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Highly Hazardous Pesticides (HHPs) are of particular concern because of the serious adverse effects they can cause to human health and the environment. This report describes the HHP risk reduction process in Ghana, from identifying HHPs among the pesticide products registered in the country, to determining regulatory and non-regulatory risk mitigation measures.

Of the 932 pesticide products registered in Ghana in December 2021, a total of 88 pesticide products were identified as meeting one or more of the HHP criteria, or 9.4% of the registered products. These HHP products contained 22 different active ingredients, or 9.6% of the total number of active ingredients registered.

Risk mitigation measures for each of the identified HHPs were defined taking into account: the type of hazard(s) the HHPs posed, their current uses in Ghana, continued need, available alternatives and level of risk. The proposed measures ranged from the continued registration of the HPP, further restrictions of its use, partial or complete phase-out over a limited period of time, to immediate cancellation of the registration of the HHP.

Keywords: Highly Hazardous Pesticide, HHP, Ghana, risk reduction, pesticide, plant protection product, human health, environment, risk, hazard.

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Photo cover: Youth spray services providers for mango producers in Sunyani area. Photo by Nelson Ganyo.

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Preface

The work presented in this report was performed in the framework of the Hortifresh West Africa programme, which was supported by the Embassy of the Kingdom of the Netherlands in Ghana. The programme was implemented from 2018 – 2022 and its mission was to establish "a sustainable and internationally competitive fruit and vegetable sector that contributes to inclusive economic growth, food and nutrition security" in Ghana and Cote d'Ivoire.

The programme contributed to this mission by, amongst others, improving the business climate and further professionalizing the value chain for vegetable production and consumption, including meeting national, regional and international phytosanitary quality standards and pesticide residue requirements. To meet these standards and to satisfy the growing interest to have less pesticides in food it was deemed necessary to reduce the overreliance on pesticides. To achieve this goal the Environmental Protection Agency (EPA) – Ghana and the Government of the Netherlands, represented by the Embassy of the Kingdom of the Netherlands in Ghana set up a collaboration in the framework of the HortiFresh West Africa programme.

The collaboration focussed on reducing or eliminating the risks posed by Highly Hazardous Pesticides (HHPs) in the country, through a comprehensive process of identification, needs and risk assessment and risk mitigation. The methodology and outcome of this collaborative work is described in this report.

We would like to thank Sheila Assibey-Yeboah, the local project manager of the HortiFresh programme, and her team for the support in facilitating the organization of all stakeholder meetings as part of project implementation activities.

We also gratefully acknowledge the technical assistance of Joost Vlaming, of Envista Consultancy in the Netherlands, for preparing the on-line spreadsheet that was used compile and analyse the data needed to identify the HHPs among the registered pesticides in Ghana.

Finally, the project would not have been possible without the support of many colleagues at the EPA, who reviewed the entire pesticide register against the FAO/WHO HHP criteria and were instrumental in defining the proposed mitigation measures to reduce the risks posed by the HHPs. The contributions of Michael Onwona-Kwakye, Lovelace Sarpong, Irene Parker-Allotey, Anifat Mahama, Kafui Boni, Felisa Owusu-Darko, Kojo Selasie Ashiadey, Nathan Quao, Emmanuel Ampadu Nyarko and Andrews Amoah are therefore recognized with great appreciation.

Abbreviations

ADI	Acceptable Daily Intake
AOEL	Acceptable Operator Exposure Level
BPDB	Bio-Pesticides Database
CCMC	Chemicals Control and Management Centre (of EPA)
C&L	Classification and Labelling
ECHA	European Chemicals Agency
EFSA	European Food Safety Authority
EPA	Environmental Protection Agency (of Ghana)
FAO	Food and Agriculture Organization of the United Nations
FFP	Filtering Facepiece
GEMS/Food	Global Environment Monitoring System / Food Contamination Monitoring and Assessment Programme
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
HHP	Highly Hazardous Pesticide
ICCM	International Conference on Chemicals Management
IEDI	International Estimated Daily Intake
LD_{50}	median lethal dose
LMIC	Low and Middle Income Country
LoEP	List of Endpoints
MRL	Maximum Residue Limit
OPEX	Operator Exposure
POP	Persistent Organic Pollutant
PPDB	Pesticide Properties Database
PPE	Personal Protective Equipment
PTC	Pesticides Technical Committee (of EPA)
TMDI	Theoretical Maximum Daily Intake
URL	Uniform Resource Locator
VSDB	Veterinary Substances Database
WHO	World Health Organization
WENR	Wageningen Environmental Research
WUR	Wageningen University & Research

