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Integrated Pest Management: Means for Sustainable Agricultural Development in the Developing Countries

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Abstract: Pest management is one of the major area of concern for sustainable development in agriculture in the developing countries. There are various studies that estimated the huge global harvest losses due to pests and effective pest control is thereby of much important to ensure the reality of the attainable production. At present, developing countries are using from a long days and is to use, a significant categories of pesticide chemicals to check this which is proved to be environmentally unsound, productivity hampering in the long run. The industrialist world already has changed their way of pest control from mere the chemical uses although the developing world is far away from that. Integrated Pest Management (IPM) is seen as the way forward to achieve sustainable agricultural production with less damage to the environment. It is often seen as to curb pest-leaded damages to agricultural production by simply treating these with alternative measures other than chemical uses. This study, in this context, attempts to inquiry the nature and scope of using IPM mode of pest control and its prospects in the developing countries aiming sustainable agricultural development.

Key words: Integrated pest management, Agricultural development, Developing countries

Introduction

Pest management is one major area of concern for sustainable development in agriculture in the developing countries. In the eight crops studied, Oerke and others (1994) estimated the global harvest losses due to pests to be about 42 % of attainable production. A study by the International Food Production Research Institute (IFPRI) has highlighted the paradox between the increase of global crop losses over time and the growth of chemical pesticide use (Benbrook and others 1998). If current trends continue, dependence solely on chemical pesticides will not be a sustainable solution, from either an economic or an environmental point of view.

Integrated Pest Management (IPM) is seen as the way forward to achieve sustainable agricultural production with less damage to the environment. While IPM has no standardized definition, it is commonly referred to as a diverse mix of approaches to manage pests and keep them below damaging levels, using control options that range from cultural practices to chemicals. In practice, IPM ranges from chemically based systems that involve the targeted and judicious use of synthetic pesticides, to biologically intensive approaches that manage pests primarily or fully through non-chemical means.

IPM has evolved from a solely technical approach to a more holistic view of the agricultural production system that connects the long-term sustainability of agricultural production with environmental, economic and social issues, including public health. A range of important stakeholders beyond the research and farming community increasingly are expressing their interest in IPM. A watershed was reached when the 1992 United Nations Conference on Environment and Development (UNCED), or Rio Earth Summit, adopted IPM as a cornerstone. National governments, international agencies and other players were asked to increase assistance to increase adoption of IPM in agriculture. Now, 10 years after the Rio conference, a relatively realistic view of sustainable development has been reached. Case studies demonstrate the economic benefits at the farm level, as well as IPM's contribution to reducing environmental and health externalities. Despite this progress, farmers' adoption of IPM is proceeding rather slowly. Even though traditional low-input farming systems often use similar techniques, in many countries, in the context of raising productivity and household income, IPM techniques still are used by only a small number of farmers, primarily in pilot initiatives supported by external donors. The Operational Policy for Pest Management of World Bank governs the financing of pesticides in project investments and mandates a preference for IPM approaches. Since IPM also is included in strategy documents, such as the Agriculture and Rural Development Strategy, Reaching the Rural Poor (World Bank 2003), it is time to review the recent developments in IPM itself and the achievements that the farmer, government and international bodies have made in IPM.

Objectives of the Study: It is observed by the agriculturists, economists, World Bank and others that pest damages a huge portion of the valued agricultural production in the whole world and Integrated Pest Management (IPM) is seen as the way forward to achieve sustainable agricultural production with less damage to the environment. In this context this study has three objectives:

Establish whether recent changes in technology and markets for commodities and inputs, together with changes in the global policy environment, support the conviction that IPM is an increasingly relevant approach and that these trends have a potential to increase the significance of IPM for sustainable agriculture.
Review the status of IPM policies, strategies and technical approaches used by different stakeholders in the IPM field and in international development. These stakeholders include multilateral and bilateral donors, international development organizations, the private sector, producers and NGOs. The review consists of a broad categorization of IPM concepts used, shows the objectives of the IPM policies and strategies and discusses how they reflect recent developments mentioned earlier. Case studies are included to indicate the extent that the policies and strategies are being implemented.
Review progress in IPM implementation in Bangladesh. Also presented are an in-depth study of the IPM components in a subset of ongoing projects and an analysis of constraints.

