REPORT OF PESTICIDE HOTSPOTS IN BANGLADESH

by

CRAIG MEISNER

DEVELOPMENT ECONOMICS RESEARCH GROUP
INFRASTRUCTURE AND ENVIRONMENT DEPARTMENT
THE WORLD BANK

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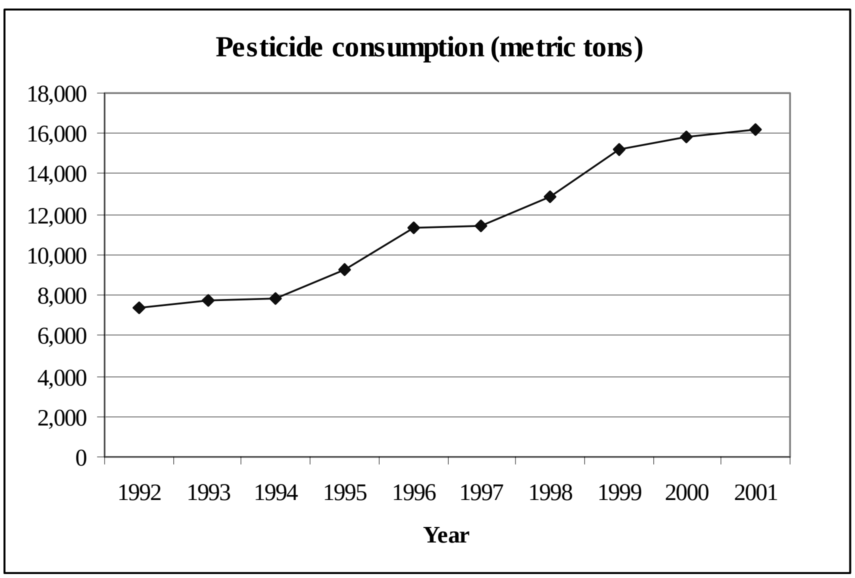
I. Introduction:

The agricultural sector in Bangladesh faces many challenges in the coming years. Owing to its rapid population growth and food security needs, land scarcity and agricultural intensification are quickly becoming issues of pressing importance. Combined with the severe agro-climatic conditions (for example, annual flooding), agricultural production will have further difficulty in meeting future demands. As a direct consequence of these difficult conditions, agriculture has been highly susceptible to crop pest attacks and diseases. Conservative estimates of annual crop losses are in the range of 10-15% without any direct intervention. In their defense, farmers have begun to use more toxic chemicals for pest control that have reputations of speed and effectiveness. The Government of Bangladesh also promotes the use of pesticides to expand its agricultural frontiers and increase output per acre of land.[1] As a result, pesticide use in general is increasing. According to statistics from the Government of Bangladesh, consumption of pesticides increased from 7,350 metric tons in 1992 to 16,200 metric tons in 2001, more than doubling in the past decade (Figure 1).



Source: Department of Plant Protection Wing, Bangladesh

Figure 1. *Trends in pesticide use in Bangladesh, 1992-2001*.

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[1] Subsidies are, to a varying extent, provided to encourage pesticide use to increase crop yields (Rasul and Thapa, 2003; Hossain 1988).

Perhaps of even greater concern than the absolute quantity of pesticides is the trend in the composition of pesticides currently in use in Bangladesh. Insecticides and fungicides account for 97% of pesticide use and have registered a steady increase over the years. An FAO analysis of active ingredients has revealed high shares of carbamates and organophosphates in insecticides and dithiocarbamates and inorganics in fungicides (see Table 2, Appendix I for details). Epidemiological studies have found carbamates and organophosphates to be carcinogenic (producing cancer), mutagenic (causing genetic damage), teratogenic (damaging to the fetus) or allergenic (Zahm, Ward and Blair, 1997). Many pesticides in use are also banned or restricted under international agreements (NOVIB, 1993; SUNS, 1998; SOS-arsenic.net, 2004). Several studies of farmers have shown that inadequate product labeling and farmers' lack of information have led to widespread overuse or misuse of dangerous pesticides. A substantial body of anecdotal evidence also suggests that pesticide poisonings and ecological damage have become commonplace in Bangladesh (Ramaswamy, 1992; Jackson 1991).

Current projections suggest that the agricultural output of Bangladesh needs to grow several times during the next several decades, as the population of Bangladesh continues to grow and incomes increase. Bangladesh will have to increase yields from the land currently under cultivation in order to serve this increased demand. Given both the formal and informal evidence to date, pesticide use warrants a careful assessment of the current situation as well as experimentation with feasible alternative production systems such as Integrated Pest Management/ and organic farming techniques. However, in order to effectively implement such programs, one first needs to identify the hotspot areas where pesticide use is high, and where farmers may benefit the most.

As in many developing countries, Bangladesh lacks sufficient information on pesticide use, even at the regional level. Given this informational gap, the purpose of this report is to present the results of a exercise that combines recent farm-level pesticide use data and Bangladesh agricultural production data to estimate pesticide use "hotspots" or pesticide-intensive areas at the district level. The identification of such areas can aid policymakers and extension agents in targeting potential areas for education and training programs aimed at reducing the dependence on toxic pesticides. The report is structured as follows. The next section describes the methodology adopted for the hotspot analysis and in Section IIII the results are presented in the form of maps along with some brief commentary. In Section IV, we discuss the findings and conclude.

