UN environment programme

Guidelines on Alternatives to Highly Hazardous Pesticides

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Glossary

CABI	Centre for Agriculture and Bioscience International
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
HHPs	highly hazardous pesticides
IPM	integrated pest management
IVM	integrated vector management
NGO	non-governmental organization
OECD	Organisation for Economic Co-operation and Development
UNEP	United Nations Environment Programme
WHO	World Health Organization

Table of **Contents**

Glossary v

1. Introduction 2

2. Defining and addressing highly hazardous pesticides 3
2.1. Making decisions about highly hazardous pesticides 3
2.2. Effectiveness of risk mitigation options 4
2.3. Advances in knowledge and technology 6
2.4. Compliance with policy 6

3. Defining and addressing highly hazardous pesticides 9
3.1. Desirable features of pest management tools 10
3.2. Solutions for farmers and traders 11

4. Who should be involved and what are their roles? 12
4.1. Regulators 12
4.2. Farmers, farmer associations and other users of pest control tools 13
4.3. Vendors, importers, producers and registrants 13
4.4. Extension services and other advisers 13
4.5. Research bodies and academia 14
4.6. Health authorities 14
4.7. Environment authorities 14
4.8. Consumers 14
4.9. Media 15
4.10. Public-interest groups 15

5. What can replace a highly hazardous pesticide? 16
5.1. Key principles in identifying alternatives to highly hazardous pesticides 16
5.2. Replacement options 17

6. Evaluating alternatives 19
6.1. Efficacy in controlling the target pest 19
6.2. Availability and means of application 20
6.3. Hazardousness and toxicity for the environment and human health 20
6.4. Durability in the face of resistance (for low-risk pesticides) 20
6.5. Technical feasibility (also called practicability or ease of implementation by farmers) 20
6.6. Cost-effectiveness 21
6.7. Legislation 21
6.8. Trade risks 21
6.9. Incentives and disincentives 21

7. References 22
Annex I: Resources 25
Annex II: Case studies 28

List of Figures

Figure I. Hierarchy of risk management options for chemicals 5
Figure II. Features of alternatives to highly hazardous pesticides 9

1. Introduction

Highly hazardous pesticides (HHPs) are those that are acknowledged to be of a particularly high level of acute or chronic hazard to health or the environment according to internationally accepted classification systems, such as that of the World Health Organization (WHO) or the Globally Harmonized System of Classification and Labelling of Chemicals (GHS), or according to their listing in relevant binding international agreements or conventions. In addition, pesticides that appear to cause severe or irreversible harm to health or the environment under the conditions of use in a country be considered to be and be treated as highly hazardous (Food and Agriculture Organization of the United Nations [FAO] and World Health Organization [WHO] 2014).

Decisions about whether an HHP should be used in a country generally rest with national pesticide regulators. Sometimes, pesticide producers or traders may decide to withdraw a product, and in other cases major buyers of agricultural products instruct their growers or suppliers not to use certain pesticides. As a result, HHPs are taken out of use in situations where health and safety considerations, environmental concerns and trade requirements determine that they cannot continue to be used.

Most pesticides (about 80 per cent) are used by farmers in crop production, with an estimated 13 per cent used in industry and by government authorities (for example, for disease vector control or highway maintenance) and about 8 per cent used in domestic environments. Women, men and children all play roles in agricultural production and also in other sectors where pesticides are used, and it is important to consider the different ways in which these groups may use and be exposed to pesticides and the different types of impact that the pesticides may have on them.

When HHPs are removed from use because of health or environmental concerns, farmers and other users need alternative ways of controlling the pests or diseases that the HHP was used to fight. There is often an expectation that whatever replaces an HHP should be equally effective, similarly priced, easy to buy and easy to use. Meeting all those expectations is not always possible and may not always be desirable. For example, the replacement of an HHP with a biocontrol agent may necessitate the training of users, which makes its use initially more complex, but the replacement of an HHP with a chemical pesticide may give rise to different health or environmental risks that are undesirable. This issue is explored further in section 5.

This document is designed to:

- Identify the roles of the different stakeholders in the process of replacing HHPs and suggest how they can support one another in order to maintain agricultural productivity while protecting health and the environment;
- Provide information and reassurance that there are viable alternatives to HHPs.

This document is not a catalogue of alternatives to HHPs as it would be impossible to produce such a thing. Each crop, pest, ecosystem and national regulatory system potentially requires different solutions for pest management, and the options and variations are therefore infinite. This document is thus a guide to the consideration of and the process of deciding on suitable alternatives to HHPs.

This document is also aligned with the Guidelines on Highly Hazardous Pesticides (FAO and WHO 2016), published under the International Code of Conduct on Pesticide Management (FAO and WHO 2014), and with the modules of the Pesticide Registration Toolkit (FAO 2016) on HHPs and on the assessment of alternatives. The Pesticide Registration Toolkit is designed to support pesticide regulators in their decision-making processes, while this document is aimed at a broader audience of policymakers, decision makers and advisers from the agriculture, health and environment sectors who may wish to engage in those decision making processes with an understanding of what is possible in terms of replacing HHPs.

2. Defining and addressing highly hazardous pesticides

A relatively small proportion of all pesticides in use are HHPs. A survey of pesticide registers in African, Caribbean and Pacific countries found that between 6 and 10 per cent of registered pesticides were HHPs (FAO 2021). The rationale for action is therefore that the cessation of use of a relatively small number of pesticides could remove many of the most serious hazards to health and the environment.

Eight criteria define whether a pesticide is an HHP (FAO and WHO 2016). These criteria were developed by the Joint Meeting on Pesticides Management, which is an international expert group that advises FAO and WHO. Those criteria are:

- **Criterion 1:** Pesticide formulations that meet the criteria of classes Ia or Ib of the WHO Recommended Classification of Pesticides by Hazard; or
- **Criterion 2:** Pesticide active ingredients and their formulations that meet the criteria of carcinogenicity Categories 1A and 1B of GHS; or
- **Criterion 3:** Pesticide active ingredients and their formulations that meet the criteria of mutagenicity Categories 1A and 1B of GHS; or
- **Criterion 4:** Pesticide active ingredients and their formulations that meet the criteria of reproductive toxicity Categories 1A and 1B of GHS; or
- **Criterion 5:** Pesticide active ingredients listed by the Stockholm Convention on Persistent Organic Pollutants in its Annexes A and B and those meeting all the criteria in paragraph 1 of Annex D of the Convention; or
- **Criterion 6:** Pesticide active ingredients and formulations listed by the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade in its Annex III; or
- **Criterion 7:** Pesticides listed under the Montreal Protocol on Substances that Deplete the Ozone Layer; or
- **Criterion 8:** Pesticide active ingredients and formulations that have shown a high incidence of severe or irreversible adverse effects on human health or the environment.

2.1. Making decisions about highly hazardous pesticides

The primary role of pesticides is to protect agricultural crops from attack and losses caused by pests and diseases. Pesticides are also used to protect people and animals from vector-borne diseases and parasites and to protect materials such as timber and fabrics from deterioration. In almost all cases, pesticides, because of their intrinsic nature and wide use, have undesirable impacts on health and the environment. HHPs have disproportionately high negative impacts on human health and/or the environment that may only become apparent after years of use. Pesticides also have different types of impact on women, children and men. Women carry the additional risk of passing toxins on to their unborn children and to infants that they are breast-feeding. The susceptibility of women to hazardous chemicals can vary on the basis of their reproductive cycle and different life stages, such as pregnancy, lactation and menopause, when their bodies undergo physiological changes that may affect their vulnerability to health damage from chemicals (International Labour Organization 2021). Children are more vulnerable to the toxic effects of pesticides because they are still developing and have smaller bodies with a proportionally higher surface area that can result in higher exposure, and their behaviour, such as crawling and putting things in their mouths, can expose them to higher pesticide doses. Women and children commonly have lower literacy levels than men and therefore cannot read and interpret pesticide labels and warning signs. They also generally do not benefit from the training that men may receive on pesticide hazards and self-protection. The roles of women and children in farming communities may also result in higher and unrecognized exposure to pesticides through, for example, their entry into fields that are being or have recently been sprayed or cooking/playing in spaces where pesticides are stored (Kawarazuka *et al.* 2020). For these reasons, HHPs require special attention from pesticide regulators, traders and users.

HHPs that meet criteria 1, 5, 6 and 7 have been assessed by expert panels and international bodies and found to be highly hazardous because of their acute toxicity, chronic health effects or environmental impact. Criteria 2, 3 and 4 depend on the classification of a chemical under the GHS, which is done by national authorities. Countries that apply the GHS, but do not have the capacity to evaluate and classify chemicals themselves, often use classifications made by other authorities such as the European Union (EU). Some pesticides are listed in more than one HHP criterion. Criterion 8 allows authorities to decide for themselves that a pesticide should be treated as a HHP if it is found that there is a high incidence of severe or irreversible adverse effects on human health or the environment. The listing of a pesticide as an HHP under criterion 8 is a matter for the national authorities or other bodies that make decisions about pesticide use, and no external validation is needed. For example, paraquat, which is an herbicide that is not listed in any of the HHP criteria 1 to 7, has nevertheless been banned by many national authorities because it is extremely toxic to humans, is widely used as a suicide agent, has no antidote and is suspected of having long-term effects on the health of people who are exposed to it in a prolonged manner.

The listing of a pesticide as an HHP under any of the eight criteria does not require any further action to be taken. The decision about how to control HHPs rests with national regulators or other decision makers. Recognizing that HHPs are more hazardous than most pesticides, several bodies and organizations that set policy directions or provide guidance to governments (including the Convention on Biological Diversity, the European Commission, FAO and WHO) have suggested that HHPs could be phased out and replaced with less hazardous alternatives.