Theoretical Framework

IPM Definitions: IPM includes divergent approaches ranging from methods based on rational management of chemical pesticides to systems based on ecosystem management that include health issues and human capital development. Ten indicators were selected to classify the IPM definitions used by the different organizations. Most organizations use IPM definitions that combine several of the elements mentioned here.

Meanings of IPM definition indicators: Mix of Techniques: This includes the basic techniques of IPM without indicating a preference. In practice, this can mean the use of chemical pesticides as a default option if preference for these strategies is heavily entrenched.
Economic Factors /Economic and Damage Threshold Levels: Farmers base their decisions on a comparative assessment of the potential crop loss and the costs of pest control. In many cases, this may lead to arationalization of previous overuse of chemical pesticides. However, actual substitution of other pest management practices for pesticide use hinges critically on the availability of locally adapted information about thresholds and the risk and time preferences of the farmers.

Selective Pesticide Use: The most suitable pesticide is used, considering potential interruption of the agro-ecosystem functions and environmental and health aspects. There are no provisions on how the integration with non-chemical pest management practices should take place.
Preference to Non-Chemical Measures: Alternative methods of pest management are chosen over the use of agro-chemicals wherever feasible.

Minimization/ Reduction of Pesticide Use: IPM practices are favored that involve a reduction of pesticide use. This is particularly appropriate if there is a positive correlation between pesticide use levels and negative impacts. However, no preference is given for replacing the most problematic pesticides with more benign practices.
Minimization/ Reduction of Risks to Health, Environment: IPM practices are favored that reduces the risks to the environment and public health. In other words, the most problematic pesticides are addressed first. Pesticide risk reduction is preferred, with the development of sound agronomic practices relegated to a lower priority.
Ecosystem Management: IPM is regarded as a management system that is based on understanding the entire ecosystem of the field and related areas.

Recognition of Farmer Knowledge ("participatory"): IPM is developed by using the farmer's indigenous knowledge and knowledge of his/her own field.

Favoring Local Solutions: Preference is given to local decision making over external and centrally planned interventions.

Sustainability Concept: IPM is regarded as a holistic approach for sustainable development combining economic, social and environmental aspects.
Almost all of the definitions agree on some basic elements of what constitutes IPM. These basics include the technical and economic dimensions, as well as the reduction of health and environmental risks and a farmer-centered view. Only one contentious area still exhibits a lack of consensus: the role of chemical pesticide use in IPM approaches. Some organizations link IPM to a reduction in chemical pesticide use, others avoid this link.
Trends Affecting Pest Management: While farmers have been doing pest management since the onset of

agricultural production, the discovery of the pesticidal properties of synthetic chemicals in the middle of the twentieth century revolutionized agriculture. DDT was discovered as an insecticide in 1939 and was used extensively in agriculture and for public health programs. Subsequently, other insecticides, herbicides and fungicides were developed. Their large-scale use started in farming in industrialized countries, resulting in large increases in production and/or cost savings on labor. The first Green Revolution, which began in the1960s, made high-yielding crop varieties available to developing countries, especially in Asia. Exploitation of the production potential of these varieties stimulated the use of fertilizer and pesticides. This dynamic led to large increases in food production in many countries but also to growing pesticide use.

Rationale for IPM: During the 1960s, due to problems with pesticide resistance in insect populations, a backlash against the agricultural pesticide revolution took place. Integrated Pest Management (IPM) was developed by entomologists as a technical system to minimize the occurrence of resistance and to sustain the long-term effectiveness of pest control (Stern and others 1959).

A second major factor that boosted interest in IPM was the concern about environmental impacts of pesticides, particularly the group of organochlorines. Rachel Carson's book, Silent Spring (1962), raised public awareness and prompted policymakers to regulate pesticide use. In the early 1970s, DDT was banned in many industrialized countries. The 2001 Stockholm Convention on Persistent Organic Pollutants enacted a global ban of DDT, except for limited use in public health. Since then, evidence of the health and environmental side effects of other pesticides has become known and led to further restrictions in pesticide availability. Thus, the rationale for IPM comes from two different angles: (Benbrook, 1996) the limitations in the long-term effectiveness of synthetic chemicals for pest management and (Carson, 1962) the concerns about the negative health and environmental side effects of their use.

