam where farmers often apply excessive quantities of fertilizer in the mistaken belief that more fertilizer will result in higher crop yields and increased profits.

Human Health Effects of Agro-Chemicals

In addition to concerns regarding the quantity of agro-chemicals utilized in Vietnam's Mekong Delta, their improper use and handling is common. A field survey undertaken at representative sites in the Delta indicated that farmers commonly mishandled pesticides and improperly applied hazardous pesticides in combination with other chemicals. Of particular concern are the symptoms of poisoning observed among farmers due to the use and unsafe handling of hazardous chemicals. Unfortunately, it is difficult to quantify this problem since most farmers experiencing poisoning symptoms do not go to the hospital and most local health officials are not able to properly diagnose pesticide poisoning. However, it is estimated that significant health costs are incurred, such as cost of medical treatment and opportunity cost of farmers' time, as a direct result of improper pesticide use by farmers.

More subtle than direct impacts of improper chemical handling by farmers are the indirect human health effects of excessive dietary updake of chemicals. Indirect impacts of chemical use can be illustated by looking at nitrogen. With the trend of intensive farming to get high yield for crops, more and more nitrogen fertilizer is being used in the Mekong Delta. When there is surplus nitrogen in the soil it is converted to ammonia of nitrate through biochemical processes and accumulates in soil and water. Nitrate can then be absorbed into vegetables and cereals in excess of the recommended concentrations for food (i.e., the daily maximum for nitrate in food and drinking water is 300 mg/day for adults and only 30mg/day for children). Examples of excessive food concentrations of nitrate can be found in many countries which practice intensive agriculture. Holland is a typical example. Vegetables produced in this country, especially in winter, can contain up to 4,000 mg nitrate/kg. It has been estimated that the average daily uptake of nitrate by adults is 1,100 mg nitrate through food and 100 mg nitrate through drinks. This uptake exceeding the standard level for adults by four times and the children's standard by a greater margin. High nitrate concentrations in drinking water have been shown to lead to nitrate disintegration to nitrite (NO_2) and the creation of nitroamin in the digestive system which causes suffocation, anermia and cancer.

Although the use of nitrogen fertilizer has increased remarkably due to intensification of agriculture in Vietnam, and in the Mekong Delta in particular, very little research has been undertaken on the effects of over-use of nitrogen fertilizer to the environment and to farmer health. In addition, some limitations remain in Vietnam's capacity to monitor nitrate concentrations in soil, food, water, especially drinking water as part of environmental monitoring programs.

Effect of Pesticides in the Environment

Run-off of pesticides to receiving water bodies has the potential to significantly impact aquatic organisms by inhibiting growth and causing reproductive failure. Uptake by humans through consumption of larger fish with elevated tissue pesticide concentrations is a human health concern. Pesticides can also leach into groundwater causing additional human health concerns as a result of drinking from contaminated wells.

In contrast to fertilizers, extensive research has been completed in Southeast Asia relating to pesticide use in rice agriculture. A 1989 survey of elven rice growing countries estimated average yield losses due to insect pests at 18.5%. Researchers are divided on how best to address the problem of crop loss to insects. Much research focuses on optimizing insecticide use in relation to increasing rice yields. Experimental results are variable with some results showing that insecticide-protected plots yielded almost twice as much as unprotected plots while other showed no significant differences in yield between the treated and untreated plots. Other research has looked at the effectiveness of natural controls on insect pests. On balance, although rice yields are higher when chemical pesticides are used, natural controls were found to be adequate under normal growing conditions. The question of how best to proceed becomes more complicated when the human health costs of pesticide use are factored in. Studies indicate that the positive production benefits of applying insecticides are overwhelmed by the increased health costs (i.e., the value of crop loss to pests is invariably lower than the cost of pesticide-related illness and the associated loss in farmer productivity).

Rice farmers are poisoned from pesticide use through direct exposure to pesticides during handling and application and from uptake of pesticide residues in their food (e.g., vegetables, root crops, frogs, fish). Farmers and agricultural workers face chronic healths effects due to prolonged exposure to pesticides with eye, dermal, pulmonary, neurologicical and kidney problems being associated with long-term exposure. Serious health effects are positively correlated with intensive pesticide use compared to less intensive pesticide use.

SITE VISIT METHODOLOGY

Course participants will complete a one day visit the Faculty of Plant Protection at Can Tho University to learn more about their research into agro-chemical use and environmental impacts in the Mekong River Delta. Knowledgeable resource people will be available to provide information about commonly-used chemicals and their agricultural benefits, and on chemical toxicity in the receiving environment and human health concerns. Additional information is provided in the attached reference readings which should be read by participants prior to the site visit.

Participants will be organized into small groups for the site visit with each group being assigned a specific task as follows.

SUBJECT	TASKS
Fertilizer Use in the Mekong River Delta	Utilization patterns Economic benefits Receptors at risk; both ecological and human Magnitude and significance of impacts Knowledge gaps Environmental costs Mitigation measures
Pesticide Use in the Mekong River Delta	Utilization patterns Economic benefits Receptors at risk; both ecological and human Magnitude and significance of impacts Knowledge gaps Environmental costs Mitigation measures
Agro-Chemicals in the Environment	Uses and effectiveness of common agro-chemicals Application rates and methods Persistence in the environment Pathways Fate and effects Alternatives to agro-chemicals in farming
Government Policy and Environmental Standards	Current agricultural policy (i.e., intensification) Environmental standards in Vietnam and elsewhere in the MRB Environmental monitoring Cost-benefit analysis Education and environmental awareness initiatives

On completion of the site visit, groups will be asked to present their findings to the class with emphasis on the practical lessons learned by participants which reinforce IREM, CEA and SEA theory taught in the course.

TAKE HOME MESSAGES

Anticipated lessons learned by the course participants in completing the case study and site visit might include:

1. Intensification of agriculture in the Mekong River Delta as part of the Vietnamese government's agricultural policy is being achieved through increasing use of agro-chemicals. Although increasing use of agro-chemicals in the Delta has been strongly correlated with higher crop yields, unintended consequences of increased chemical use have been negative impacts to human health and environmental well-being.
2. Potential for agro-chemicals to accumulate in the environment and cause adverse human health and ecological effects. Direct exposure occurs primarily through handling and application of chemicals by farmers and to ecological receptors due to run-off to receiving water bodies. Indirect exposure is most prevalent through the food chain where bioaccumulation of chemicals occurs – dietary uptake by humans occurs through consumption of fish and other aquatic organisms. Additional sources of pesticides to humans are from residues on unwashed vegetables and other crops.

3. Knowledge gaps are evident relating to the persistence of agro-chemicals, contaminant pathways, and their fate and effects in the receiving environment. Better understanding of the behavior and effects of agro-chemicals is necessary in support of efforts by environmental managers and policy makers to better regulate agro-chemical use and to refine environmental standards used in assessing environmental health and the effectiveness of mitigation measures and policy changes.

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