In considering the impacts of HHPs, attention should be given to data, records and anecdotal evidence that may exist in the health and environment sectors. Hospitals, rural clinics and doctors often have experience of dealing with people who have been poisoned by pesticides, but there may not be a system for recording and reporting these cases. It is also important to generate and consider gender and age disaggregated data, especially when it comes to pesticide poisonings. As stated above, the toxic impacts of a pesticide vary significantly in women, children and men, and these differences should also be considered in regulatory and policy decisions. Similarly, cases of wildlife or livestock poisonings and environmental contamination by pesticides may e known in the environment sector, but may not be recorded or reported. The impacts on wildlife, which may seem trivial or isolated, may have much wider ecological implications. Reductions in populations of important organisms such as birds, predatory insects or reptiles may be gradual and take time to be noticed and recorded. Pesticide regulators should make efforts to identify and investigate such evidence, as it can significantly contribute to regulatory decisions about pesticides.

The FAO Council suggested that the activities of FAO could include pesticide risk reduction, including the progressive banning of HHPs (FAO 2006a). In 2015, the International Conference on Chemicals Management adopted a resolution that recognized HHPs as an issue of concern and called for concerted action to address HHPs, with “emphasis on promoting agroecologically-based alternatives and strengthening national regulatory capacity to conduct risk assessment and risk management” (International Conference on Chemicals Management [ICCM] 2015). Several regional pesticide regulatory bodies (the Coordinating Group of Pesticide Control Boards of the Caribbean, the East African Community and the Southern African Pesticide Regulators Forum) have developed or are developing HHP strategies that aim to identify and reduce the harm caused by HHPs, and a growing number of countries are evaluating their pesticide registers and removing or restricting HHPs.

Given that HHPs are disproportionately harmful compared with other pest management options, many pesticide regulators and other decision-making bodies have acted to eliminate that harm. This raises two key questions:

1. What is the most effective action, taking into account gender considerations?
2. What will replace an HHP if it is taken out of use or restricted?

The following sections address these questions.

2.2. Effectiveness of risk mitigation options

In discussions about HHP use, the issue of risk mitigation or risk reduction often arises. This relates to the measures taken to protect people and the environment from the harm that HHPs are known to cause while the pesticides continue to be used. Although risk mitigation measures in theory take account of gender and age, the availability of recommended equipment and the applicability of the suggested measures, in some cases the risk mitigation measures implemented on the ground may overlook some of issues for consideration, such as whether women or children should be working with pesticides or whether personal protective equipment is available or affordable.

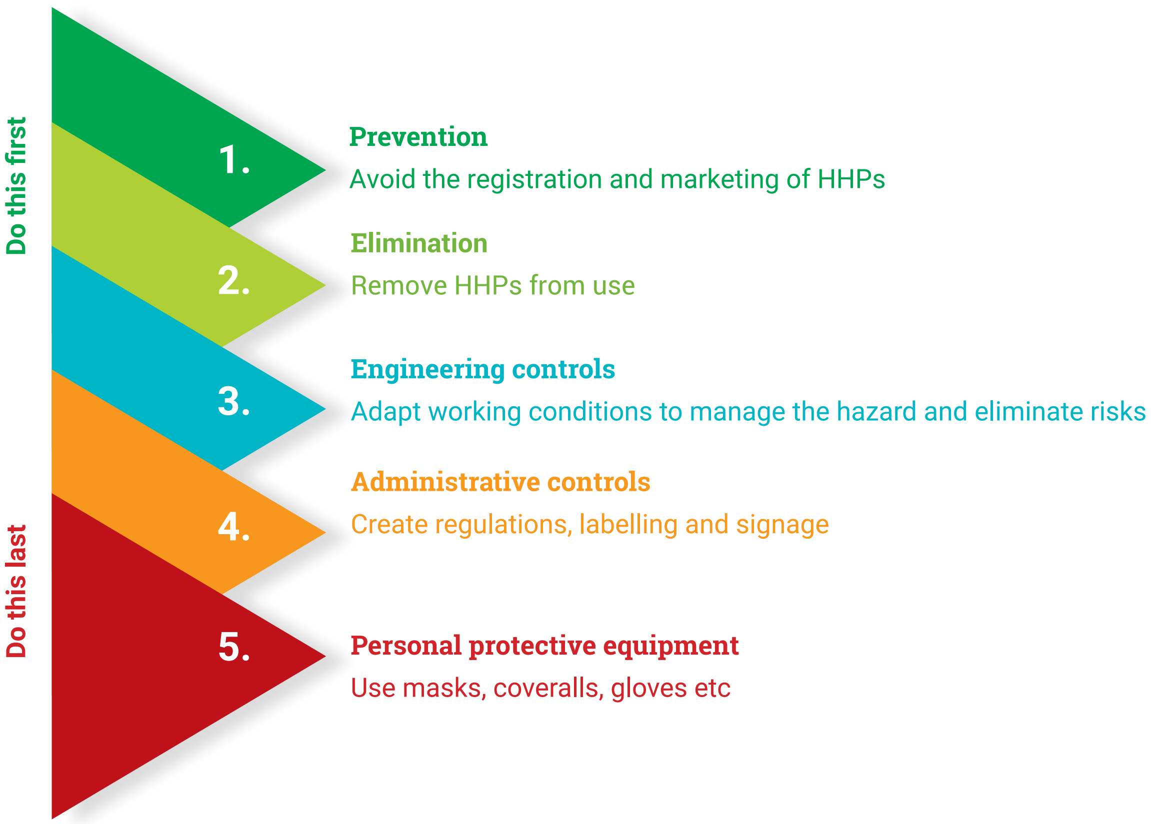
For example, in some countries, HHPs are permitted for use and include label instructions that require personal protective equipment to be used. In most lower- and middle-income countries, such equipment is not available or is expensive, which means that farmers and other users of pesticides do not buy and use it. Training in the correct use and maintenance of personal protective equipment may also not be available. In hot countries, such personal protective equipment is uncomfortable, so even in the rare cases that it is available pesticide applicators choose not to use it. An HHP that can be used safely only when personal protective equipment is used cannot therefore be used safely in countries where such equipment is not available, not affordable or not used. Article 3.6 of the International Code of Conduct on Pesticide Management states that "pesticides whose handling and application require the use of personal protective equipment that is uncomfortable, expensive or not readily available should be avoided, especially in the case of small-scale users and farm workers in hot climates" (FAO and WHO 2014). Consideration also needs to be given to the people who are exposed to the HHP because of their work and presence in the area where the pesticide is stored, prepared, applied or disposed of. This includes women and children, who are also less likely to have access to mitigation measures because of the training needed, the cost or even the physical fit of the personal protective equipment, for example. Other administrative or engineering controls exist and are used in some places to mitigate the health or environmental impact of hazardous pesticides. In countries where enforcement is weak, however, the monitoring of health or environmental risks does not exist, high-quality equipment or equipment using advanced technology is not available or not used, pesticide applicators are not trained or licensed and engineering and administrative controls do not work well and cannot be relied upon to manage risks.

Figure I shows the widely recognized hierarchy of risk management options for chemicals, which applies well to pesticide use.

Taking an HHP used in agriculture as an example, figure I can assist with risk management as follows:

Risk management option 1 proposes that HHP use can be prevented by avoiding the registration and preventing the import, production or marketing of pesticides known to be highly hazardous. This can be done by including the HHP criteria in the pesticide registration process and by checking

Figure I. Hierarchy of risk management options for chemicals



whether products are registered or prohibited in other countries. The registration status of pesticides in other countries can be found on national websites in many cases or through the websites of regional regulatory bodies. Much of this information is listed in section 6 of the present document and can also be found in the Pesticide Registration Toolkit (FAO 2016). Pesticide Action Network International also maintains a list of banned pesticides, which draws on publicly available information, and efforts are made to update it annually.

Risk management option 2 indicates that the most effective measure for reducing the risks caused by HHPs that are already registered and used is to eliminate their use altogether. This can be done by revising and adopting the pesticide registration criteria, by using the HHP criteria and by re-evaluating all the pesticides on the market against these criteria.

Risk management option 3 suggests that there may be ways in which the HHP can continue to be used, with measures being applied to reduce the associated risks. These might include safer containers, different application methods or changes in formulation. In practice, such measures have been found to be largely ineffective, particularly in lower- and middle-income countries where the higher cost of such measures, lack of training and literacy and limited access to the relevant technology makes them inapplicable.

Risk management option 4 proposes administrative controls that may include regulations, for example, to limit to specially trained individuals the purchase and the role of applying the HHP. Other administrative controls may include the licensing of pesticide applicators or the labelling of HHPs to make their hazards more obvious. Administrative controls are only as effective as their enforcement, which is often weak.

Risk management option 5 suggests the use of personal protective equipment such as masks, coveralls, gloves and boots. In lower- and middle-income countries, personal protective equipment is rarely available, rarely used, costly and generally unknown among pesticide users. As a risk management option, personal protective equipment is therefore largely to be considered as the last and weakest option.