IPM is more an approach to sustainable crop protection than a technology or a technology package. In IPM, the available techniques are combined in an integrated management strategy aimed at keeping pest levels below a desirable level (box 1).

Box 1. Integrated pest management technical toolbox

The main features of IPM involve the use of non-chemical methods of pest control:

Biological controls: the use of the natural enemies of crop pests, often called *beneficial*s, which include parasites, predators, and insect pathogens. Environmentally friendly chemical interventions sometimes are included in biological controls, such as the use of semiochemicals, including pheromones and feeding attractants, and biopesticides, for example, specific and beneficial friendly insecticides.

Cultural and crop or livestock management controls: tissue culture, disease-free seed, trap crops, cross protection, cultivation, refuge management, mulching, field sanitation, crop rotations, grazing rotations and intercropping.

Strategic controls: planting location, timing of planting and timing of harvest.

Genetically based controls: insect- and disease-resistant varieties and root stocks.

Source: Adapted from Schillhorn-Van Veen and others 1997

IPM combines natural forms of control, taking advantage of ecological relationships in the agricultural system, with economically derived rules for the application of pesticides. However, the pesticide use in IPM differs from the approach used in conventional pest control. When possible, IPM relies on pesticides that target specific pests, can be applied at lower rates and are less toxic to beneficial organisms. New application methods are being developed that employ biological materials such as pheromones and feeding attractants to lure the target pest to the pesticide. Application rates, timing and frequency are chosen to minimize effects on beneficials. Pesticides that can be substituted for one another are interchanged to slow the development of pest resistance to pesticides. Often, the level is determined by the damage in economic terms. Implementation of IPM comprises:

knowledge about the techniques: management skills to adapt the available tools to the conditions of the local agro-ecological environment and information concerning the status of pests, predators and other environmental factors influencing crop damage.

Therefore, IPM is a more complex approach to pest management than a purely chemicals-based control strategy, the latter often following calendar dates or growth stages of the crop.

The following factors also all affect the adoption of IPM: The state of the agro-ecology; the history of pesticide use; the farmer's access to knowledge, information and inputs; his or her attitude toward pest management and risk avoidance and the prices of inputs and commodities. It is quite evident that the use of purely chemical pesticides rarely qualifies for being called IPM if this choice is not preceded by an information-intensive decisionmaking process. However, purely biologically based pest management strategies often are economically viable only over the longer term, because the biological equilibrium of the soil requires time to adjust. In such cases, rationalization of pesticide use may be the first step toward making pest management more sustainable. Following Benbrook and others (1996), the adoption of IPM can best be described as a continuum ranging from low to high use of biologically based techniques. A similar approach was used in a recent study of IPM adoption in the United States (GAO 2001). Approximately 70 % of the growers adopted 1 of 4 categories of pest management practices: prevention, avoidance, monitoring, or suppression. The USDA counted use of any one of these practices as fulfillment of the IPM target set by the government. However, most of these farmers used practices that could not be directly related to the reduction of chemical pesticides. According to the GAO study, these practices could be called "rudimentary IPM" but would not qualify for a biologically based definition of IPM. For example, the GAO study assessed that biologically based IPM techniques--protecting beneficial organisms, disrupting pest mating, using biological pesticides and using crop varieties genetically modified to resist insects in corn--were used by only 18 % of the growers.

Advancements in Technology and New Modes of Delivery: Results of biotechnology research, including genetic modification, offer new tools for reducing dependency on chemical pesticides
(box 2). New products for biological control are more widely applied, especially in niche markets. The agrochemical industry is developing more specific, targeted agro-chemicals, which fit better into an IPM approach than the older broad-spectrum compounds. Organic farming has evolved into a globally recognized industry and has many linkages to IPM systems with regard to the technologies used in production. Because information is key to IPM, the spread of the Internet and other information and communication technologies has enhanced access to options. Finally, participatory approaches to farmer training and awareness creation increasingly ensure sustainability of pest management practices.

Box 2. Genetic engineering: effects on pest management

Several genes coding for Bacillus thuringiensis (Bt) endotoxins have been introduced in several crops. The major concern is that these crops can select for Bt-resistant insects, especially in cases in which only one insecticidal protein gene has been used, including similar limitations of a finite lifetime as chemical pesticides.

