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# CONCLUSIONS AND RECOMMENDATIONS

The farmers in the Bagmati subregion fall into two distinct categories. The farmers in the midhills of Kabhre, Dhading, Rasuwa, Nuwakot, and Sindhupalchowk districts are generally subsistence farmers, although with improvements in accessibility and availability of services, some of them are beginning to commercialise their farming operations. The use of pesticides by these farmers is limited. They depend on natural diversity. There is a need to educate these farmers on the usefulness of biotic factors for pest management. The expensive production technologies with which the usage of pesticides is closely associated must also be promoted, but it should be carried out in a manner that reinforces the use of biotic factors and not recklessly, as is happening in many parts of the subregion. Extension training programmes should be implemented to educate them about the dangers of pesticides to human health and the environment. The other farmers in this region, growing commercial crops such as vegetables and potatoes in Bhaktapur and Dhading, have already been exposed to the use of pesticides. Extension programmes must ensure safety and judicious use based on the critical needs of farmers.

Their level of literacy may not enable them to clearly understand the instructions on the labels and this often results in poor selection of pesticides and misuses. Dieldrin is specifically recommended for controlling termites in houses and it proved to be effective in killing aphids in broad-leaved mustard in the course of experiments. The urban consumer is prone to pesticidal hazards and extended misuse leads to consequent environmental hazards and pest resistance. Thus, registration of safer pesticides; regulations and strict licensing schemes for trained dealers, retailers, and commercial users; and periodic monitoring of their activities are necessary. In addition, integrated pest management and use of bio-control agents, judicious use of the diverse ecosystem, for example, use of local herbs with potentials for pest control, should be considered. Training and creating mass awareness about pesticidal hazards are also important.

## Integrated Pest Management

Integrated pest management (IPM) is a pest management system that uses a rational combination of biological and chemical means in economically beneficial ways. Broadly speaking, IPM is based on ecological knowledge and includes crop biology, pest biology, and biology of predators and parasites as well as other abiotic environmental factors. Pest containment is based on cultural, biological, physical, and chemical methods, and these tools of pest management are used according to the need of farmers and the economics of crop production. The strategies involved include identifying pests, estimating the number of natural enemies and pests, and determining the stages of plant growth as well as the vigour of plant health. Management costs play a decisive role. IPM requires strong, practical research input for effectiveness. However, research need not be costly as it is field-based. IPM appears complicated, but when farmers visit their farms at least once every day, and they are encouraged to develop their knowledge of pests and their natural enemies, great success can be achieved as in Indonesia, for example.

It is quite difficult to post reasonably knowledgeable experts who can work with farmers in the districts and villages. Constant working and learning with the farmers alone can make IPM

more simple, more efficient, and, therefore, more profitable. However, this can be achieved by imparting training to the JTA/JTs working in the villages and also to the subject matter specialists working in the districts. Trainers' training in IPM constitutes, therefore, the most practical approach.

**Biodiversity: Aid to Pest Management**

Hill agriculture has a unique feature. The same commodity is cropped in diverse micro-environments as the altitudinal range is wide. For example, rice cropped in the river valleys of the Trishuli (<600 mm) in the Kathmandu Valley (1,260m), and on the slopes of Chautara (600-1,200m), in essence resemble the humid tropics of South India, the Po Valley of Italy, and parts of the Korean peninsula. These diverse micro-environments within a short distance of the Bagmati subregion are the habitats of a whole range of pests that affect rice. These various pests, in turn, provide habitats for even more diverse bio-control agents that thrive on them. An earnest attempt to harness these resources for pest management is indeed a practical probability. One can argue that the pests are dangerous, which is indeed a possibility, but the near-complete, natural bio-control potential of subsistence farming provides better manipulative possibilities. An example can be given of this. *Brevicoryne brassicae*, an aphid pest of leafy mustard (*rayo*), cabbage, cauliflower, broccoli, etc in Kathmandu is also found in Kakani. The probability of finding thriving population of its bio-control agent in subsistent farmers' plot of Kakani is much better and this can be easily bred and released in Kathmandu in order to control the dreaded aphids. Thus, bio-diversity is an essential tool for pest management and is highly recommended for extensive practical use.

**Biotic Factors**

Before the advent of modern synthetic pesticides, the farmer's chief weapon against pests was the use of their natural enemies such as predators, parasites, and pathogens to control them or periodically deny them food, i.e., plants, through ordinary practices. In addition, varieties less susceptible to attack and use of more susceptible crops as traps were often employed as control measures. Biotic methods of pest management are now advocated in multiple control schemes.