II. Simulation methodology[2]

In the absence of detailed information on pesticide use at the farm level for all areas of Bangladesh, we make use of a recent World Bank farm-level pesticide survey conducted in 2003.[3] Structured questionnaires were used to collect information on crop yield, inputs, pesticide use and practices, applicator precautions and averting behavior, health effects (if any) and environmental effects. For the purposes of this report only the information on crop inputs and outputs were used (e.g. crop production and pesticide use). Specific crops included rice (Boro), potatoes, green beans, cabbage, eggplant and mango production all of which are well-known pesticide users (Figure 2).

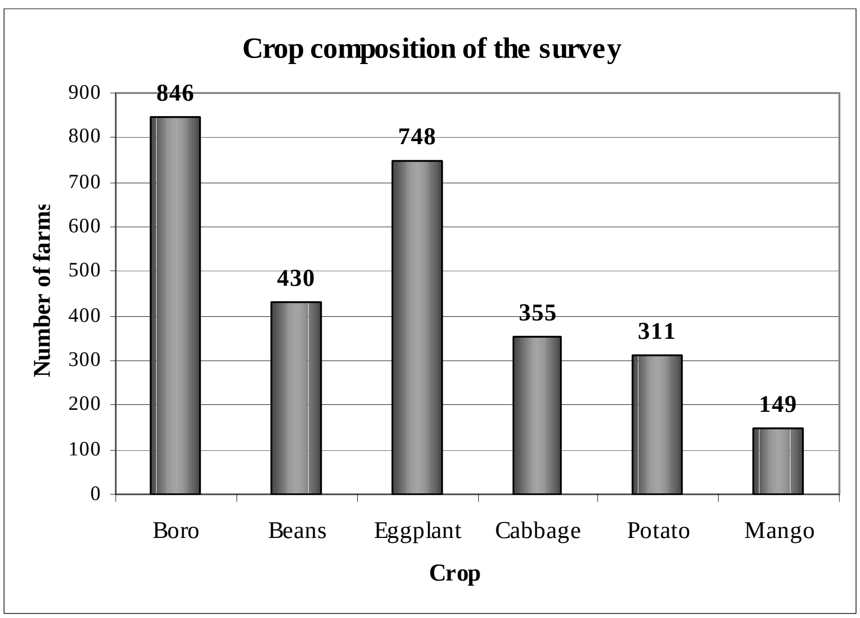


Figure 2. *Crop composition of the World Bank survey, 2003*.

2 For a detailed explanation of the simulation methodology, see the learning module "*Identifying Pesticide Hotspots: The case of Bangladesh*" by Meisner and Dasgupta, 2004.

3 The survey was conducted by the Development Economics Research Group, Infrastructure and Environment Department of the World Bank in the summer of 2003.

The survey sample was also distributed among several districts to capture any possible differences in production or pesticide use. The survey covered the following districts: Bogra, Chapainawabgunj, Rajshahi and Rangpur (Rajshahi division); Chittagong and Comilla (Chittagong division); Jessore (Khulna division); and Kishoreganj, Munshiganj, Narsingdi and Mymensingh (Dhaka division) (see Figure 3).[4]

Figure 3. ***Geographical distribution of the survey (sample size indicated)*****.**

Among the various production and input information collected, the survey contained information on the type and application amounts of pesticides used for each crop. Using this information, pesticide use intensities (measured as kg of pesticide per kg of crop output) were calculated for each crop. The intensities were then multiplied by actual agricultural production data obtained from the Agricultural Census of Bangladesh for the years 1994-1995 and 1999-2000 (see diagram in Figure 4). Summing across all crops in each district, the estimates yielded pesticide use loads for each district. As the number of

[4] Note that the selection of each district is according to the new district classification of 64 districts.

crops were limited to only those considered as major crops (from above), these estimates should be interpreted as underestimates of the true extent of pesticide use in each district.

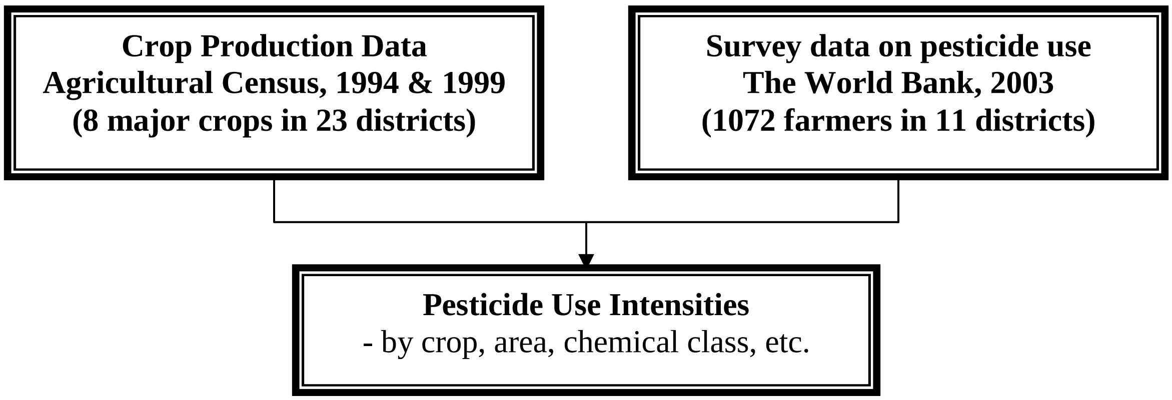


Figure 4. ***Pesticide Intensity Calculation*.**

By simply summing all pesticides (measured as kg of active ingredient) used in crop production, this implicitly assumes that all pesticides are alike in terms of their toxicity. However, to better gauge the relative hazardousness one would account for the pesticide's relative toxicity. To do this, we constructed *risk-weighted* measures by defining risk as the relative toxicity or lethality of each active ingredient. Risk-weighted measures place a greater weight on more toxic substances and provide a more convenient measure of comparing the use of one pesticide over another from a health-hazard perspective. To gauge the relative toxicity of each active ingredient, a measure called the LD_{50} (or lethal dose 50%) is used. LD_{50} is a statistical estimate of the number of milligrams (mg) of toxicant per kilogram (kg) of bodyweight required to kill 50% of a large population of test animals. Pesticides with a lower LD_{50} value are more toxic, thus in the calculations used for this exercise, each pesticide load was multiplied by $1/LD_{50}$ to account for its relative toxicity and giving greater weight to more toxic substances. All of the results presented below are risk-weighted unless specifically indicated.