2.3. Advances in knowledge and technology

HHPs are generally pesticides that were developed several decades ago. The science associated with pesticide chemistry and understanding of the health and environmental impacts of pesticides have advanced significantly since then. Regulatory processes now require more studies to be conducted in greater depth than would have been required, for example, when the nematicide fenamiphos was first registered in 1968. These older chemicals may have been re-evaluated under current regulatory requirements by many authorities, but in other jurisdictions they may still be registered on the basis of their original evaluation. In most countries, pesticides are registered for a fixed period of time. When the registration period expires, regulators can re-evaluate pesticides to decide whether they meet current health, safety and environmental requirements, which may have changed during the registration period. Many regulatory authorities in lower-and middle-income countries lack the capacity to re-evaluate pesticides because they are overstretched evaluating and registering new pesticides.They may also lack the knowledge and resources to re-evaluate older products against more recent standards and criteria. Particularly in higher-income countries, newer pesticide evaluation requirements have resulted in many HHPs being withdrawn by their manufacturers or rejected by regulators because they were unable to meet modern requirements.

2.4. Compliance with policy

Agricultural policy

Agricultural policy in many countries and regions is moving towards more sustainable approaches that aim to protect the environment from the negative impacts of agricultural activities. Many policies aim to stop the widespread use of pesticides that contaminate the environment, reduce biodiversity and affect beneficial organisms such as pollinators. HHPs, however, are generally incompatible with policies for sustainable agriculture and therefore need to be removed from use. FAO has published the useful Guidance on Pest and Pesticide Management Policy Development (FAO 2010). As an example, the European Commission in its Farm to Fork Strategy (European Commission 2020) has committed that it “will take additional action to reduce the overall use and risk of chemical pesticides by 50% and the use of more hazardous pesticides by 50% by 2030”.

The Guidelines on Highly Hazardous Pesticides (FAO and WHO 2016) give examples of policies and administrative measures that can enhance lower-risk pest management including:

- Promotion of integrated pest management (IPM)[1] and integrated vector management (IVM)[2] through investment in training, communication and further research and through the monitoring of their effectiveness;
- Improvement of the availability and distribution of low-risk biological alternatives;
- Use of good agricultural practice schemes and other non-regulatory options to promote substitution of HHPs by pest management approaches and products that pose less risk;
- Consideration of the use of financial incentives (e.g. subsidy or taxation instruments) to favour low-risk products, such as biological control agents and most biopesticides, over high-risk products;
- Development of schemes whereby pesticides are available only on prescription from a plant protection officer;
- Encouragement of the development of professional pesticide application services to prevent application by individual farmers. Such schemes may require safeguards against unnecessary applications.

Health policies

Health policies have multiple objectives and are likely to include protecting people from unintended exposure to harmful substances. These would include HHPs at work or as contaminants in food or water. Since it is difficult, and sometimes impossible, to protect agricultural workers from exposure to the pesticides that they are using, particularly in lower and middle-income countries, and to keep pesticides out of water or food entirely, the use of HHPs will likely need to be halted for there to be compliance with such policies. Indicator 3.4.2 of Sustainable Development Goal 3, "Ensure healthy lives and promote well being for all at all ages", calls for a reduction in deaths by suicide. Given that pesticides are the third most common means of suicide globally, with a higher prevalence in lower- and middle-income countries, and that an estimated 160,000 people die from pesticide ingestion annually, it has been demonstrated that removing HHPs that cause human deaths is the most effective way of saving lives (Eddleston and Gunnel 2020).

Health policies may also aim to improve diets by encouraging greater consumption of fresh fruit and vegetables. Consumer concern about pesticide residues in food has sometimes resulted in reduced consumption of fresh produce, particularly when publicity about the residues of dangerous chemicals is released. The removal of HHPs from use and the elimination of pesticide residues from produce, to the extent possible, are therefore beneficial to such policies. Support for organic or biological farming and the labelling of sustainably produced food items are also ways of incentivizing farming to use fewer pesticides and safer production and pest management systems. At the same time, farmers who use no or fewer pesticides may have their efforts undermined if neighbours continue to use pesticides that drift on to their fields or if post-harvest treatments are applied to protect produce en route to markets. This shows the need for policies that address pesticides to be effectively integrated across all sectors, including agriculture, health and the environment.

Environmental policies

Environmental policies aim to keep pollutants out of the environment, protect and enhance biodiversity and natural resources, protect habitats and prevent the poisoning of wildlife. Many such policies will be designed to comply with international agreements such as the Convention on Biological Diversity and to support national attainment of the targets of the Sustainable Development Goals. The Aichi Targets of the Convention on Biological Diversity required Parties to take various actions to protect and enhance biodiversity. For example, Aichi Target 3 stated that "by 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied". These targets have now lapsed and the new Kunming-Montreal Global Biodiversity Framework adopted under the

1 IPM is defined in the International Code of Conduct on Pesticide Management (FAO and WHO, 2014) as "the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human and animal health and/or the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms".

2 IVM is defined in the International Code of Conduct on Pesticide Management (FAO and WHO, 2014) as "the rational decision-making process for the optimal use of resources for disease vector control. It aims to improve efficacy, cost-effectiveness, ecological soundness and sustainability of disease vector control interventions for control of vector borne diseases".

Convention includes a target to reduce the overall risk from pesticides and highly hazardous chemicals by at least half by 2030. Sustainable Development Goal 3 sets target 3.9, which is, by 2030, to reduce substantially the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination. The continued use of HHPs risks undermining the achievement of these objectives in many ways. This justifies the removal of HHPs from use.

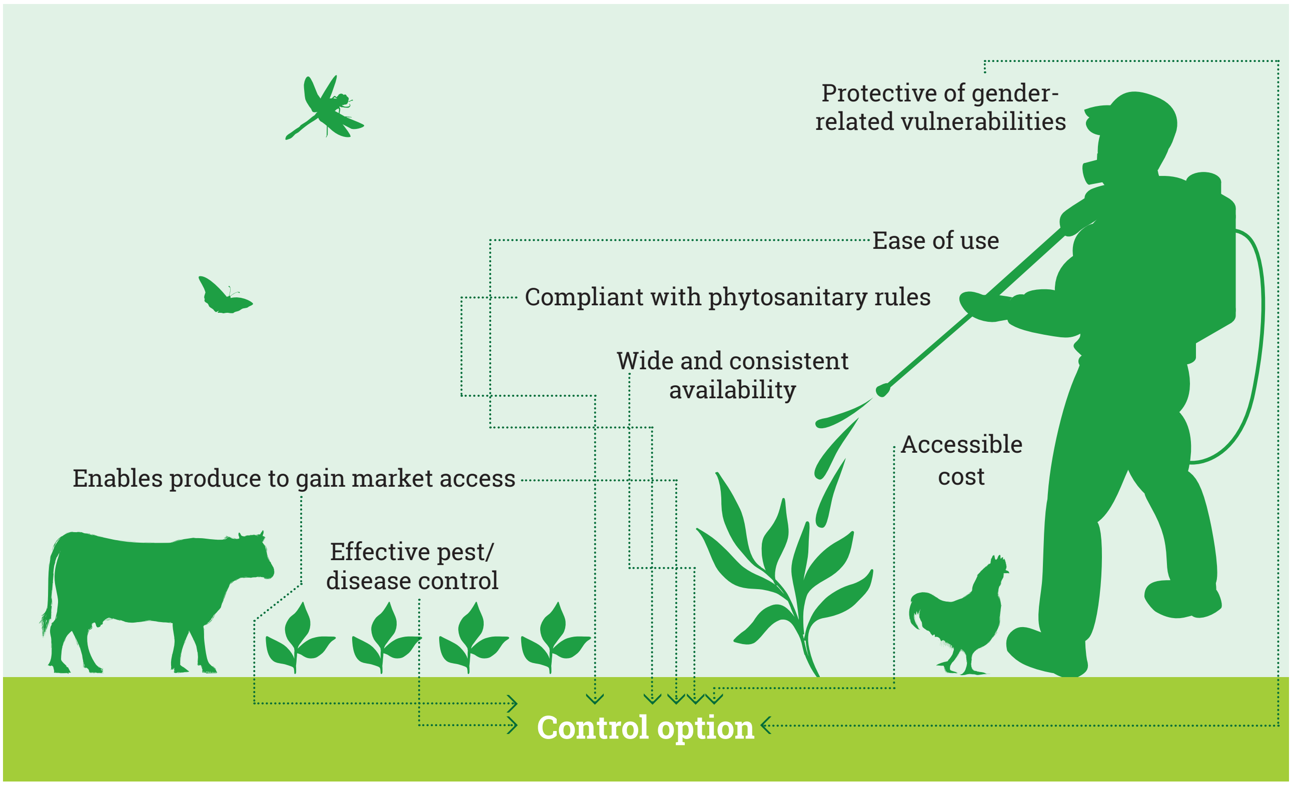
A portrait of a young woman who owns an African organic vegetable farm holding a seedling tray of vegetable seeds. to be transported to the nursery, greenhouse. Female business owner. © Shutterstock/ Kikujiarm

3. Defining and addressing highly hazardous pesticides

The decision to remove a HHP from use requires clarity regarding what is available to replace it. Figure II shows the features of pesticide alternatives that may need to be addressed in the choice of control option. In some cases, alternative methods or products may be available already, and removal of the HHP may not have any negative impact on farmers or other users. If no alternatives are readily available, then a comprehensive understanding of what the HHP is used for is needed to ensure that its replacements fulfil all the functions of the HHP. Some HHPs may not need to be replaced if, for example, they are no longer used because the crop is no longer grown or the pests that the HHP was used on are no longer present.

HHPs are often perceived as being cheap, effective and easier to use than, for example, biopesticides. These perceptions are false because the full costs of using HHPs include their negative impacts on health, biodiversity and the environment and possible trading losses because of unacceptable pesticide residues. Efficacy is often misjudged, because HHPs are commonly broad spectrum and therefore also kill many beneficial organisms that can help to control pests. This can lead to pest resurgence, which requires the more frequent application of the pesticide. Ease of use is a falsehood, because the use of HHPs requires personal protective equipment, which is expensive and uncomfortable, and application equipment that is well maintained and calibrated.