In a recent study, herbicide-tolerant soybean was estimated to have saved US farmers $216 million on weed control in 1999 (USAID 2001). Herbicide-tolerant crops also are useful in environmentally beneficial no-till systems. However, there is a risk of "gene jumping" into weed populations, which then would become resistant.

Using biotechnology, new virus-resistant crops have been developed, but they have been commercialized only in small areas with a few crops, for example, sugarcane, papaya and squash.

Research and risk assessment trials on transgenic arthropods to introduce self-destructing insect individuals into the wild pest population are ongoing.

New vaccines for animal and human health are being developed using genetic engineering with the potential to reduce pesticide applications to control vector.

Molecular markers and DNA fingerprinting can be used to speed up resistance breeding in crops and to develop diagnostic tools.

Sources: USAID/AFS 2001, Raman and others 2001, Dargie 2002.

Biotechnology as a New Tool in IPM: Biotechnology research in plant sciences has made significant advances and is contributing new options to the IPM toolbox. In the broad sense, biotechnology includes techniques such as host plant resistance breeding, molecular markers and insect population control. Transgenic techniques have the potential to increase productivity through introducing pest resistance traits in high-yielding varieties and to combat pathogens where no adequate control measures existed before. Since the introduction of genetically modified (GM) crops in 1996, the production of transgenic crops has grown from 1.7 million hectares (ha) to 52.6 million ha in 2001.

Table 1: Global area of transgenic crops by trait, 2001

Varieties	%ages
Herbicide resistance	77%
Insect resistance	15%
Stacked genes	8%
Total	100%

Source: James 2001a.

The production concentration is 99 % in four principal countries; Argentina, Canada, China and the United States. Other countries that grew GM crops in 2001 were Bulgaria, Germany, Indonesia, Mexico, Romania, Spain and Uruguay (James 2001b). In developing countries, 13.5 million ha of transgenic crops were grown in 2001, 26 % of the total global area of 52.6 million ha. In the past couple of years, the % increase in area of GM crops has been higher in developing countries than in the industrialized countries (James 2001b).

Currently, the use of transgenic crops is restricted to a few herbicide-resistant and insecticidal varieties. The distribution of GM crops by traits can be seen in Table 1.

"Stacked genes" is a term that indicates the presence of both herbicide tolerance and insect resistance in the same variety. The global production of virus-resistant GM crops is less than 1 % (James 2001a). Smallholders in a developing country can benefit from using GM crops. In China, the number of pesticide applications in cotton dropped from 20 to about 7 per season when switching to the Bt cotton variety (Huang and others 2002).

Genetic engineering within an IPM system can offer new pest management tools, but genetic engineering requires sound risk and benefit assessment; appropriate regulatory systems; and caution regarding to environmental, social and economic impacts of transgenic varieties, which have to be evaluated on case by case basis. So far, biotechnology research is dominated by the private sector, which has made huge investments in the technology and targeted it primarily at crops and traits of interest to the industrialized countries.

Biological Control: Traditionally, biological control has been an important component of IPM. The concept of biological control is based on the use of agro-ecological principles to check escalating populations of pests and diseases by counterbalancing natural forces. Entomological research started with the introduction of parasitic and predatory insects to control other insects. Progressively, research has drawn from the entire biological system of microbes—fungi, bacteria and yeasts--and plants to combat different pests, diseases and weeds. Pheromones are used as attractants and biocides are derived from plants such as the Neem tree, or from specific bacteria or fungi. Additional techniques involve the introduction of sterile insect individuals and the use of pest behavior modification chemicals. One of the most successful cases in economic terms is the biological control of the cassava mealybug (box 3).

Box 3. Biological control of the cassava mealybug

Cassava is a major staple food for more than 160 million people in Africa. In the early 1970s, the cassava mealybug accidentally was introduced with planting material. The pest had no natural enemy in Africa and threatened production. The International Institute of Tropical Agriculture (IITA) introduced a parasitoid wasp from Paraguay that keeps the pest within its ecological limits there. Since 1981, the wasp has been released in many African countries and the ecological balance between the mealybug and the predator was restored. Consequently, average cassava yields in Sub-Saharan Africa have increased steadily from 6.7 tons/ha during the 1970s to 8.5 tons/ha in the 1990s. The costs and benefits of the research and release program have been estimated to give an internal rate of return of 261 percent over 40 years. Although the emergency nature of the cassava mealybug problem due to the lack of plant quarantine and other institutional failures probably renders the economic gains exceptionally high, the case demonstrates the potential of biological control in pest management. IITA researchers repeated this success with subsequent research on the cassava green mite, the mango mealybug and the water hyacinth.