III. Results

Comparison of pesticide use in 1994-1995 versus 1999-2000

As indicated earlier, pesticide use is on the rise in Bangladesh, and further evidence of this trend is provided below in Figures 5 and 6. In particular, several districts where pesticide use was high in 1994-95, including Dhaka, Rajshahi and Rangpur, have intensified in terms of overall (absolute) pesticide use by 1999-2000. The district of Rangamati experienced a decrease during the same comparative time interval.

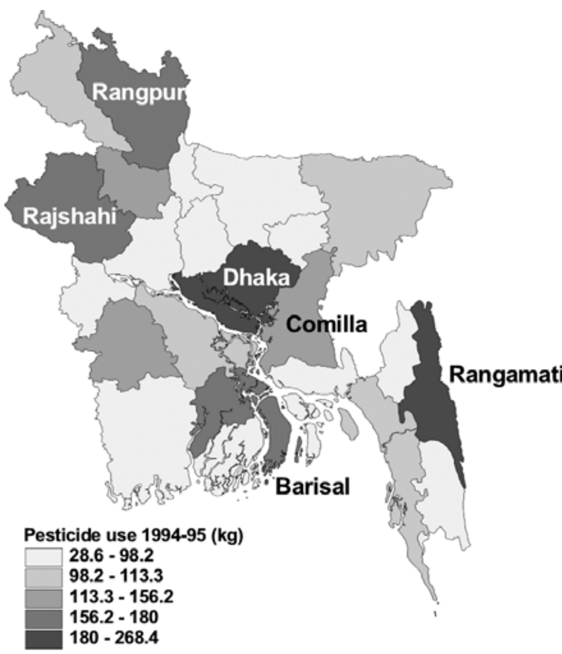


Figure 5. ***Pesticide use (un-weighted), 1994-1995.***

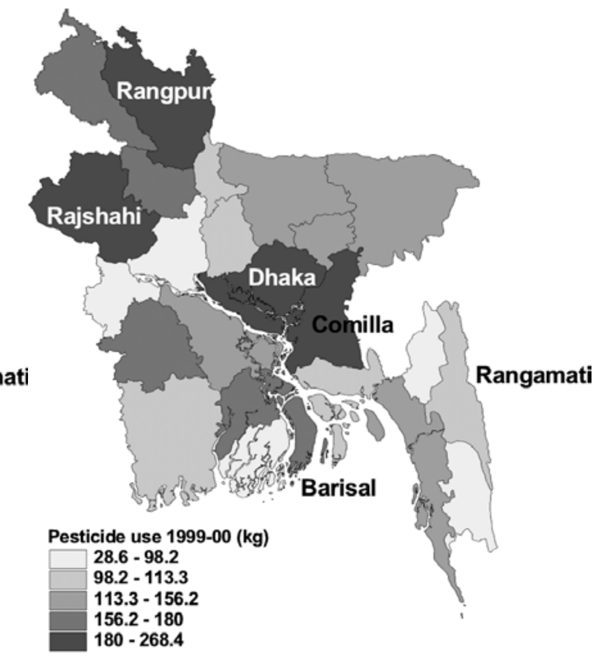
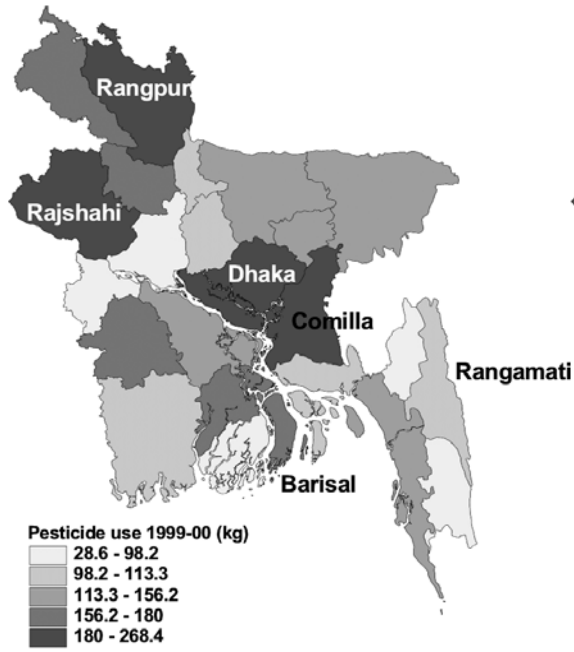


Figure 6. ***Pesticide use (un-weighted), 1999-2000.***

As discussed above, although un-weighted pesticide amounts are useful in terms of overall country regulatory policy (e.g. trade), in terms of health hazards, it is more useful to weight these estimates by the relative risk of each pesticide used. Below in Figures 7 and 8, we compare the un-weighted and risk-weighted measures for 1999-2000. Although Dhaka, Rajshahi and Rangpur remain high on the list in terms of riskier pesticide use, the districts of Comilla and Barisal fall with respect to the others, while Jessore rises in terms of risk-weighted pesticide use.