Figure II. Features of alternatives to highly hazardous pesticides



3.1. Desirable features of pest management tools

Availability

Ecosystem services are freely available to anyone who knows how to use them. Notably, when training is provided in the use of ecosystem services or other alternative pest control methods, it is not generally directed towards the men and women doing the work, who usually have limited or no access to such training, despite being equally important contributors to agricultural production. Products such as traps can often be produced locally at a low cost. Insect predators and parasites can be bred in local insectaries, but some investment and training are need for them to be established effectively. Other products, such as biopesticides and low-risk, selective pesticides, may need changes in current supply chains to ensure constant availability. It is important that farmers have access to the tools that they need when they need them, otherwise they are likely to revert to using HHPs.

Ease of use (application methods)

Non-chemical control options often require knowledge that is generally provided through training. Once trained, women and men farmers can use alternative controls as easily as chemical sprays, if not more easily. In some cases, the alternative action may be as simple as observing and allowing natural predators to eat pest insects. In other cases, farmers may need to place traps in a number of locations and to monitor what is caught.

While training can be seen as costly, it can ensure sustainability, better health, improved biodiversity and a higher income, which will benefit both farmers and the population as a whole. It is also important to recognize that the correct use of chemical pesticides also requires training in the prevention of health and environmental hazards; sprayer calibration and maintenance; the timing, dosage and conditions of application; and other topics. Such training is, however, rarely given to farmers. An investment in chemical pesticides also requires a financial outlay and hence carries the risk of getting into debt, whereas non chemical options often do not incur any up-front financial risk.

Gender-sensitivity

Despite their major and often overlooked contribution to agricultural production, women commonly have significantly less access to personal protective equipment, training opportunities and financial resources such as credits and loans, are more likely to be illiterate and less educated than men and are differently and generally more severely affected by the toxic effects of pesticides. There is also the risk that they will transfer the toxicity to their unborn children. The gender considerations of pesticides and their more sustainable alternatives should be addressed by regulators and policymakers to ensure that women are adequately protected and that they have equal access to training, education, information about alternatives to HHPs and financial resources for the transition to alternatives.

Pest/disease control effectiveness

Pests cannot be eradicated completely, and it is not always desirable to do so if natural predators or parasites play a role in the control, as since their food source may disappear if no pests are present. Agroecological methods, IPM and non-chemical control tools aim to keep pests at below the level at which economic losses will be caused. There is also evidence that in some cropping systems the use of pesticides seems to stimulate higher levels of pest infestation, while the absence of pesticides in the same systems does not reduce yields (Horgan and Kudavidanage 2020). There is even evidence that the use of synthetic pesticides and fertilizers to maximize yields actually makes crops more nutritious and hence appealing to pests (Martinez *et al.* 2021). Alternatives to HHPs that include ecosystem services, traps and barriers, biopesticides and cultural controls are generally more effective and always more sustainable than the use of HHPs.

Compatibility with production systems

Agricultural production systems are evolving to meet consumer demands for safer food and more environmentally and socially sound practices. National policies and the protocols of major trading organizations also require practices that increasingly preclude the use of HHPs. Alternative pest and disease control options, such as agroecology and biopesticides, are generally compatible with the most stringent production standards and do not leave pesticide residues that might jeopardize international trade. The use of HHPs is largely incompatible with agroecological pest management practices, biological control and similar production systems. Increasingly, HHPs need to be removed from use in order for farmers to be compliant with the production systems that national policies require them to apply and the trading protocols that they adhere to.

3.2. Solutions for farmers and traders

Yield losses and yield reductions

Concern about yield losses and crop damage from pests and diseases that result from the removal of an HHP can be unfounded and can also generally be addressed using agroecological, cultural, physical and biological methods before other chemicals are considered. While pesticides are marketed to protect crops from damage and losses, chemicals are by no means the only tools available. Farmers can be better informed that the presence of a pest does not necessarily mean that yield and crop losses will result. There are even cases where some pest damage stimulates better crop growth (Creelman and Mullet 1995; Guo *et al.* 2014). Pesticides can increase pest damage by generating pest resurgence (Trumper and Holt 2002) and resistance (Guedes and Cutler 2013), can inhibit crop growth in some cases and can damage overall agricultural productivity as a consequence of wider ecological damage caused by the pesticides, such as the suppression of pollinators and soil biota. Pesticide use almost doubled globally between 1990 and 2019 (FAO 2022), but increased pesticide use has not translated into equivalent reductions in crop losses, which have remained largely static at between 20 and 40 per cent of potential yields. Farmers that do not use synthetic pesticides or limit their use to be compatible with ecological systems consistently report improved livelihoods owing to lower input costs combined with consistent yields.

Blemishes and cosmetic appearance

In the case of cosmetic appearance, consumer awareness programmes have been successful in increasing acceptance of blemished but otherwise undamaged produce. Such initiatives also reduce food waste. Improved access to markets, storage, cold chains and packaging all contribute to produce reaching the consumers in better condition. The use of pesticides for cosmetic reasons should be discouraged.

Phytosanitary requirements

International trade in agricultural produce is subject to phytosanitary requirements that aim to prevent the transboundary movement of pests and diseases. Exporters must have the tools to comply with these requirements, otherwise their markets may be jeopardized. The International Standards for Phytosanitary Measures (FAO and the International Plant Protection Convention [IPPC] 2017) do not specify the use of pesticides to control pests and diseases of concern. Authorities may use any suitable treatments or control measures, the majority of which are not based on chemicals.

Post-harvest treatments

The protection of agricultural products that have left the field until they are consumed may be needed for a matter of hours for soft fruits or flowers or for months for grain or root crops. In all cases, multiple options exist, including temperature and light control, anaerobic storage to prevent pests from being able to breathe and the partial processing of the crop to destroy fungal or bacterial pathogens.

4. Who should be involved and what are their roles?

A regulatory decision to take an HHP out of use has an impact on many stakeholders. It has generally been found to be beneficial to involve the stakeholders listed below early in the decision-making process so that they can prepare themselves and ensure that viable alternatives are made available in good time.

4.1. Regulators

Pesticide regulators would normally lead the process of decision-making regarding the replacement of HHPs with suitable alternatives. The replacement of HHPs creates an opportunity for regulators to facilitate provision of the most effective and sustainable pest management solutions and not to act exclusively as a gateway for blocking or authorizing the sale and use of chemicals.

As stated previously, the replacement of an HHP with another synthetic chemical pesticide may be unnecessary given that so many agroecological, cultural, mechanical and biological options are available. The replacement of an HHP with another chemical pesticide may be an option as a temporary measure, while long-term more sustainable options are sought or developed or when no other non-chemical option is available. Nevertheless, it should be borne in mind that all chemical pesticides have some undesirable health and environmental effects, which is why they need to be evaluated and regulated. The removal of one set of chemical related problems and their replacement with a different set of problems is termed "regrettable substitution". Regulators can:

- Work with agronomists, farmers, the private sector, researchers and others to identify effective pest management strategies and tools that cause no harm to people and the environment (recognizing that the alternative to a chemical pesticide may be a combination of a number of agroecological, cultural, mechanical and biological options);
- Prioritize and incentivize the registration of low-hazard products, such as biopesticides and semiochemicals, taking into account gender-related concerns with regard to pesticides and access to alternatives, as noted in section 3.1 above on desirable features of pest management tools;
- Use the FAO Pesticide Registration Toolkit (FAO 2016) to find data sources and regulatory decisions from other countries that can help to guide national decision-making processes;
- When a pesticide's registration expires, re-evaluate that pesticide against current criteria and not against the criteria that existed when the pesticide was first registered years previously;
- Prevent the registration of HHPs that meet criteria 1, 5, 6 or 7 or have been classified by other countries under GHS criteria 2, 3, or 4, or have been banned or restricted in other countries because of hazards;
- Work with neighbouring countries to harmonize regulatory decisions about pesticides and thereby prevent cross-border smuggling.

Informed decision-making requires data, including gender-disaggregated data, which is often absent or limited, especially in lower- and middle-income countries. Several of the stakeholders listed below may be able to provide or generate data that can guide regulatory decisions. Otherwise, data from other countries, international organizations or academia can be helpful.

Indian woman harvesting cotton in a cotton field, Maharashtra, India.© Shutterstock/ CRS PHOTO

Regulators may also lack the capacity, tools and experience to evaluate and register possible alternatives to HHPs, which may include biopesticides, semiochemicals, macrobial organisms or genetically modified organisms. In such cases, the involvement of specialist organizations or advisers, specialist training and the use of new tools and methods may be necessary. Limitations related to the evaluation and registration of new pest management products should not stand in the way of consideration of their viability as replacements for HHPs.

There may also be situations where an HHP is replaced by agronomic practices rather than a product. In such cases, regulators may not have a role in evaluating or registering a product, but rely on extension services or researchers to describe and disseminate a solution.

Other regulatory bodies can also be consulted and included in evaluations and decision making processes. Such authorities include those responsible for phytosanitary controls, import controls, food security and public health.