Source: CGIAR 2001, Zeddies and others 2001, Waibel 1999.

Some of the states of the Former Soviet Union (FSU) have been active in reviving a large-scale biological control system (box 4). Cuba is another example of a large-scale adoption of biological control. Agricultural production in Cuba received a hard blow at the fall of the Soviet Union since the source of subsidized farm inputs disappeared. Cuba imported $80 million worth of pesticides in 1991 but only $30 million after the break-up of the Soviet Union. Cuba already had introduced biological control in the early 1980s to reduce reliance on chemical pesticides but, with the disappearance of Soviet farm subsidies, was forced to intensify this effort. The IPM system is based on a large number of production centers for biological control agents throughout the country. This decentralized system enables easy access for the local farmers and solves the problem of the relatively short shelf life of most biological control agents. The system functions satisfactorily but is very labor intensive and may be suitable only for countries with low labor costs (WRI and others 2001).

Box 4. Biological control in Turkmenistan

Since 1998, the World Bank has encouraged the Government of Turkmenistan to re-establish its biological control scheme in cotton production, which had been nearly abandoned after independence. Biological control was introduced in the early 1980s after chemical pesticides became ineffective and residues, especially persistent organochlorine compounds, were found in water, soil and food. The break-up of the centrally planned economy of the Soviet Union led to a deterioration of the mass rearing facilities for the control of insect pests in cotton. Since 1998, the government rehabilitated insect rearing facilities (primarily for *Trichogramma* and *Bracon*) and introduced cost recovery from farmers. With over 90 percent of cotton crop protection now under biological control, there are greatly reduced environmental and health risks.

Source: Schillhorn-Van Veen 2000.

The global production and marketing of living biological control agents, such as beneficial insects and natural enemies, has increased fairly rapidly in the last decade with an annual turnover of US$160 million in 2000 (Jarvin 2000). Biopesticides--based on naturally occurring fungi, bacteria, viruses, protozoa and entomopathogenic nematodes--used to control insect pests and constitute about 1 % of the global insecticide market (Dent 1999). Presently, Bt marketing and products have the largest share, but other promising products include the mycoinsecticide, Metarhizium, used for locust control and nuclear polyhedrosis viruses (NPVs). NPVs are manufactured in some developing countries, for example, India and Thailand. Factors such as regulatory requirements, governmental support and marketing strategies have determined adoption by farmers in these two countries (Dent 1999). However, risks accompany the introduction of biological control agents in new habitats, as well as the use of pheromones or biopesticides. Therefore, risk assessment is needed for each case.

Organic Farming: Consumer demand for organic products is rising at an annual rate of 15 % to 30 % in the major markets of Europe and North America. The global area under organic production is more than 17 million ha (IVA 2002), but that equals only 1 % of the world's arable land (including permanent crops) (FAO 2000a). Organic production offers important opportunities to developing countries, because it provides a niche market with a premium price. Latin America already holds over 20 % of the worldwide organic area. A clear distinction exists between IPM and organic farming, which outlaws almost all chemical pesticide use. Nevertheless, the spill-over from the increased interest in organic farming is benefiting IPM in two ways. First, over the last decade, consumer awareness of the environmental and health impacts of modern food production has increased, partly in reaction to food scares and scandals involving pesticide misuse. The spread of organic farming has contributed to public awareness of low-input agricultural production systems, which include IPM. Partly in reaction to the growth of the niche markets for organic food, major retailers and food processors have been launching sustainability initiatives.

Second, the increasing area under organic farming is contributing to mainstream agronomic techniques that use nonchemical pest management practices. Examples are intercropping, crop rotation, double-digging, mulching and integration of crops and livestock (FAO 1999a). Organic farmers rely on natural pest control techniques—such as biological control and plants with pest control properties--rather than on synthetic pesticides. However, organic farming does not allow the use of inorganic fertilizers, something that might be important within an IPM regime where soil fertility is low (FAO 1999b).