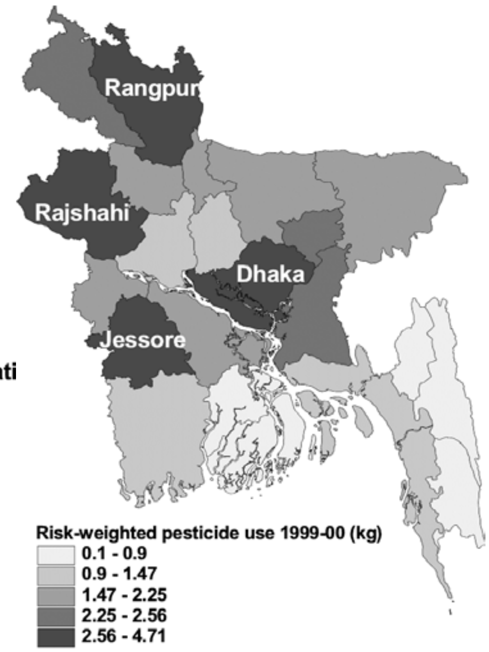


Figure 7. ***Pesticide use (un-weighted), 1999-2000*.** **Figure 8.** ***Risk-weighted pesticide use, 1999-2000*.**

Pesticide use by WHO classification

Developing on the estimates of risk-weighted pesticide use, a convenient categorical method has been developed by the World Health Organization (WHO) based on the LD_{50} measure.[5] Pesticides are divided into 4 major hazard groups: Category Ia & Ib (extremely hazardous), Category II (moderately hazardous), Category III (slightly hazardous), and Category U (least hazardous or unlikely to present acute hazard under normal use). Field evidence suggests that human poisonings correlate reasonably well with these toxicity ratings (Levine and Davies, 1982).

From our simulation results, we can categorize pesticides according to the WHO classification system. In Table 1. we see that in among the pesticides selected by farmers in the World Bank survey, 19% were Class Ia or Ib, and in terms of the amount that was applied to crops nearly 6% were Ia or Ib. Using the agricultural census data for 1999-

[5] The WHO toxicity rating is based on the lowest published oral LD_{50}, typically tested on rats. While WHO ratings generally reflect acute toxicity, they also take into account other toxic effects such as reproductive and developmental toxicity (WHO, 2002).

2000, we see that geographically the distribution of Ia & Ib use is concentrated in the districts of Dhaka, Jessore, Rajshahi and Rangpur (Figure 9).

Table 1. ***Frequency of pesticide applications by WHO classification***

Classification	**By farmer application frequency (%)**	**By farmer application dose or load (%)**
Class Ia & Ib	19.12	5.71
Class II	58.58	41.51
Class III	7.50	15.01
Class U	14.80	37.70
Total	100.00	100.0

Note: Based on 51 active ingredients and 161 formulations (commercial names).

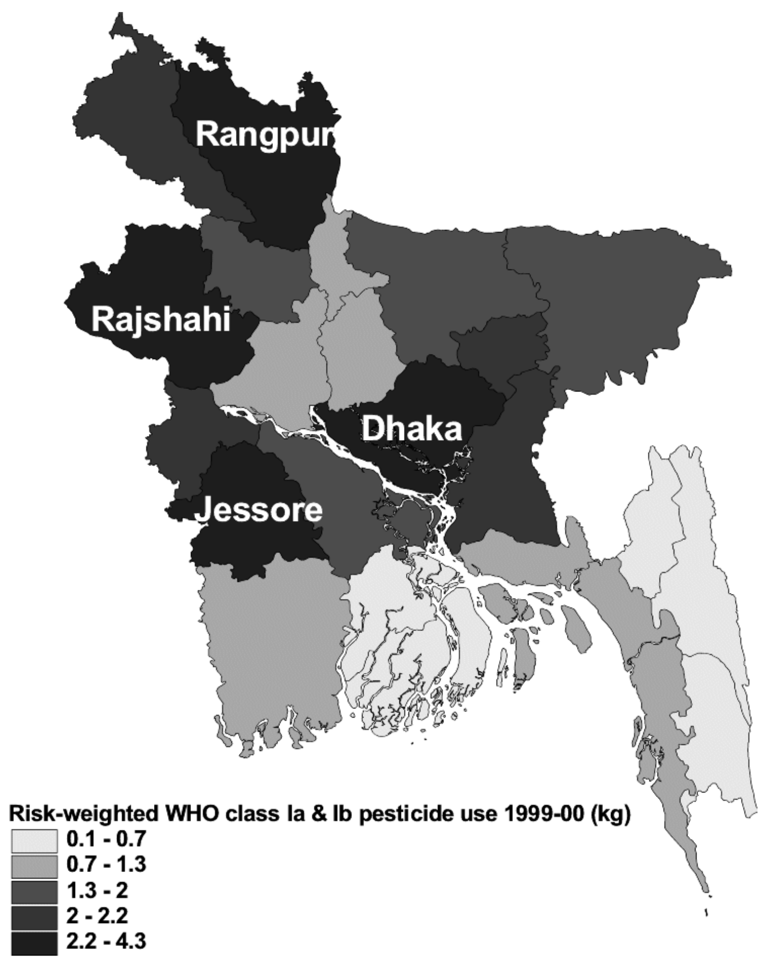


Figure 9. ***WHO classified Ia & Ib pesticides, 1999-2000.***

Pesticide use by chemical class

As noted earlier, epidemiological evidence has suggested that specific chemical classes are associated with acute health and chronic disease problems. In particular, carbamates, organophosphates and organochlorines have been identified as priority classes for monitoring and evaluation. By categorizing pesticides into these constituent classes, we estimated the amount of risk-weighted pesticides that fall into these chemical classes. In Figures 10 through 12 below, we see a noticeable pattern for Rajshahi and Rangpur as consistent top priority districts with respect to all three chemical classes, Dhaka and Comilla for organochlorines, Kustia and Jessore for carbamates and Kishoreganj for organophosphates.