Summary

Highly Hazardous Pesticides (HHPs) as defined by the International Code of Conduct on Pesticide Management (FAO/WHO, 2014) are of particular concern because of the serious adverse effects they can cause to human health and the environment. HHPs generally constitute a relatively small share of pesticides registered in a country, and yet they can cause disproportionate harm. This is notably the case in low- and middle-income countries where necessary risk mitigation measures may not be feasible or are difficult to enforce. The FAO and WHO issued specific Guidelines on HHPs (FAO/WHO, 2016) to help countries address HHPs. The guidance contains criteria for the identification of HHPs and describes the steps of the HHP risk reduction process.

The Ghana Environmental Protection Agency (EPA) is responsible for the authorization of pesticides in Ghana. The EPA has expressed its firm intention to reduce or eliminate the risks posed by HHPs in the country, through a comprehensive process of identification, needs and risk assessment, and risk mitigation, including the introduction of low risk alternative pest management options.

This report describes the HHP risk reduction process in Ghana, from identifying HHPs among the pesticide products registered in the country, to determining regulatory and non-regulatory risk mitigation measures. This process was assisted by Wageningen Environmental Research (part of Wageningen University and Research) and by Falconsult, in the Netherlands. This collaboration was executed under the HortiFresh West Africa programme and partially funded by the Government of the Netherlands.

As a first step, technical guidance was developed for the identification of HHPs, based on the guidelines published by FAO and WHO, and specifically tailored to the situation in Ghana. A team at the Chemicals Control and Management Centre of EPA was subsequently trained to review the registered pesticides in Ghana and key stakeholders were informed about the intended process.

In early 2022, all 932 pesticide products registered in Ghana in December 2021 were assessed against the eight HHP criteria recommended by FAO and WHO (FAO/WHO, 2016). As a result of this evaluation, a total of 88 pesticide products were identified as meeting one or more of the HHP criteria, or 9.4% of the registered products. These HHP products contained 22 different active ingredients, or 9.6% of the total number of active ingredients registered. The majority of pesticide products identified as HHP were reproductive toxicants Category A and B according to the *Globally Harmonized System of Classification and Labelling of Chemicals*, or Class Ia and Ib of the *WHO Classification of Pesticides by Hazard*.

Next, current uses of the identified HHPs in Ghana were evaluated, as well as continued needs for these products and possible alternatives. Key stakeholders were consulted during this process. In addition, occupational and dietary risk assessments were conducted of HHPs that were in actual use, employing internationally recognized models and applying local conditions of use of the pesticides.

Risk mitigation measures for each of the identified HHPs were then defined taking into account: the type of hazard(s) the HHPs posed, their current uses, continued need, available alternatives and level of risk.

- For HHP products containing three active ingredients (aluminium phosphide, propiconazole and triadimenol), the current registrations were proposed to be maintained.
- The use of HHP products containing four active ingredients (dimethomorph, magnesium phosphide, mancozeb and thiacloprid) was recommended to be restricted.
- The phase-out was recommended of HHP products containing another five active ingredients (carbofuran, chromium trioxide + arsenic pentoxide, glufosinate-ammonium and lufenuron).
- For pesticide products containing two active ingredients, carbofuran and mancozeb, it was recommended to develop a road map towards phase out of all or many of their uses.
- The registrations of HHP products with the remaining 10 active ingredients were recommended to be cancelled immediately.

These risk mitigation measures were subsequently submitted to the EPA management, the Pesticides Technical Committee and for final consideration and approval by the EPA Board.