4.2. Farmers, farmer associations and other users of pest control tools

Farmers are knowledgeable about and experienced in dealing with pests and diseases and should be included in consultations about replacing HHPs. In general, farmers are open to innovation when it seen to be to their benefit financially and technically (i.e. the innovation makes their farming better in some way). Farmers and other users of pesticides are widely conditioned to buy pesticides from local suppliers, but can equally become used to finding pest and disease management solutions in their local ecosystems and to buying non chemical pest management tools such as traps, barrier netting and biopesticides. Diagnosis of and advice on crop pests and diseases is also increasingly available through apps, such as the evolving Pests and Alternatives app by the IPM Coalition, that can guide farmers to ecological and non-chemical solutions. Ensuring that women and men farmers have equal access to information and tools is an important for the effective replacement of HHPs and the uptake of alternatives. The removal of an HHP that may be in widespread use is best done in consultation with its major users to ensure that they have confidence that viable, cost-effective alternatives are available. When farmers and other pesticide users are not included in decisions to remove pesticides, they may resort to using illegally imported or counterfeit pesticides that may pose additional hazards to people, crops and the environment, or they may face crop losses as a result of having inadequate access to effective pest management tools.

4.3. Vendors, importers, producers and registrants

Ensuring that agricultural input suppliers are engaged in the process of removing and replacing HHPs increases the likelihood of compliance with regulatory decisions and the effective provision of alternatives in a timely and cost-effective manner. Suppliers are often able to identify alternatives to HHPs and other pesticides owing to their connections with other countries, manufacturers and international networks. While some suppliers may wish to protect the market for pesticides classified as HHPs, giving those suppliers the option of promoting alternatives, with possible additional benefits such as fast-track registration for bio-control products, can act as an incentive for the replacement of HHPs.

4.4. Extension services and other advisers

Government extension services

Government extension service providers should be informed and trained so that they may advise farmers on agroecological and non-chemical pest and disease management. Where effective agricultural extension services operate, they are important in guiding and influencing farmers on best practices. The review of pesticide use and the removal of HHPs from use is an opportunity to revise the advice that is given by extension services so that it supports national policies and strategies for sustainability, risk reduction and food safety in agriculture.

Traders

Traders in agricultural produce, in local and export markets, can be important drivers for change in agricultural practice. When markets demand safe, residue-free food and non-food products, such as flowers and cotton, traders can instruct farmers to switch to different techniques to protect their crops, avoid the use of certain pesticides and adhere to pre harvest treatment intervals. The use of HHPs frequently leads to the rejection of imports because pesticide residues exceed the Maximum Residue Limits (MLRs) in importing countries. The replacement of HHPs is therefore in the interest of food traders, and they can be important stakeholders in supporting changes in practices on the farm and during the post-harvest treatment of produce. The demand for organic and sustainably produced fibres and other products is also driving traders to demand reduced pesticide use and safer pest management options.

Standard-setting bodies

A growing number of international trading platforms for important agricultural commodities are setting their own standards for pesticide use along with many other parameters such as social working conditions and environmental conservation. Growers that sell their produce through one of these platforms may already have been required to stop using certain HHPs, and they will have been advised on the alternatives to use. National action to remove HHPs is likely to increase the number of farmers that comply with these standards and potentially open new markets to them. The inclusion of standard-setting bodies in discussions about the removal of HHPs is likely to accelerate such processes and benefit a larger number of growers.

4.5. Research bodies and academia

HHPs are rarely replaced by a single product. Often the experiences of other countries can be drawn on in terms of the removal of HHPs from use and the use of viable replacements to control the same pests and diseases. In some cases, it may be necessary to find a control solution for specific crop–pest combinations, and the proposed alternatives need to be field-tested for efficacy. National research bodies and academic institutions have an important role to play in this process, and their involvement as early as possible is therefore crucial so that solutions are developed and made available in a timely manner. For better evidence-based policy development, it is also essential that research bodies and academia look into the gender related perspectives of access and usability of such alternatives and to support gender-sensitive occupational safety and health with regard to pesticide exposure and its adverse effects.

4.6. Health authorities

Medical practitioners, poison-information and toxicology services, data managers and others in national health systems may have information on the health impacts of HHPs that pesticide regulators and users, who are primarily in the agriculture sector, are not aware of. Their engagement in decision-making processes is important to ensure that the pesticides of highest concern in terms of their impact on health are being prioritized for action. It is important to note, for example, that some pesticides that cause a particularly high number of fatalities when ingested are not automatically classified as HHPs because they do not meet the first seven of the eight HHP criteria defined by the FAO/WHO Guidelines on Highly Hazardous Pesticides (FAO and WHO 2016). Examples of such chemicals are paraquat, aluminium phosphide, mixed formulations of chlorpyrifos, and cypermethrin (Dawson *et al.* 2010). Health authorities with the appropriate capacity could track the impact of the changes that result from the ban of an HHP, for example by comparing the death and poisoning rates from particular pesticides before and after a ban, using gender- and age disaggregated data.

4.7. Environment authorities

HHPs often contaminate environmental media and reduce biodiversity through the direct or indirect poisoning of beneficial organisms, including pollinators and pest predators. It can be difficult, however, to identify the specific environmental impacts of individual pesticides as, often, many pesticides are used in the same environment. Nevertheless, environment authorities, researchers and civil society organizations may have important knowledge about the impact of pesticides that should be part of the debate on the replacement of HHPs. The same may apply to authorities that are responsible for water quality. Like health authorities, environmentalists with the appropriate capacity can track the changes that come about as a result of HHP bans, such as increases in pollinators or other beneficial organisms. Environment authorities may also have specific objectives to work towards, such as the newly adopted target of the Kunming-Montreal Global Biodiversity Framework of the Convention on Biological Diversity, which calls for a reduction of the overall risk from pesticides and highly hazardous chemicals by at least half by 2030 (Convention on Biological Diversity 2022).

4.8. Consumers

Consumer awareness about food safety and other sustainability measures related to agriculture, is an increasingly important driver in raising farming standards in many countries. The inclusion of consumer organizations in decision-making on pesticides at an early stage not only contributes consumer opinions to the debate, but also ensures consumer support for the changes that are introduced. For example, if as a result of HHP bans food is safer but also has more surface blemishes, consumers can be taught to accept such changes without complaint. Women play key roles as the primary buyers and preparers of food in most societies. Focusing on raising women's awareness of food safety, therefore, and on their capacity to demand safe food from retailers can work to empower them in situations where they often feel disempowered in the face of the commercial power of supermarkets, food processing industries and even market stall holders and shop owners.

4.9. Media

The media can play an important role in raising awareness about the hazards of pesticides and the benefits of alternatives and about food safety and environmental concerns, including gender-specific risks at the global, regional and national levels. They can also be engaged to report responsibly on pesticide suicides. The reporting should not sensationalize such acts or provide information about such methods of suicide, and it should direct distressed individuals to appropriate support services or help within their own communities.

4.10. Public-interest groups

Public-interest, civil society, non-governmental and similar organizations often have good knowledge of and access to resources that can be helpful in identifying problematic pesticides and finding viable alternatives to HHPs. The involvement of such organizations in discussions is beneficial in terms of finding appropriate solutions to priority problems and of gaining the confidence and support of communities served by such organizations. Public interest groups can also play a key role in raising awareness among community-based organizations about the gender-specific risks of hazardous pesticides and the related needs of women and vulnerable groups.

Farmer working on soybean plantation, examining crops development in early growth stages, Responsible organic farming of soya bean plants.© Shutterstock/ Bits And Splits

5. What can replace a highly hazardous pesticide?

Before the time-consuming and complex process of replacing an HHP is initiated, it is worth considering the extent to which the HHP in question is used. The regular review of the national pesticide register can help to identify HHPs and other pesticides, the usefulness of which has lapsed for various reasons. In some cases, national regulators have found that certain of the HHPs registered for use are not actually used or may be used very little or are not imported or sold. This may be because the pesticide was registered at an earlier stage for crops that are no longer grown or for use against pests or diseases that are no longer prevalent. In these cases, it is easy to deregister the HHP with confidence that there will not be any negative impacts and no replacements are needed.

Many HHPs, however, are in active use and do require viable alternatives.

5.1. Key principles in identifying alternatives to highly hazardous pesticides

The pest problem has to be understood

HHPs are often broad-spectrum chemicals and may have been used against many different pests on many crops or in other situations where pest control is needed. There are also cases where HHPs continue to be used because they provide solutions to some very specific and difficult pest problems. It is vital to understand the pest or disease problems that need solutions in order to identify a range of alternatives that could be applied or tried as replacements for HHPs within the context of an IPM or IVM approach.

Not simply replacing one chemical with another

Experience has shown that the replacement of one chemical with another may simply replace one set of problems with another – a process known as "regrettable substitution". The replacement pesticide may not be listed as an HHP, but it may nevertheless pose health or environmental hazards that could be avoided if agroecological techniques or biopesticides that pose no health and environmental risks are considered. The replacement of HHPs creates opportunities to rethink pest management strategies and potentially to embrace less chemical and more ecological methods.

Providing solutions rather than products

Pesticide regulators are often seen simply as a mechanism for the approval or rejection of pesticide products on the grounds of safety and efficacy. When alternatives to HHPs are being sought, all suitable options that remove hazards and minimize risks to the greatest possible extent should be considered. Regulators should work with extension services, researchers, agricultural input suppliers, farmers and others to provide the safest and most effective solutions for agricultural pest and disease management. This may not be a chemical, but could be a cultural practice, a resistant seed variety, a physical trap or the introduction of a parasitic organism.