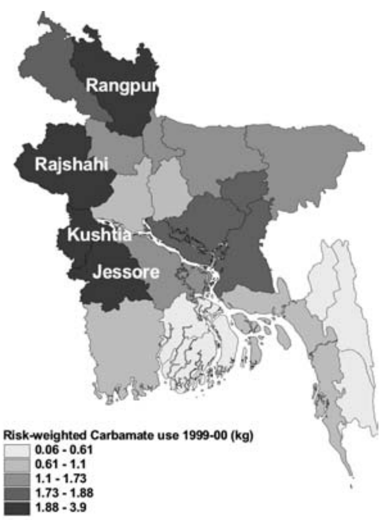


Figure 10. ***Carbamate use, 1999-2000*.**

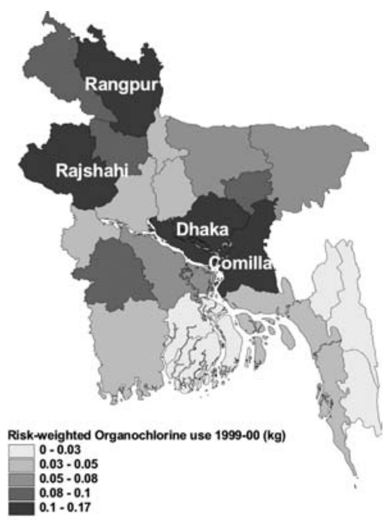


Figure 11. ***Organochlorine use, 1999-2000*.**

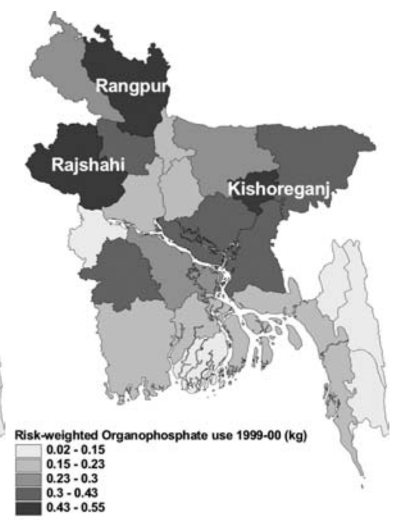


Figure 12. ***Organophosphate use, 1999-2000*.**

Prevalence of Persistent Organic Pollutants (POPs)

Yet another broad class of pesticides receiving widespread international attention are persistent organic pollutants or POPs. POPs pose a severe long-run threat because they can accumulate in the environment over time.[6] Whatever the source of POPs, air and water dispersion makes their toxic impact potentially global. Near the top of the food

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[6] Epidemiological studies have been conducted associating human exposure to specific POPs or classes of POPs with cancers and tumors at multiple sites; neurobehavioral impairment including learning disorders, reduced performance on standardized tests and changes in temperament; immune system changes; reproductive deficits and sex-linked disorders; a shortened period of lactation in nursing mothers; and diseases such as endometriosis, increased incidence of diabetes, and others.

chain, POP accumulations have become extremely hazardous in some species of mammals, birds and fish. Recognizing these growing concerns, the United Nations has recently sponsored several rounds of international negotiation to address the global contamination by twelve particular POPs.[7] During the survey conducted by the World Bank in 2003, the use of two POPs were encountered, heptachlor and endrin. As can be seen in Figure 13 below, the presence of POPs were found in the districts of Comilla, Chittagong, Dhaka, Rajshahi and Mymensingh.

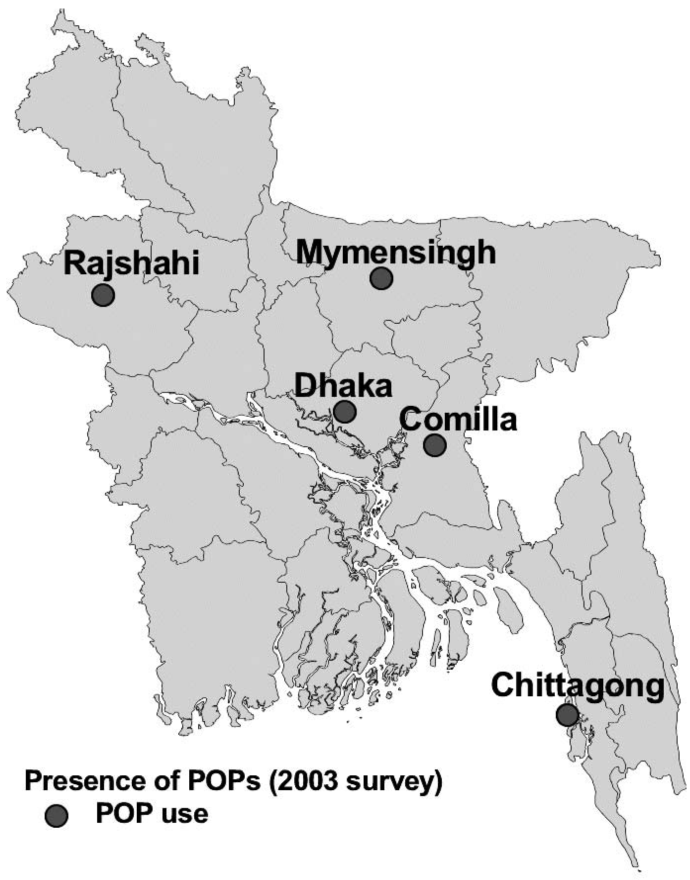

Figure 13. ***Prevalence of Persistent Organic Pollutants, 1999-2000*****.**

[7] The twelve initially targeted are: Aldrin, DDT, Dieldrin, Endrin, Chlordane, Heptachlor, Hexachlorobenzene, Mirex, Toxaphene, PCBs, PCDDs and PCDFs. For a detailed discussion, see UNEP (1997).