1 Introduction

While all pesticides can be dangerous, highly hazardous pesticides (HHPs) are of particular concern because of the serious adverse effects they can cause to human health and the environment. HHPs generally constitute a relatively small share of pesticides registered in a country, and yet they can cause disproportionate harm. This is notably the case in low and middle income countries (LMICs) where necessary risk mitigation measures may not be feasible or are difficult to enforce. As a result, the risk of human and environmental exposure to HHPs tends to be relatively much higher in LMICs, where these pesticides tend to be widely used (FAO/WHO, 2019).

HHPs continue to be used in many LMICs for various reasons, which include: the low direct cost to farmers and other pesticide users (even though external costs for public health and environmental damages tend to be much higher than of low risk pesticides); entrenched commercial interests to maintain the trade in HHPs; limited capacity for pesticide risk assessment and monitoring to identify pesticides posing high risks; inadequate investment towards alternative pest management solutions, such as biopesticides or integrated pest and vector management; farmer's reluctance to adopt lower risk alternatives which may be perceived as risky; etc.

However, low risk alternatives exist for almost all HHPs, as is shown in countries that have banned or severely restricted such pesticides, generally without a negative effect on agricultural production. Nevertheless, the identification and implementation of alternatives to HHPs requires clearly targeted government policy and effective collaboration between all stakeholders in the sector(s) where the HHP is still being used (e.g. pesticide regulatory bodies, agricultural extension services, pesticide industry, research institutes, agricultural producer organizations).

HHPs have been the subject of international discussions and policy recommendations for almost two decades, among them:

- In 2006, the FAO Council requested FAO and its members to draw specific attention to HHP risk reduction.
- The International Code of Conduct on Pesticide Management, in 2014, stipulated that prohibition of the importation, distribution, sale and purchase of highly hazardous pesticides may be considered if, based on risk assessment, risk mitigation measures or good marketing practices are insufficient to ensure that the product can be handled without unacceptable risk to humans and the environment.
- In 2015, the 4th Meeting of the International Conference on Chemicals Management (ICCM4) recognized HHPs as an issue of international concern and called for concerted action to address HHPs.
- And recently in September 2023, ICCM5 adopted a Global Framework on Chemicals in which one of the targets is the phase-out of highly hazardous pesticides in agriculture by 2035. It also launched a Global Alliance on Highly Hazardous Pesticides.

The Government of Ghana has been regulating the risks of pesticides through national legislation, in particular the Environmental Protection Agency Act, (Act 490) (Ghana Parliament, 1994) and in the Pesticides Control and Management Act, (Act 528) (Ghana Parliament, 1996). In addition, Ghana is a Party to the Rotterdam and Stockholm Conventions which both attempt to minimize the health and environmental risks of chemicals, including of several pesticides.

Under the Part II, of Act 490, the Environmental Protection Agency (EPA) is responsible for the authorization of pesticides in Ghana. The EPA Chemicals Control and Management Centre (CCMC) is responsible for registering all pesticides, monitoring their use and enforcing pesticide regulations and the licensing of pesticide dealers among others.

Regarding the authorization of pesticides in Ghana, Section 31 of Act 490 states that "the Agency may … only register a pesticide if it is satisfied that the pesticide is safe and effective for the use for which it is intended and that the pesticide has been tested for efficacy and safety under local conditions".

Furthermore, the Act (section 37) stipulates that "the Agency, if satisfied that a registered pesticide under the existing conditions of its registration or provisional clearance … may cause hazard to people, animals, crops or the environment, may … suspend or ban the pesticide or cancel the registration or provisional clearance at any time …"

As such, the evaluation of the hazards and risks posed by HHPs, as well as decisions on possible risk mitigation measures, including bans or restrictions of HHPs, falls within the authority of the EPA.
The Ghana Environmental Protection Agency had indicated that it wishes to reduce or eliminate the risks posed by HHPs in the country, through a comprehensive process of identification, needs and risk assessment, and risk mitigation, including the introduction of low risk alternative pest management options. This firm intention has been expressed by the Government to agricultural producers, input supply companies and consumer organizations.