Every natural organism has its natural enemies in the form of predators, parasites, pathogens, and competitors. For instance, woolly aphids, a dreaded pest affecting apples, has more than eight types of ladybirds and crysopa as natural predators, a few aphilinids as parasites, and a few entomophagous *fungi* as pathogens. These control the pest population. The main advantages of using these agents for control compared to the use of pesticides are (a) selectivity; (b) a manufacturing process is not required; (c) bio-control agents seek pests wherever they lurk; (d) bio-control agents increase in number over time; (e) pests do not get the opportunity to build up resistance; and (f) control is self-perpetuating. Bio-control agents could be conserved, inoculated, and used. This strategy should be studied and utilised extensively in strip farming practices for pest control, i.e., in the form of one strip of those of a different crop between two suitable ones which form a barrier to pest migration and consequent damage.

Several plants have pest-controlling properties; *Ageratum conyzoides, Artemisia asiatica, Acorus* sp are a few examples. These can be used by farmers in pest management.

Cropping of indigenous varieties with greater resistance to pests also provide gene diversity. Non-crop plants, e.g., weeds, growing adjacent to cropped fields are also useful control factors. These could be of immense importance.

**Ecological Factors**

Ecological factors are both biotic and abiotic. They exert an important influence by arresting the population explosion growth of pests. Biotic factors have already been mentioned above and some of the major abiotic factors are discussed below.

The diverse agriculture of the Bagmati Zone falls under different temperature regimes, i.e., cool temperature (over 2,800m in Sherpa and Tamang villages); warm temperate (over 800m in the Kathmandu Valley); and subtropical (river basins). The biodiversity of this region is a reflection of the abundant abiotic factors favourable to plants and animals. The major factors are annual precipitation; monsoon; light hour regimes; seasonal fluctuation of temperature; wind velocity; proximity of the solid surfaces of hill slopes providing variations in reflected warmth and light around the cropped area; and the presence or absence of frost, fogs, and mists.

It is common knowledge that in winter, when growing potato crops are subjected to several days of morning fog, they are invariably attacked by late blight. Similarly, severe insect epidemics in rice are reduced substantially if there is continuous rainfall for several days (probably due to the lower temperature). Severe winters favour sexual reproduction of some aphids in primary hosts and, consequently, in spring the offspring invade annual crops - their alternate host. Early rain in spring results in the growth of lush green vegetation and activates hibernating pests to grow and damage crops grown in summer. Abiotic factors are important mechanisms for population control but their manipulation is seldom practicable, especially in field crops. However, this principle could be successfully used to lengthen the storage period of apples in the Sindhupalchowk and Rasuwa districts. The low winter temperature can be used to contain weevils and moths in store godown as is practiced in some areas of China.

**Floral Diversity**

The flowering stage of plants coincides with the evolution of pollen and nectar-eating insects and birds. Wasps, bees, and syrphids fall within the *Hymenoptera* and *Diptera* categories. The majority of the natural enemies of pests fall into these orders and floral diversity helps to retain the evolutionary balance maintained by nature. The chronological sequence of non-crop, flowering plants provides food to the beneficial adult insects of these groups in the form of both pollen and nectar. Therefore, floral diversity is an important factor in natural, biological pest control. Flowering weeds in and around crop fields and hedges should, therefore, be conserved.

**Quarantine Issues**

Quarantine is a legal process which checks the spread of an obnoxious pest in a habitat from a similar habitat elsewhere. In Nepal, it is often considered in terms of checking the entry of pests from foreign countries and quarantine checkposts are established in the border areas. However, in-country quarantine should also be considered within the context of Nepal. The seeds of important crop varieties, fruits, vegetables, cuttings, and seedlings are distributed from one centre to another and throughout the production area. There is a possibility (as has been found

on several occasions) of pests spreading in a so far unpolluted environment. The spread of greening disease in citrus is an example. Its spread within Nepal follows the pattern of the horticultural development activities of the concerned department. A few years back, a Malathion-resistant strain of *Sitophilus oryzae* was detected in the Seed Processing Factory at Hetauda. This factory belongs to the Agricultural Inputs' Corporation which deals with the supply of improved seeds of high-yielding varieties, mainly cereal grains. The possible spread of such resistant strains to clean areas, and consequent infestation, leaves farmers with no alternatives for safe control, which can be provided by Malathion (one of the safest pesticides in current use). Therefore, quarantine is more relevant within Nepal which is a land-locked country. Bihar and U.P. pests are in no way different from *terai* pests. Similarly, the cold desert areas of Mustang and Dolpo may not differ very much from areas of the Tibetan Plateau. However, mango orchards of the low lying Indrawati Basin in Sindhupalchowk differ a lot from those of Sarlahi regarding pest infestation and control. Strong quarantine measures are necessary to prevent the spread of insects and diseases.