Risk assessment is essential for risk reduction

Because the pesticides in question are particularly hazardous, a priority consideration in their replacement should be the protection of human health and the environment. Replacements for HHPs should also be subject to risk assessments. As an interim measure, it may be beneficial to replace an HHP with a lower-risk, readily available control option, such as a WHO class U[3] pesticide, while even lower risk options are sought or developed. Resistance management should also be considered to ensure that a narrowing of the control options for particular pests or diseases will not accelerate the development of pest resistance to the remaining

3 Unlikely to present acute hazard in normal use (WHO 2020a).

control options. Resistance is significantly less likely to develop when agroecological techniques and biopesticides are used in place of or alongside chemical pesticides.

Rapid action is needed

As HHPs are deemed to be disproportionately harmful, once they have been classified as such, it is beneficial to act as quickly as possible to remove those harms. This might require processes to be modified to allow fast-track approvals of very low risk products. An approach involving stages might also be used, whereby very harmful pesticides are replaced with less harmful products as an interim measure while other zero- or very-low-risk solutions are sought or developed.

Stakeholder consultation is beneficial for the effective replacement of highly hazardous pesticides

As described in section 4 above on who should be involved and what are their roles, there are multiple considerations in the removal and replacement of HHPs that may require input from several and various stakeholders. Some stakeholders will support the process, while others may oppose it. Experience suggests that the inclusion of as many stakeholder groups as possible in the process results in more sustainable and effective solutions for the replacement of HHPs.

5.2. Replacement options

5.2.1. Agroecology or ecosystem services

Nature has a way of balancing itself, and when there is an abundance of food, something will emerge to eat it. This is the reason that agricultural pests exist, because agriculture has accumulated, in a single location, vast amounts of the food that the pests favour. This reduces the resources that are needed for the pests to forage, they can stay and feed in a single location with plenty of food and they can breed rapidly and expand their populations. As pest populations expand, so do the population of animals that feed on those pests. Predatory and parasitic insects, mites, nematodes, birds and other organisms will commonly enter agricultural fields to feed on abundant pests and keep their populations in check. Plants at field margins that may be classified as weeds may provide habitats and food for beneficial organisms. Furthermore, the soil is an important ecosystem that harbours millions of microorganisms and macroorganisms, the vast majority of which are beneficial to agriculture or are benign.

Understanding agricultural ecosystems and working with them to benefit from their services and to avoid damaging them is the basis of agroecology. Ecosystem services that control pests can often keep the damage caused by them below thresholds that would cause economic losses. Ecosystem services also have the benefit of being free to farmers.

Many farmers have extensive knowledge of their ecosystems and traditional farming methods that have been neglected and superseded by modern farming methods. Having an understanding of and reviving traditional farming knowledge is particularly useful in the drive for sustainability and resilience in agriculture. Women also play vital roles in agricultural productivity. Their inclusion in training sessions and programmes to improve productivity, sustainability and resilience of agriculture has been shown to yield significant benefits (FAO 2011a). There is evidence that the gap in agricultural yields attained by women and by men could be narrowed by the provision of better agroecology training and inputs to women farmers rather than support for the use of agrochemicals (Watts and Williamson 2015).

5.2.2. Cultural practices

Ensuring the appropriate distance between plants, calculating planting and harvesting times, field hygiene, including crop residue management, intercropping and companion planting, plant nutrition, tree pruning, mulching, crop rotation and soil tillage practices are all examples of cultural practices that can significantly influence the presence and level of pests and disease in crops.

5.2.3. Physical controls

Physical barriers or traps can protect crops in many ways and with high efficacy. Barriers includes products such as fine mesh netting or barrier crops that are too high, too dense or undesirable for pests to cross that are planted in field margins. The physical removal of pests such as weeds, egg clusters and sedentary or slow animals can also be effective.

5.2.4. Crop resistance

Some varieties of crops show resistance to particular pests or diseases. They can thus be selected as an important prevention or control mechanism to avoid the use of pesticides, which may include HHPs. The cost of buying the seeds of such varieties or the planting materials may be higher, but this may be offset by the reduction in pesticide costs.

5.2.5. Biological control agents

Macrobial agents

Examples of macrobial organisms that are raised in artificial i nsectaries a nd released into the environment to control pests include insects that eat other insects; parasitic insects or mites that lay their eggs in the eggs or larvae of pests; nematodes that infect pests; and releasing sterile male insects that cannot fertilize females' eggs. Generally, these organisms are already present in the environment in which they are released. Sometimes, when no suitable predator or parasite is present, a new macroorganism may be introduced, but this must be done with caution to ensure that the newly introduced organism does not interfere with the functioning of the ecosystem in unpredictable ways.

Microbial agents

Fungi and bacteria and the toxins that they produce have been formulated into pesticidal agents that can be highly effective against pests and diseases.

Semiochemical agents

Semiochemicals are naturally produced chemicals that influence the behaviour or physiological responses of pests. Examples include pheromones that can be used to lure insects into traps or to confuse them so that they are unable to mate; repellents that cause pests to leave a particular area; or feeding inhibitors that reduce a pest's consumption.

5.2.6. Botanical pesticides

Botanicals are products that are extracted from plants and that have a pesticidal effect, for example toxic, repellent or inhibitive. Widely used examples are neem and pyrethrum. It should be noted that botanical pesticides cannot be assumed to be safe and still need to be assessed for safety before use.

5.2.7. Synthetic chemicals

Synthetic chemical pesticides that are not classified as HHPs are plentiful. Products that are highly target-specific or that are delivered through mechanisms that limit the exposure of people and non-target organisms are increasingly available. Examples include chitin inhibitors, which affect only organisms that produce chitin for their exoskeletons, and chemicals that are used in combination with a lure, such as pheromones or light, so that the pest comes to the poison as opposed to the poison being dispersed in the environment in search of the pest. The spraying of pesticides always causes some negative impact on the environment and frequently has a negative impact on the health of the people exposed to the pesticides. Pesticides also often disrupt other non-chemicals methods of pest management. It is for this reason that synthetic chemical pesticides should be used as a last resort, and, when they are used, methods that limit their dispersion in the environment should also be used, such as lure and kill traps.

6. Evaluating alternatives

Effective pest control requires an understanding of the crop affected by the pest or the situation in which the pest occurs, the environment in which it occurs and the ecology and life cycle of the pest. Many options may exist, and the efficacy of what seems like the best solution may need to tested. The solution may also be unique to the particular situation and not replicable elsewhere.

The replacement of an HHP is similar to the process of evaluating and registering a new pest management tool, such as a biopesticide, semiochemical or synthetic pesticide, with the added factor of ensuring that the solution replacing the existing tool is adequate to manage the pests or diseases in question while protecting health and environment. In keeping with the Guidelines on Highly Hazardous Pesticides (FAO and WHO 2016), regulators are advised to give preference to agroecological methods and IPM/IVM tools when replacing HHPs.

Regulators commonly take on the role of gatekeepers and allow or block the use of a product in their country. They could equally and more effectively take on the role of ensuring that farmers and others have solutions to their pest and disease problems. As mentioned above, those solutions are not necessarily chemical. They may also be different seed varieties, cultural practices, such as changing the timing of planting or the distance between rows, mechanical tools, such as traps or barriers, natural enemies and pathogens, semiochemicals, such as attractants or repellents, and biopesticides.

Regulators may not be aware of all the options that exist, which is why the involvement of a wide range of stakeholders in the replacement of HHPs can be valuable. A variety of stakeholders, such as agricultural input suppliers, researchers and non-governmental organizations (NGOs), may have knowledge of and experience in dealing with specific crop-pest relationships and may be able provide an effective solution to replace an HHP. Additionally, the process of pesticide evaluation is an opportunity to compile gender disaggregated data and to consider the specific perspectives of women, men, children nd vulnerable groups in relation to the impacts of pesticides and the availability and usability of alternatives and to improve their access to information and training.

It is to be noted that stakeholders often have their own interests to protect, so agricultural input suppliers, for example, may not be enthusiastic about a cultural practice that can replace an HHP if there is no product for them to sell in its place. Environmental NGOs may not favour the use of chemical pesticides to replace HHPs and, most importantly, farmers may not favour HHP replacements that are more expensive or take more effort to use. Nevertheless, all stakeholders can also make useful contributions and bring new ideas.

Information about available alternatives to HHPs and how to evaluate them is collated in the following section. As several of the sources address more than one of the considerations listed below, instead of the resources being repeated, they have been listed separately in annex I. To get the most out of the resources, users of these guidelines should browse through the resources, look at the websites and contact the relevant organizations to learn what they can offer, including training where relevant.

The next sections outline the issues that should in general be looked at when alternatives to HHPs are being considered.

6.1. Efficacy in controlling the target pest

Does the proposed solution work well in controlling the pest or disease affecting the specific crop and under the conditions in which the crop is grown in the country in question? Similar experience from other countries may be a good indicator of success, but it is not a guarantee. It is important to test the efficacy of the new solution under local conditions. This will also build the confidence of farmers and other people who will be using it in the future. The FAO Guidelines on Efficacy Evaluation for the Registration of Plant Protection Products (FAO 2006b) is a helpful tool in this regard.

6.2. Availability and means of application

Are all the elements needed for the effective application of the solution available in the country? Are the products registered? Some countries have found that, when a biopesticide is found to be a good alternative to an HHP, the national regulatory system is unable to evaluate and register it. A situation of this type may provide an incentive for the registration system to be modified so that it can deal with biopesticides, but this will take some time. Interim solutions may therefore be needed. These can include the temporary registration of the solution or temporary permission being granted to use a product for research or trials. The availability of and access to alternative control options, as well as training in and information on their use may give rise to gender, age and ability considerations that should be taken into account in the evaluation.