IPM as Part of Knowledge-Intensive Sustainable Agriculture: For a long time, IPM research was carried out as component technology development and frequently dealt with individual pest species in specific crops. Only in recent years has a farming-systems and farmer-centered view been adopted, providing for more interdisciplinary research. In these more holistic approaches, the agronomic characteristics of the cropping system are considered along with the social and economic constraints that affect the adoption of IPM practices. IPM research has become more oriented toward the needs of various farmer groups, but, within academic research institutions, incentive systems for funding and awards continue to constrain interdisciplinary studies and promote research on isolated issues (Dent 1996).

Many research institutions have difficulties reaching farmers. Since IPM is a knowledge-intensive system, farmer education approaches have been developed. CGIAR's Systemwide IPM (SP-IPM) program uses "pilot sites" to build effective Farmer-Scientist-Extension (FSE) partnerships (CGIAR 2002). Participatory and farmer-centered IPM training programs are platforms that enable a closer interaction between farmers and researchers. Within Farmer Field Schools (FFS) or local agricultural research committees (CIALs), farmers perform on-farm research and create a link between local and formal research (ODI 2000). The FFS concept has spread to many Asian countries, where it is used in national IPM programs, most prominently in irrigated rice (Weel and others 1999). CABI has used Farmer Participatory Research (FPR) to help validate research results in farmers' fields. IPM concepts also have been introduced for livestock disease control (box 5).

Farmer participation and capacity building facilitate the inclusion of indigenous knowledge in IPM systems. To reiterate, to achieve a sustainable adoption of an IPM system, economic issues need to be considered in tandem with social and environmental benefits and local cultural values.

Box. 5. Integrated management of livestock diseases

Due to emerging resistance of the pathogens to the drugs, the effectiveness of intensive treatment of livestock with veterinary drugs against vector-borne diseases is limited. For example, because the lack of animal traction due to trypanosomiasis (sleeping sickness) limits agricultural development, effective control and management of the Tsetse fly are crucial in many areas of Africa. The International Livestock Research Institute (ILRI) is combining several tools to develop an integrated approach to resistance management in West Africa. The United Kingdom's Department for International Development (DFID) supported research in collaboration with the Zimbabwe Department of Veterinary Services and has developed an integrated method of Tsetse fly control. By using pheromones, the Tsetse flies are attracted to traps of cloth soaked in insecticides. Compared to aerial spraying, this targeted approach greatly reduces the amount of chemicals used. This system is used throughout Zimbabwe and in the neighboring countries of Botswana and Zambia.

Source: DFID 1999.

Market Trends and Changes in the Policy Environment: Requirements of the food industry regarding pesticide residues have become a major force encouraging adoption of IPM practices. The demand for food safety and quality is rising, creating niche market opportunities for certified products, including organic food products. IPM is gaining recognition as a global policy issue, at both the national and international levels.

Demand for Food Safety and Quality

Consumers increasingly demand that environmental and social considerations in agriculture be taken into account. Food safety concerns about pesticide residues and recent outbreaks of foot-and-mouth disease and mad-cow disease in Europe have changed consumer demand patterns for food products. Food processors and retailers are setting higher standards regarding product quality. The rapid growth of organic products has enhanced the public's awareness that there are alternatives to conventional food products. Regulations, such as the United States' regulation on pesticide residues in imports and the new European Union (EU) regulation on maximum residue limits, directly influence the pesticide use on produce destined for these important markets. Developing countries repeatedly have found that shipments with pesticide residues surpassing the limits have been rejected. This adherence to standards has driven some of the smaller export companies out of business. The food processing industry is responding to these developments with increased interest in IPM as a method for quality assurance. A European Retailer Initiative has been formed to issue standards throughout the supply chain, including good agricultural practice and limits for pesticide residues (EUREPGAP 2001). Inspired by the market success of certified organic agriculture, attempts are being made to establish IPM certification schemes, for example, by the International Organization of Biological Control .