**Marketing Constraints**

In Chapter 3 we have detailed the uses of pesticides and some aspects of marketing in the Bagmati subregion. Additional issues will be discussed in some detail in the following paragraphs.

Both private sector dealers and the AIC are actively involved in pesticide marketing, but neither of them offer satisfactory services in a manner that is accessible to the farmers. Both have a very limited range of pesticides in stock which farmers are compelled to buy in the event of unavailability of recommended safer pesticides. The shops of both of these pesticide dealers are located in the district headquarters or nearby areas such as Nagadesh in Bhaktapur; Banepa in Kavre; and Bidur in Nuwakot. Farmers have to travel long distances to buy necessary pesticides, therefore valuable time is lost, sometimes resulting in crop losses due to pest damage.

The packages of solid formulations and liquid bottles pose further problems for the farmers. The land holdings of Nepalese farmers are small, hence, small amounts of pesticides are required. Packages and bottles of appropriate volume are not sold in the market. This results in unnecessary, additional costs and the extra pesticide is either lost or spilt, thereby endangering the vicinity. Accidental poisoning may occur. The labels on the packets are often written either in English or Hindi, or both. Many farmers are unable to read and understand these languages. The use of Nepali, or alternatively pictograms, would enable the farmers to clearly understand the instructions.

The registration of safer pesticides, periodic training to dealers working in various marketing chains, licensing, and constant monitoring of their activities are needed to improve the situation.

**Quality Control**

The quality of pesticides in the market is less than desirable as has been discussed before in this paper. Farmers are often cheated. Lack of monitoring leads to several biological problems. A sub-lethal dosage of pesticide often enhances the resistance of pests. Consequently, farmers no longer

benefit from the usefulness of control technology. Sale of substandard pesticides should be checked. For this, a series of control measures, including checks on the products for sale on the dealers' premises and tests of their quality in the pesticide laboratories. Laboratory quality assurances, good laboratory management practices, laboratory accreditational schemes, and collaborative inter-laboratory studies on pesticides are necessary as such laboratories have not been set up in Nepal. It is important to set pesticide standards similar to those of our neighbouring countries and check chemicals in their laboratories. In regional meetings on pesticide regulations, it has been recommended that such reference laboratories be established in an appropriate country for this purpose. AIC should set standards for buying pesticides and carry out quality checks. Private dealers should check all pesticides for sale and observe the ISI mark, so that only pesticides of good quality are sold in the region. Farmers must only be encouraged to buy pesticides that have been checked, and this can solve the problem of substandard pesticides to a great extent.

**Policy Constraints**

A remarkable feature of pesticide use in Nepal so far has been the absence of any pesticide policy. Even today, when there is great concern for the quality of life and the quality of the environment, pesticides, which are among the greatest man-made pollutants, are used carelessly. There is no clearly-defined policy controlling their sale and use. The lack of a crop protection division; the lack of capacity to enforce pesticide laws; the absence of facilities to monitor pesticide quality; and failure to check for residues in food, fodder, feed, soil, water, and air have resulted in difficulties in monitoring the existing situation objectively. However, attempts have been made. In fact, policy aspects have been documented in this paper. The existing facilities are not managed properly and are often neglected. Therefore, measures cannot be implemented properly in the absence of the smooth functioning of existing facilities. The Entomology Division, which has made pioneering attempts in this sector, instead of developing into a Plant Protection Division, remained only a cereal crop research division, whereas it was expected that it would cater to horticultural, agricultural, arboricultural food storage, and pest control aspects as well as to research. Their laboratories never received timely and sufficient funds, whereas other departments unduly poured money into a senseless array of projects in the name of research. Policy needs and implementation should also be considered.