If live organisms are needed, can they be reared and delivered to the areas in need effectively? The establishment of insectaries or fermenters requires financial investment, technical knowledge and time. The operation of these facilities also requires high levels of knowledge, skill and experience. Such facilities can contribute to long-term sustainability and create new livelihoods, but while they are being established interim solutions will be needed. It may be that live organisms can be delivered from elsewhere. Mechanisms for transporting biopesticides across large distances and storing them have improved in recent years making it possible to buy biopesticides from distant suppliers.

In some cases, a product may be available, but the mechanisms for its application in the field need to be given special consideration. Different nozzles, filters and agitation mechanisms may be required to spray biopesticides, the timing of the applications needs to be carefully worked out to maximize effectiveness and parasitic or predatory insects are applied in very different ways from those used for chemical sprays. In some cases, different equipment is needed; in others, it is rather knowledge and guidance that is needed.

6.3. Hazardousness and toxicity for the environment and human health

Replacements for HHPs should not bring new hazards to human health and the environment. The selection of agroecological methods, biopesticides and mechanical tools, for example, removes virtually all hazards. The use of other chemical pesticides registered in a country to replace a banned HHP, however, may lead to a continued impact on health and the environment. It is important for regulators in their decision-making to consider this issue and gender-, age- and ability-related issues that are unlikely to have been considered when the HHP was registered. It is of course beneficial to reduce the negative impacts of HHPs by removing them from use and replacing them with less hazardous alternatives, but it is even more beneficial to remove health and environmental hazards altogether by replacing HHPs with pest control options that do not pose any risks to human health and the environment.

6.4. Durability in the face of resistance (for low-risk pesticides)

Having a limited arsenal of chemical pest management tools increases the risk of the target organisms developing resistance to the chemicals. The prevention of resistance is often ensured by changing the control measures so that pests do not develop resistance to any one approach. The removal of HHPs clearly reduces the range of chemical control options available, but the wider use of agroecological strategies and biopesticides reduces the risk of pest organisms developing resistance. Resistance is therefore significantly more common when chemical pesticides are used, and resistance to biopesticides and agroecological pest management strategies is rare. The FAO Guidelines on Prevention and Management of Pesticide Resistance (FAO 2012) are helpful in this respect.

6.5. Technical feasibility (also called practicability or ease of implementation by farmers)

Following on from section 6.2 above the question here is whether farmers are able use the alternative products, tools or strategies introduced to replace HHPs. In the case of biopesticides, for example, modifications may be needed in the application equipment, in the timing of the applications and in the expected results, which may be slower to come than with chemical pesticides. The use of mechanical traps or barriers requires new skills and knowledge in relation to their placement, monitoring and repair or replacement. The use of agroecological practices may require training and follow-up support for women and men farmers so that they can carry out the new practices effectively.

In all cases, agricultural extension or other advisory services, agricultural input suppliers and other providers of advice and guidance to farmers need to be informed and equipped so that they can support those who are expected to replace the use of HHPs with new methods.

6.6. Cost-effectiveness

Alternatives to HHPs should not be prohibitively expensive or so expensive that women or men farmers suffer economic losses. It is important that farmers are able to continue protecting their crops from pest and disease damage with inputs that are compatible with the farming practices used and the value of their crops. Calculation of the comparative cost of the different options is important in convincing farmers to change their practices. It may be, for example, that the initial outlay for materials and equipment such as barrier netting, traps or hedgerow planting is high, but, over time, costs are lower than if frequent pesticide applications are carried out. There may be cases where farmers need help with initial investments, through grants or concessional loans, to encourage them to change their practices. There is also a need to strengthen women's access to finance, such as credits or loans, to enhance their investment capacity and thus their adoption of suitable agricultural inputs and technologies, including for pesticide management.

6.7. Legislation

Alternatives to HHPs that are based on biopesticides, macroorganisms (predators or parasites) or chemicals need to be evaluated and registered under most regulatory systems. Any alternative that is being considered for use should therefore either already be registered in the country or must go through the registration process, which may take some time. Many countries apply fast-track registration processes for biopesticides or products that are fundamentally less hazardous that chemical pesticides. In some cases, the regulations or the process for evaluating and registering the products may not be in place, in which case interim authorizations may be needed while the relevant regulations are defined and processes are set up.

6.8. Trade risks

HHPs can jeopardize the export of agricultural produce because they may lead to unauthorized or unacceptably high pesticide residues in crops. Alternatives should be evaluated to ensure that they do not also leave residues that may jeopardize exports. In the case of biopesticides or macroorganisms, exporters should ensure that their use meets the phytosanitary requirements in the importing countries.

6.9. Incentives and disincentives

Where mechanisms exist to support and encourage farmers to use or not to use certain products, steps should be taken to ensure that the economic, fiscal or other incentives or disincentives in place do not hinder the deployment of an alternative to an HHP. Those incentives or disincentives should, if possible, rather facilitate or encourage the use of the alternative.

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Annex I: Resources

Centre for Agriculture and Biosciences International

The PlantwisePlus Knowledge Bank of the Centre for Agriculture and Biosciences International (CABI) has gained extensive experience running advisory plant health clinics in many countries around the world. Much of the knowledge that the CABI has accumulated is on the Plantwise website, where searches can be made according to pest, crop or country. This is useful for understanding the control options for the various crop–pest combinations. The site also contains links to other useful CABI resources and to those of other organizations.

The CABI BioProtection Portal is an online open-access resource that helps growers and agricultural advisers to identify, source and correctly apply biocontrol and biopesticide products to combat pests in their crops. As of May 2023, the portal had information relating to 39 countries across four continents.

Food and Agriculture Organization of the United Nations

The International Code of Conduct on Pesticide Management (FAO and WHO 2014) provides a comprehensive framework for the lifecycle management of pesticides. Various sets of guidelines that elaborate on articles of the Code have been developed and published online. The Guidelines on Highly Hazardous Pesticides (FAO and WHO 2016) are particularly useful in the context of the present document.

Other guidelines relating to the Code that may be helpful can be found on the FAO Pest and Pesticide Management website, and a Compendium of FAO and WHO guidelines and other resources (FAO and WHO 2021) has also been published.

Pesticide Registration Toolkit (FAO 2019) is a comprehensive web-based system designed to help pesticide regulators gather and interpret all the information required to make informed decisions about pesticides. It includes a section on information sources, which links to many useful sites, some of which are described in this section. A special topic within the toolkit addresses HHPs and provides links to further helpful guidance and resources.

The FAO website provides information on integrated pest management. IPM is the careful consideration of all available pest control techniques and the subsequent integration of appropriate measures that discourage the development of pest populations. It combines biological, chemical, physical and crop specific (cultural) management strategies and practices to grow healthy crops and minimize the use of pesticides, reducing or minimizing risks posed by pesticides to human health and the environment for sustainable pest management. IPM can be a useful approach for replacing HHPs and promoting sustainable agriculture.

The FAO website also provides information in agroecology. Agroecology is the application of ecological concepts and principles for the optimization of the interaction between plants, animals, humans and the environment, while taking into consideration social aspects that need to be addressed for a sustainable and fair food system. Agroecology can support food production and food security and nutrition by building synergies, while restoring the ecosystem services and biodiversity that are essential for sustainable agriculture. Agroecology can play an important role in building resilience and adaptation to climate change.

Globally Harmonized System of Classification and Labelling of Chemicals

The GHS is an internationally agreed system for classifying and labelling chemicals to clearly indicate the hazards that they present to users and others. The determination of which hazards relate to which chemicals and their degree of severity is a matter for national authorities. There is no centralized database of GHS classifications for chemicals, but it is possible to refer to the publicly accessible databases of other regulatory authorities for guidance. For example, the GHS classifications are listed in the EU Pesticides Database. It can be difficult to find information about national listings of GHS classifications, but a useful resource that links to the GHS listings of a number of countries is the ChemSafetyPro website, which is compiled by a group of chemical regulatory experts who recognize the value of this information and the difficulty in finding it.

IPM Coalition

The Pesticides and Alternatives app was launched in 2020 by the IPM Coalition. At present, this android app provides information on pesticide restrictions in five countries (Brazil, Colombia, India, Kenya and Malaysia) and under several trading standards of members of ISEAL, the International Social and Environmental Accreditation and Labelling Alliance. The app also includes information on control options from the CABI Plantwise protocols and approved pesticides for the control of many pests on specified crops. The app will be expanded with time to include more data.

National pesticide registers

Many national pesticide regulatory authorities publish their pesticide registers on the Internet, and they can be found using normal search engines. Two that are widely referred to by other regulatory authorities are those of the EU and the United States of America.

The EU Pesticides Database allows searches by active ingredient, by maximum residue level and by emergency authorization. When searching by active ingredient, the search can be refined even further to give low-risk ingredients and candidates for substitution. The information retrieved indicates the regulatory status in the EU and provides links to relevant documents.

The regulatory status of pesticides in the United States and associated documentation can be accessed through the United States Environmental Protection Agency Pesticide Chemical Search database.

Organisation for Economic Co-operation and Development

The Organisation for Economic Co-operation and Development (OECD) brings together high-income countries to share experience and set standards in many areas, including pesticide management. Its guidelines and reports are published and available for all to use. In the area of pesticide management, OECD guidelines are valuable also to regulators and decision makers in low- and middle-income countries because they are based on the accumulated experience of many countries that have already dealt with issues that may be new to less developed countries. OECD work on agricultural pesticides is part of its initiatives related to chemical safety and biosafety.