WHO class Ia & Ib pesticide use by major crop from the Agricultural Census

Among the major crops covered by the Agricultural Census, below we present the maps for banana, bean, cabbage, eggplant, potato, rice and sugar. We present only these major crops since these were also the only major crops covered by the World Bank survey. Due to the geographic variation in cropping patterns in Bangladesh, pesticide use in that particular crop will vary widely across districts. However, one common finding is that the location of the largest production tends to coincide with the largest in terms of overall and WHO Ia & Ib pesticide use for that particular crop. For example, according to the census for the period 1999-2000, rice production was largest in the districts of Rangpur, Kishoreganj, Rajshahi and Comilla. These were also identified as being the highest in terms of highly toxic, as well as overall, pesticide use.

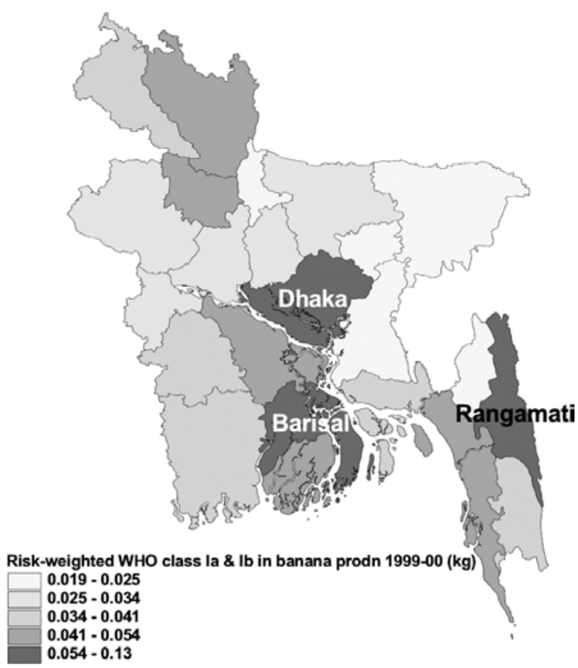

Figure 14. ***Pesticide use in bananas, 1999-2000*.**