Market Trends for Pest Control Products: The markets for chemical pesticides have undergone rapid changes. The crop protection industry of the industrialized countries has witnessed a consolidation through acquisitions and mergers resulting in a few global research-based companies. The 27 large and medium-sized research-based agrochemical companies that existed in 1983 have declined to 8 in 2002. The six largest multinational agrochemical corporations account for about 85 % of the total annual worldwide pesticide sales, estimated at US$29 billion. Developing countries have bought 37 % of that total (table 2). Several forces drive the consolidation of the pesticide industry. First, research, development and registration of new products are becoming increasingly costly. The German Agrochemical Industry Association estimates that the total cost of product development from compound screening through registration is more than US$100 million (IVA 1999). Second, some companies have adopted the concept of life science (pharmaceutical-agrochemical-seeds) in the company profile. This orientation contributes 4 Recent industry data show that the total pesticide sales of the multinational companies declined by more than 7%, from US$27.5 billion in 2000 to US$25.6 billion in 2001 (IVA 2002).

Table 2: Global Crop Protection Market, 2000 (in $ millions)

Product type	Industrialized countries	Industrialized countries	Total
Herbicides	9,311	,483	13,794
Insecticides	3,888	4,121	8,009
Fungicides	3,913	1,888	5,801
Others	1,028	330	1,358
Total pesticides	18,140	10,822	28,962
Biotech	2,373	671	3,044
Total	20,513	11,493	32,006

Source: James 2001a.

Third, globalized trade patterns necessitate a company's presence in all major markets to ensure rapid market penetration with new products and fast recovery of research and development investments.

The ongoing consolidation of the agrochemical industry affects IPM prospects in developing countries. Research-based multinational companies focus on product development for crops with a large area in markets in Japan, North America and Western Europe. They consider other markets, such as minor crops in high-value markets of OECD countries and many crops in developing countries, to be of secondary importance. Because niche markets do not offer enough economic incentives for large corporations to invest in product development, fewer and fewer innovative pesticide products are being made available to the small markets for crop production in developing countries, Intuitively, one might expect that IPM would benefit from this situation, because farmers' attention would shift to non-chemical tools. However, the opposite has happened. Farmers and extension services are still caught up in the thinking of the Green Revolution, relying on pesticides as quick solutions for their pest management problems. The pesticide industry is investing large amounts to advertise their products worldwide.

In addition, the increasing availability of generic, non-brand, off-patent pesticides, which tend to be inexpensive but more toxic for human health and the environment, is not benefiting IPM adoption. The spread of generics is a disincentive to IPM systems since those pesticides, especially insecticides, tend to be broad-spectrum compounds that destroy the agro-ecosystem balance by killing natural predators that help to keep pests below economically damaging levels. Since generic pesticides are not produced under a respected company's brand name, they involve variable safety regulations. A recent study from Pakistan showed that an increase in the share of generics in the pesticide market has contributed to the deterioration of standards in quality assurance, distribution, use and disposal (Ahmad 2001 and others). In some developing countries, such as China and India, the production and use of generic compounds is increasing. OECD expects that the production of chemicals will continue to shift from industrial to developing countries (OECD 2001).

IPM as a Global Policy Issue: The 1992 United Nations Conference on Environment and Development (UNCED) and its Agenda 21 were an important step for spreading the concept of IPM. In chapter 14 of AGENDA, IPM Fig.s prominently as a key element of sustainable agricultural development. For the first time, governments and NGOs agreed on the need for a long-term perspective on resource conservation, safeguarding the environment and economic development. Although the optimistic view of the 1992 Rio Earth Summit has waned in the last decade and given way to more realistic expectations about the feasibility and political acceptance of the sustainable development paradigm, the global interest in IPM has continued to grow.

The need to address IPM as a global policy issue is based on three considerations: Due to increased international trade, pests travel globally. One prominent example is white-fly, which has become a major problem on all continents and in such various production systems as Production of flowers, vegetables, cassava and cotton (Gutierrez and Waibel 2002).

Global trade and food standards are changing and influencing developing countries' opportunities in international trade. IPM can help ensure access to export markets and foster global integration.

Pesticides have externalities that, in many cases, not confined to national boundaries, for example, the contamination of international waters. IPM has environmental, health and social benefits that are difficult to specify and often not accounted for on the local level.

Policies at global and national level are increasingly interdependent as they influence pest management through regulations of international trade, food and environmental safety and intellectual property rights. Recent examples of initiatives at the global level are the Pesticide Risk Reduction Initiative of OECD and FAO (OECD 1999); and the pesticide-related international conventions on Prior Informed Consent, signed in 1998 (Rotterdam Convention) and Persistent Organic Pollutants, signed in 2001 (Stockholm Convention). A Global IPM Facility has been cofounded and supported by the World Bank, FAO, United Nations Environment Programme (UNEP) and United Nations Development Programme (UNDP). The facility's mission is to promote the adoption of IPM through, for example, addressing the problem of limited access to IPM expertise by developing country farmers, governments and NGOs (World Bank 2002).