Regional pesticide regulatory bodies

The Asia and Pacific Plant Protection Commission brings together 25 countries on common issues relating to phytosanitary standards under the International Plant Protection Convention and pesticide regulatory matters. Member countries of the Commission are Australia, Bangladesh, Cambodia, China, the Democratic People’s Republic of Korea, Fiji, France, India, Indonesia, the Lao People’s Democratic Republic, Malaysia, Myanmar, Nepal, New Zealand, Pakistan, Papua New Guinea, the Philippines, the Republic of Korea, Samoa, Solomon Islands, Sri Lanka, Thailand, Timor-Leste, Tonga and Viet Nam. The secretariat of the Commission is hosted by the FAO Regional Office for Asia and the Pacific in Bangkok.

The Southern African Pesticide Regulators Forum brings together 16 members of the Southern African Development Community to coordinate pesticide regulation and management. Its member countries are Angola, Botswana, the Comoros, the Democratic Republic of Congo, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, the United Republic of Tanzania, Zambia and Zimbabwe.

The East African Community comprises six member countries and has established a forum for coordination and collaboration among their pesticide regulators. Its member countries are Burundi, Kenya, Rwanda, South Sudan, Uganda and the United Republic of Tanzania.

The Permanent Interstates Committee for Drought Control in the Sahel hosts the Sahelian Committee for Pesticides, which was established in 1994 and is the longest established and most closely harmonized regional pesticide regulatory body. Member countries of the Permanent Interstates Committee are Benin, Burkina Faso, Cabo Verde, Chad, Côte d'Ivoire, the Gambia, Guinea, Guinea-Bissau, Mali, Mauritania, the Niger, Senegal and Togo. Decisions of the Sahelian Committee for Pesticides are adopted by all member countries so that the evaluation process is carried out only once.

The Sahelian Committee for Pesticides has now expanded its membership. It now includes the members of the Economic Commission for West African States that are not members of the Permanent Interstates Committee for Drought in the Sahel. This has added Ghana, Liberia, Nigeria and Sierra Leone. The new body is known as the West African Committee for Pesticide Registration, with its secretariat located at the Institute of the Sahel in Bamako.

The Coordinating Group of Pesticide Control Boards of the Caribbean brings together the pesticide regulators of 14 members (Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Lucia, Saint Vincent and the Grenadines, Suriname and Trinidad and Tobago) to coordinate their actions related to pesticide management. Its secretariat is hosted by the Caribbean Agricultural Health and Food Safety Agency in Suriname.

Rotterdam Convention

Criterion 6 of the HHP criteria defined by the FAO/WHO Guidelines on Highly Hazardous Pesticides (FAO and WHO 2016) is the listing, in Annex III to the Rotterdam Convention, of pesticides and industrial chemicals that have been deemed to be particularly hazardous and therefore require prior informed consent from importing countries in international trade. Within the website of the Convention is a section devoted specifically to activities focused on alternatives to HHPs, which includes some specific examples of replacements for pesticides listed in Annex III to the Rotterdam Convention.

Stockholm Convention

Criterion 5 of the HHP criteria defined by the FAO/WHO Guidelines on Highly Hazardous Pesticides (FAO and WHO 2016) is the listing, under the Stockholm Convention, of pesticides and industrial chemicals that have been deemed to be persistent, environmentally dispersed, bioaccumulative and toxic. A section of the Convention website addresses alternatives to persistent organic pollutants.

Strategic Approach to International Chemicals Management

The Strategic Approach to International Chemicals Management is an international, multi-stakeholder process that aims to strengthen all aspects of chemicals management. HHPs are a priority that was identified by the International Conference on Chemicals Management at its fourth session. National focal points of the Strategic Approach and other stakeholders, including from civil society and private sector organizations that have a particular interest in the topic, could be useful in sharing their experience and knowledge of HHP risk reduction.

United Nations Environment Programme

UNEP is primarily concerned with the environmental impact of pesticides, but not exclusively, bearing in mind that the presence of pesticides in the environment affects human health as well. Several documents and reports that address different aspects of pesticides have been published by UNEP, some in collaboration with other agencies. A useful entry point for accessing UNEP documents related to pesticides is the website Pesticides – Relevant information.

World Health Organization

The International Programme on Chemical Safety shows that chemical safety is a key health topic for WHO. Pesticides are an important component of that work, and there are many related publications, guidelines and other helpful material available.

The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification (WHO 2020a) is the document governing criterion 1 of the HHP criteria defined by the FAO/WHO Guidelines on Highly Hazardous Pesticides (FAO and WHO 2016). It is a useful reference for determining the acute toxicity of all pesticides.

Pesticide self-poisoning accounts for 14 to 20 per cent or approximately 150,000 suicides each year. Pesticide suicides are particularly common in low- and middle income countries. Evidence has shown that banning HHPs that are commonly used in suicides is a very cost-effective way of saving lives and reducing suicides (WHO 2020b).

Annex II: Case studies

Bangladesh

Between 1996 and 2007, 21 pesticides were partially or completely banned by the Bangladeshi resulting in a shift towards the use of less-hazardous pesticides of WHO toxicity classes II, III and U pesticides. All HHPs of WHO class I toxicity were banned in 2000. As a result, there have been significantly fewer deaths from pesticide exposure since the bans, without any apparent harmful effect on agricultural production.

China

In 2013, the National Pesticide Registration Review Committee of China took action to ban or limit the use of seven pesticides: asomate, chlorpyrifos, chlorsulfuron, metsulfuron-methyl, tribenuron-methyl and urbacid. In addition, aldicarb, phorate and isocarbophos were banned in 2018; ethoprop, omethoate, methyl isothiocyanate and aluminium phosphide were banned in 2020; and chloropicrin, carbofuran and methomyl were banned by the end of 2022. Additional bans and restrictions on other HHPs are under consideration. The measures were taken to guarantee the safety, security, and quality of agricultural production methods, agricultural products and the environment and to safeguard people's health and lives.

Cotton

Cotton crops are the biggest users of pesticide globally, and HHPs are widely used in efforts to control cotton pests. An international, multi-stakeholder initiative called the Better Cotton Initiative works to improve conditions for cotton farmers and the sustainability of cotton production. Among its recommendations is the use of an extensive protocol that strengthens controls over which pesticides are used and how they are used. A number of indicators in the Better Cotton Initiative protocol propose that pesticides meeting criteria 1 to 7 of the HHP criteria defined by the FAO/WHO Guidelines on Highly Hazardous Pesticides (FAO and WHO 2016) should not be used, or their use should be phased out. Adherence to Better Cotton Initiative criteria demonstrates that millions of farmers are able to produce cotton successfully without using many HHPs.

Denmark

Denmark has implemented successive pesticide action plans since the 1980s, with a view to reducing the use and impact of pesticides used in agriculture. This later led to a strategy that was adopted across the EU. Steps designed to optimize pesticide use and to reduce the need for pesticides, such as the planting of resistant varieties of crop, have been widely applied. Many pesticides had also been removed from use to protect groundwater or in compliance with EU Directives. In 2009, IPM was adopted as a permanent strategy and, with the help of research and advisory bodies, farmers have moved away from the use of pesticides altogether (Kudsk and Jensen 2014).

Middle East

A regional IPM approach, implemented in Algeria, Egypt, the Islamic Republic of Iran, Iraq, Jordan, Lebanon, Morocco, State of Palestine, the Syrian Arab Republic and Tunisia between 2004 and 2012 resulted in a 60 to 70 per cent decrease in pesticide use and improved net returns for farmers and other social benefits. The crops involved were tomatoes, apples, grapes, peaches, mint, pistachios, cucumbers, watermelons, wheat, strawberries, date palms, citruses and olives (Beniwal S., Sharaf N. and Ceccarelli S. 2011).

Mozambique

Following a comprehensive review of its complete pesticide register, in 2014 Mozambique cancelled the registrations of 61 pesticide products containing 31 different active ingredients and announced risk reduction measures for another 52 pesticide products.

The initiative was prompted by the Government's concern about the use of hazardous pesticides and its desire to promote the sustainable intensification of agricultural production.

The project was also intended to serve as a pilot to gain experience for other countries and for the development of FAO guidelines and was implemented as part of the Quick Start Programme of the Strategic Approach to International Chemicals Management.

The initiative used a seven-step process that included:

- Review of registered pesticides to identify HHPs;
- Review of pesticide import trends as a proxy for pesticide use;
- Field surveys of pesticide use in key crops;
- Assessment of pesticide user risks;
- Assessment of environmental hazards;
- Consultation with stakeholders and capacity-building;
- Cancellation of HHPs and other risk reduction measures.

The process is described in some detail in the FAO publication Addressing Highly Hazardous Pesticides in Mozambique (FAO 2015).

Sri Lanka

In 1995, 1998 and 2008, a series of pesticide bans were enacted in Sri Lanka with the primary objective of reducing deaths from self-poisoning (suicides), the number of which was extremely high. In total, eight HHPs were banned, and death rates from pesticide suicides fell dramatically. Further research showed that the pesticide bans had no negative impact on agricultural productivity.

West Africa

An estimated 116,000 farmers in Benin, Burkina Faso, Ghana, Guinea, Mali, Mauritania, the Niger and Senegal participated in an FAO-supported integrated production and pest management programme between 2006 and 2010. While the programme initially set out to monitor and reduce the presence of persistent organic pollutant pesticides in the regional river systems, it rapidly expanded to all pesticides when they were found to be contaminating the scarce and sensitive water systems. By the end of the programme, participating farmers had substantially reduced their use of synthetic pesticides on cotton, cowpea, henna, jatropha, mango, sesame, shea nut, rice and vegetable crops, with increased yields and increased farmer incomes (Settle *et al.* 2014).