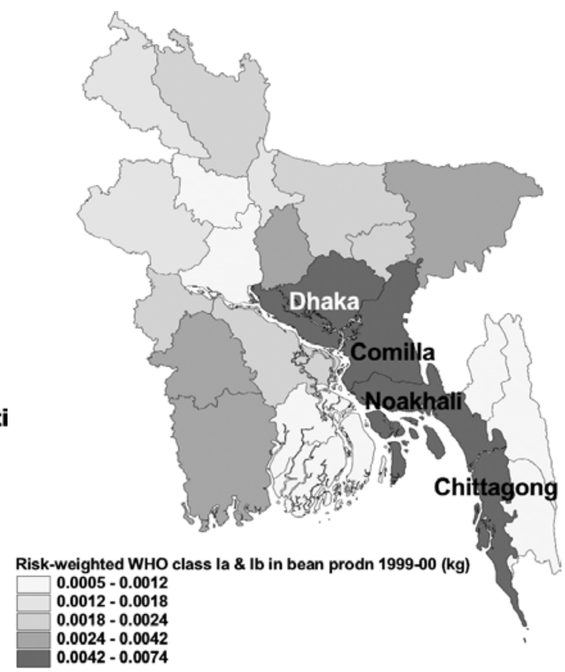

Figure 15. ***Pesticide use in beans, 1999-2000*.**

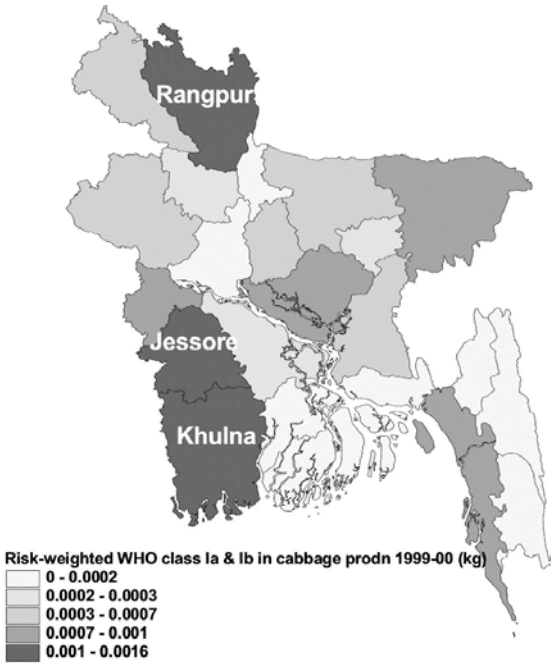

Figure 16. ***Pesticide use in cabbage, 1999-2000*.**

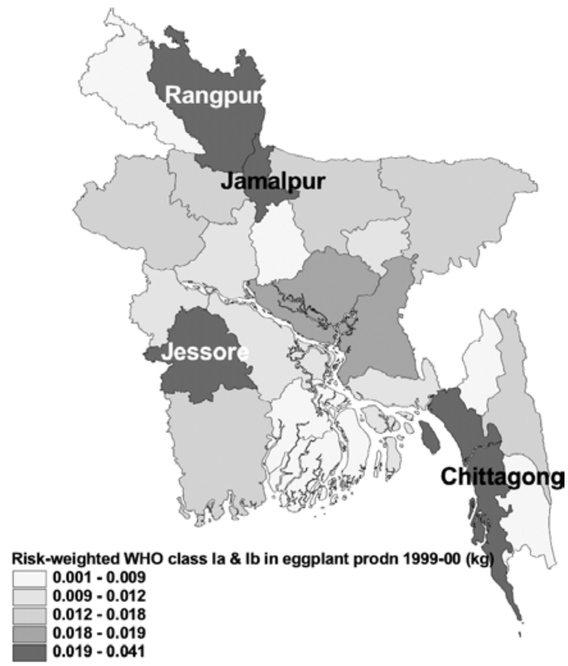

Figure 17. ***Pesticide use in eggplant, 1999-2000*.**

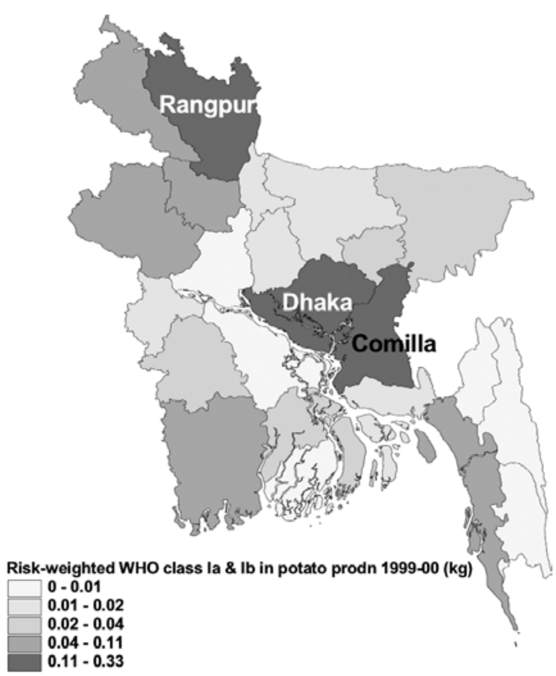

Figure 18. ***Pesticide use in potato, 1999-2000*.**

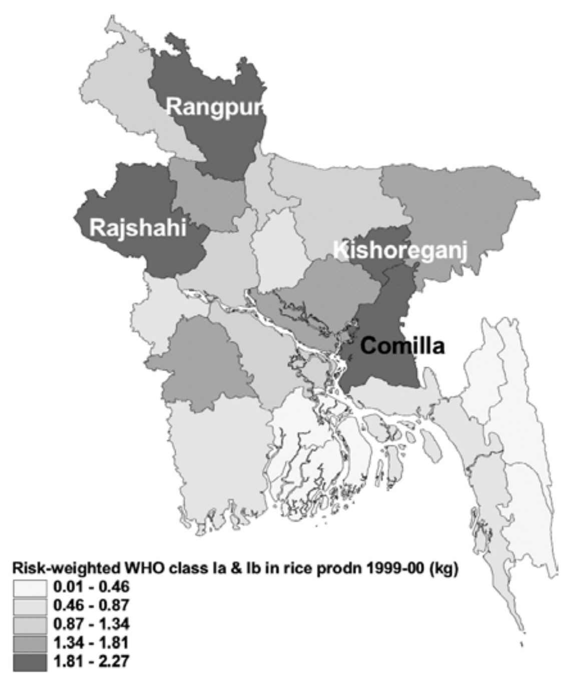

Figure 19. ***Pesticide use in rice, 1999-2000*.**

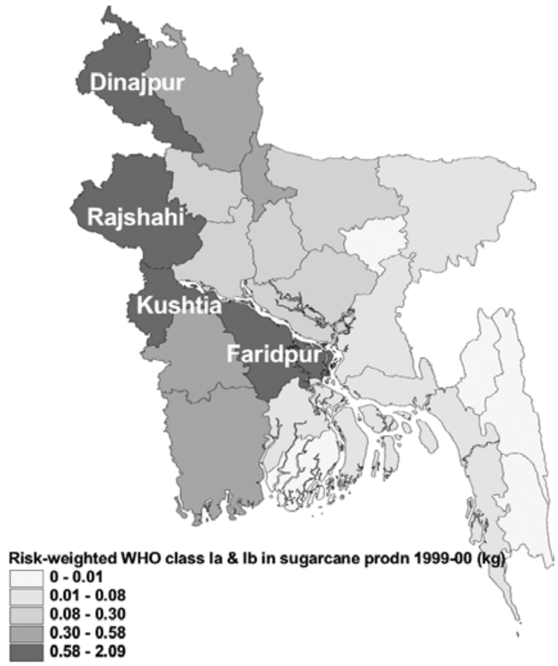

Figure 20. ***Pesticide use in sugarcane, 1999-2000*.**

IV. Discussion and conclusions

This report has presented a relatively current snapshot of pesticide use in Bangladesh for a number of major crops. As detailed, dis-aggregated, information on pesticide use is not currently available, the findings of this report attempts to cast some light on the overall extent of pesticide use in Bangladesh, as well as, highlight areas where particularly toxic pesticides are concentrated.