**Other Environmental Protection Measures**

Birds, snakes, and frogs are important elements in maintaining natural balance. The usefulness of mynas, drangoes, and shrikes in regulating the insect population number can be easily determined by observing their voracious insectivorous behaviour during land tillage. Most frogs are carnivores in their adult life, as are snakes. Falcons, harriers, hawks, and eagles are mostly predators of small rodents and birds. Their role in balancing the population of obnoxious insects is important. Bait-poisoned rats and use of bio-accumulative, persistent, broad-spectrum poisons of the organochlorme group are the greatest hazards. Their use must be severely restricted if not completely banned. The insectivorous spiders in paddy agro-ecosystems are similarly affected by the indiscriminate use of pesticides. To avoid this, pesticide registration, regulations, safe use, and strict adherence to the international code of conduct for use of pesticides are essential. Acts and regulations in themselves have no meaning if effective training and educational schemes

are not implemented, so that the people involved in the chain of activities related to pesticides acquire knowledge of safe use. A network of people to implement IPM and promote the safe use of pesticides should be developed and delegation of responsibility is required in order to improve efficiency.

**The Recommended Approach for Judicious Use of Pesticides**

Pesticides are never recommended as the only pest management tool in Nepal. They should only be used as a last measure. The recommended methods for controlling the principal pests in rice are given below.

1. Paddy Pests

   Paddy Hispa (*Dicladispa armigera*)
   - Clean weeds to deprive hispa of its alternative host.

2. Borer Complex (*Tryporiza incertulas; T. annotata; Chilo supressalis; C. zonalus; Sesamia inferens*)
   - Burn the stubble to kill hibernating larvae and pupae.
   - Keep a field of volunteer plants.
   - Collect the tips of seedlings to get rid of the egg masses.

3. Plant and leaf hoppers (*Sogatell furcifera; Nephotattix* spp.; *Cicadella spectra;* and *Kolla* spp.)
   - Collect hoppers by means of light traps.

4. Rice bug (*Leptocoryza acuta*)
   - Clean gramineous weeds where alternative hosts may be present.
   - Early planting protects from pest attack.
   - Clean volunteer plants.

5. Rice Blast (*Piricularia oryzae*)
   - Use resistent crop varieties.
   - Clean cultivation.
   - Uproot and burn affected plants.
   - Use seeds that have not been infected.

Similar examples can be cited in the case of other pests as well, but more often such preventive methods do not work and use of pesticides is essential. The recommended approach for judicious use of pesticides is given below.

1. Use of pesticides for seed treatment is cost-effective, because the volume of pesticide

required is minimised and clean seeds prevent early infestation.

2. Pest control is necessary to render the crops pest-free when they are transplanted to a larger area where there is little use of pesticides and limited possibility of pesticide hazards.
3. Need-based use of pesticides, i.e., timely survey and identification of pests by standard survey methods, e.g., by estimating pest numbers by means of standard hand net, light traps, or yellow tray methods is necessary.
4. Use of safer formulations. Granular pesticides are the safest.
5. Use of gloves, boots, and goggles while mixing pesticides in containers.
6. Use of safe aprons and clothing, e.g., loose trousers and long, loose dresses.
7. Use of pesticides, either in the morning or late afternoon hours, when the wind is of low velocity and the problem of drift is minimised.
8. Read the labels of containers carefully and adhere strictly to the instructions.
9. Pesticides should be kept in a locked cupboard so that they are out of the reach of children, pets, and other domestic animals.
10. Pesticides should be stored far away from food stuffs or medicines.
11. Knives for opening pesticide containers should be kept separately.
12. Empty pesticide containers should be destroyed and should not be re-used for any other purpose.
13. Application of pesticides should never be carried out against the direction in which the wind is blowing.
14. Spilling pesticides should be avoided and clean water and soap should be used for washing.
15. Long-handled mixers should be used while mixing spray and bare hands should never be used.
16. While handling pesticides, smoking, chewing tobacco or betel nut, or even drinking water should be avoided.
17. After application, hands and other exposed parts of the body should be thoroughly washed with soap and water. New washed cloths should be used. Clothes worn during spraying or dusting should be washed thoroughly.
18. The nozzle or other parts of the equipment used should not be blown by mouth and contaminated washes from spray appliances should be buried.
19. The appliances and empty containers should not be washed near streams, wells, or ponds so that contamination is avoided.
20. In the case of suspected poisoning, the nearest physician should be called immediately and, where such facilities are far away, first-aid treatment, i.e., induced vomiting, washing, or placing the victim in a safe environment, is necessary.

In addition to these recommendations, care should also be taken during transportation and storage of pesticides in retail shops.

1. Pesticides should never be transported by porters or mules. The bullock carts used for transporting food should not be used for transporting pesticides.