IPM Implementation Strategies: Four levels of involvement were studied to categorize the scope and status of the IPM strategies. Policy and strategy documents as well as specific projects were reviewed to assess the scope of involvement in four major areas:
Support to research on technologies used in IPM approaches and to genuine interdisciplinary IPM research
Field-level implementation of IPM, such as training extension workers and farmers to use IPMapproaches.
Support to developing countries to build national institutional capacity for development of national IPM programs
Support for a conducive public policy environment in developing countries, including regulatory reform and dismantling pesticide subsidies.

Conclusions

The shift toward recognizing the sustainability dimension of IPM is evident in policy documents of the World Bank, ADB, OECD, DFID and the other organizations studied. These documents link IPM to issues such as environmental and health protection, long-term sustainability of resource use and compatibility with local preferences. Discussion continues concerning the inclusion of biotechnology, especially genetic modification technologies, in IPM approaches. In many countries, IPM interventions have been planned without a clear view of the problems in pest management based on thorough analysis of the technical, institutional and socioeconomic constraints. In some cases, they are "add-on" activities in regular project components such as research and extension that tend to be isolated. Projects could benefit from a comprehensive approach to pest management, integrating interventions in a national IPM strategic plan. Simultaneous and coordinated interventions based on identifiable targets and benchmarks are likely to be more effective. The safeguard policy on pest management should address more specifically the deficiencies in the institutional framework and the lack of capacity of client country agencies. Additional tools may be required to assist countries like Bangladesh to upgrade their regulatory and economic policies influencing pest management and improve their institutional capacity in research, development, information delivery and environmental monitoring.

Policy Suggestions: Sustainable agricultural development requires multi-dimensional approach and introducing IPM is the one important of those. However from the growing concern over increasing food security, marketable surplus from agriculture and for the purpose of the sustainable development of the farm and the farmer of the developing countries following steps could be taken:

Biotechnology as a New IPM Tool: Genetic engineering's potential for food security and sustainable agricultural practices should be recognized by government and private organizations.
Importance of adequate regulatory frameworks is required by all organizations.
Strategy for transparency with objective information reaching farmers, consumers,
and decision-makers is required.
Use of biotechnology required because it focus on product research and large-scale commercial agriculture.

Biological Control: Support should be targeted toward research and technology development as_Biological control involves high up-front research cost and slow adoption .
Biological efficacy of most products is too unreliable, so increasing awareness should be developed.
Need to increase local knowledge on biological control, cultural practices and resistant varieties.
.nvolvement of national and International organizations to support development of biopesticides.

IPM as Part of knowledge-intensive Sustainable Agricultural Systems: When introducing IPM, all should made a participatory approach fundamental, because IPM is a knowledge-based technology.
Holistic and interdisciplinary IPM research systems should be promoted.
Increased collaboration among scientists, private sector and farmers is necessary to address farmers' concerns and

ensure adoption of research results.
Strengthening public research is essential to address needs of poor smallholders.

Organic Farming: Support research on biological control, which benefits both IPM and organic systems.
Low-input agricultural systems and increased demand from industrial countries provide opportunities to raise incomes in developing countries.
establish organic standards and certification procedures with public and private partners.
Information Communication Technology and Precision Farming: .nsure access to information as a key factor for farmers' decision-making ability. not only to large-scale farmers but for the small holders.

Demand for Food Safety and Quality: IPM's importance for addressing food safety and quality should be especially recognized by the private sector and the NGOs.
IPM should target as an important element in the development of export markets for high-value agricultural products as the domestic consumers are yet to take this positively.
It is important to prepare national pesticide residue standards to comply with the market and food quality regulations in cooperation with the industrial countries.

Market Trends for Pest Control Products: To train farmers to rely less on pesticide more depend in IPM, while trying to optimize profits, is discussed. The large influence of the private sector on the farmer is recognized.
A stronger role for the pesticide industry in promoting IPM need to concur with the commitment to reduce pesticide use.

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