The methodology combined information from a recent World Bank farm-level pesticide use survey and Agricultural Census data from the Government of Bangladesh to estimate absolute and risk-weighted pesticide use for each of the 23 districts. The estimates were then grouped into several categories to highlight areas of high relative toxicity according to WHO Ia & Ib pesticides and by high priority chemical classes. The findings suggest that policymakers may focus their efforts in a select number of districts, depending on what their priorities might dictate. For example, if the immediate priority is to substitute out the most highly hazardous pesticides, directed interventions towards areas where WHO class Ia & Ib pesticides are still in high use might be considered. After addressing more short-term objectives, longer-term strategies may involve decreasing overall pesticide use, and shifting agricultural production towards, say, IPM adoption. In this case, efforts may be directed towards areas that are more dependent on high quantities. In sum, policymakers may use this information for a variety of targeted interventions from the monitoring of particularly toxic pesticides (e.g. for the implementation of bans or restrictions) to developing programs of pesticide awareness (e.g. health considerations, protective measures, or IPM adoption).

References

Hossain, M. (1988) Nature and Impact of the Green Revolution in Bangladesh. Research Report No. 67. International Food Policy Research Institute, Washington, DC.

Jackson, G. J. (1991) Agrochemical Usage in Asia Region: A Reference Compendium. Mimeo.

Levine, R.S., and J.E. Davies (1982) Pesticide Toxicity and Mode of Action. In J.E. Davies, V.H. Freed, and F.W.Whittemore (eds.), *An Agromedical Approach to Pesticide Management: Some Health and Environmental Considerations*. Miami, Fla., USA: University of Miami School of Medicine in cooperation with the Agency for International Development (USAID) and Consortium of International Crop Protection.

Meisner, C. M. and S. Dasgupta (2004) Identifying Pesticide Hotspots: The Case of Bangladesh. Mimeo. Available at: http://www.worldbank/nipr.

NOVIB (1993) Pesticides Misuse in Bangladesh. The Pesticides News, No. 22, Dec. 1993. The Pesticides Trust. London, U.K.

Ramaswamy, S. (1992) Pest Control and Environment. Notes for discussion at a seminar on environment and agriculture. Agriculturalist Association of Bangladesh, Dhaka, p.19.

Rasul, G. and G. Thapa (2003) Sustainability Analysis of Ecological and Conventional Agricultural Systems in Bangladesh. *World Development*, **31**(10): 1721-1741.

SOS-Arsenic.net (2004) Agrochemicals: Imported Pollutants in Bangladesh. Available at: http://www.sos-arsenic.net/index.html.

SUNS (1998) Pesticide Overuse Takes Serious Turn in Bangladesh. Monday, Jan. 24, (Dhaka, Jan. 23 IPS/Tabibul Islam).

UNEP (United Nations Environmental Programme) (1997) **Decisions Adopted by The Governing Council at its Nineteenth Session**: 13C. International Action to Protect Human Health and the Environment Through Measures Which Will Reduce and/or Eliminate Emissions and Discharges of Persistent Organic Pollutants, Including the Development of an International Legally Binding Instrument, Geneva.

World Development Report (2002) **Building Institutions for Markets**, World Bank: Washington, DC.

WHO (World Health Organization) (2002) **The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 2000-2002**, Geneva, World Health Organization. Available at:
http://www.who.int/ipcs/publications/pesticides_hazard/en/

Zahm, S. H., M. H. Ward and A. Blair (1997) **Pesticides and Cancer**. In: Occupational Medicine: State of the Art Reviews. Vol. 12: Pesticides (Keifer, M., ed). Philadelphia: Hanley and Belfus, Inc., 269-289.

Appendix I

Table 2: Active Ingredients Used (sold) in the Agricultural Sector, Bangladesh

Consumption (million tons)	*Year*								
Insecticides	**1990**	**1991**	**1992**	**1994**	**1993**	**1995**	**1996**	**1997**	**1998**
Carbamate Insecticides	170	182	202	-	210	250	270	290	300
Chlorinated Hydrocarbons	30	24	32	-	28	35	15	1	-
Organophosphates	720	751	821	-	855	810	950	980	1,020
Pyrethroids	9	9	14	-	13	14	15	5	15
Other Insecticides	26	26	33	-	18	45	50	50	30
Total Insecticides	**955**	**992**	**1102**	-	**1124**	**1154**	**1300**	**1326**	**1365**
Herbicides									
Bipiridils	-	-	-	-	-	12	20	20	19
Phenoxy Hormone Products	9	10	10	-	6	32	30	30	28
Other Herbicides	26	25	23	-	27	22	13	13	15
Total Herbicides	**35**	**35**	**33**	-	**33**	**66**	**63**	**63**	**62**
Fungicides									
Benzimidazoles	-	-	1	-	1	7	5	5	7
Diazines, Morpholines	-	-	1	-	1	5	4	4	2
Dithiocarbamates	130	125	131	-	120	132	155	170	320
Other Fungicides	4	5	3	-	6	6	5	5	23
Inorganics	142	130	175	-	200	320	375	410	350
Triazoles, Diazoles	276	260	1	-	1	5	6	4	6
Fungicide &Bacterial & Seed Treatment	**276**	**260**	**312**	-	**329**	**475**	**550**	**598**	**708**
Rodenticides									
Anticoagulants	-	-	1	-	1	2	2	1	2
Other Rodenticides	-	-	5	-	-	5	4	5	4
Total Rodenticides	-	-	**6**	-	**1**	**7**	**6**	**6**	**6**

Source: FAO