The Government of the Netherlands agreed to collaborate with the Ghana EPA to achieve this goal through the HortiFresh West Africa programme. The programme's objective is to promote a sustainable and internationally competitive fruit and vegetable sector that contributes to inclusive economic growth, food and nutrition security in Ghana. The programme has identified the use of pesticides, and especially of HHPs, as one of the bottlenecks for horticulture sector transformation. By eliminating or highly reducing the use of HHPs in horticulture, trust in the Ghana fruits and vegetables sector by regional and international markets will be increased. Limiting the use of HHPs will also facilitate complying with – both public and private – sustainability standards and will result in a reduction of the health and environmental risks of pesticide use in the country.

This report describes the methodology and outcome of the collaborative activity, in particular the first steps of identifying HHPs in Ghana, assessing their risks and proposing concrete risk mitigation actions.

2 Process

2.1 FAO/WHO methodology for risk reduction of Highly Hazardous Pesticides (HHPs)

Highly Hazardous Pesticides (HHPs) have been defined in the International Code of Conduct on Pesticide Management (FAO/WHO, 2014) as: *pesticides that are acknowledged to present particularly high levels of acute or chronic hazards to health or environment according to internationally accepted classification systems such as WHO or GHS or 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 conditions of use in a country may be considered to be and treated as highly hazardous.*

The FAO/WHO developed a three-step approach to help national or regional pesticide regulators with limited resources to reduce the risks of Highly Hazardous Pesticides (FAO/WHO, 2016).

The FAO/WHO three-step approach comprises: 1) identification of HHPs, 2) assessing the risks, needs and possible alternatives, and 3) discuss, adopt and implement risk mitigation measures (Figure 1).

Figure 1 *Three-step process for the management of Highly Hazardous Pesticides (FAO/WHO, 2016).*

In the first step all pesticide products authorized in a country/region are checked against the eight FAO/WHO criteria for HHPs (Table 1). Any pesticide that meets one or more of these criteria is considered to be a HHP. The result of this "HHP scan" is a long-list of pesticide products that require further attention.

The second step involves an assessment of the identified HHPs to determine whether further action is desirable. This includes risk assessments and an evaluation to determine whether current uses of the long-listed HHP products are actually needed.

The third step uses the outcome of the second step to determine for each HHP product whether risk mitigation measures are required and if so, which mitigation options would be appropriate. Cancelling of a registration of a formulated pesticide product or banning of an active ingredient are also risk mitigation options.

This three-step process was also followed in Ghana.

2.2 Step 1 – HHP identification

The HHP scan was conducted on the basis of the Register of Pesticides as at December 2021 (Ghana EPA, 2021). At that date, the register listed 932 pesticide products containing 230 active ingredients.

The HHP scan was carried out by a team from the Chemicals Control and Management Centre (CCMC) of the Ghana EPA, with technical support of Wageningen Environmental Research and Falconsult in the Netherlands.

A HHP identification guideline was elaborated and agreed upon which described the different steps in the process, the way in which the HHP criteria would be interpreted (Section 3.1), as well as the data sources that would be used to check whether a pesticide product would meet the HHP criteria (Section 3.2). This guideline was used to ensure transparency during the identification process and harmonization between the different members of the team conducting this step.

A dedicated on-line spreadsheet was developed, modified from the HHP identification spreadsheet available in the FAO Pesticide Registration Toolkit (FAO, 2021). All pesticide products in the Register were then transferred into the spreadsheet, including information on active ingredient(s) and their concentrations in the products. The spreadsheet allowed the one-time entry of active ingredient data needed to assess the HHP criteria. Pesticide product information and active ingredient data were combined in a summary sheet indicating which of the HHP criteria were met for each product. Since the spreadsheet was available on-line, different members of the CCMC team could work on HHP identification simultaneously, speeding up the process.

All HHP criteria were evaluated for all products in the Register of Pesticides. Step 1 was conducted in the period January – April 2022. More details about the HHP criteria evaluated and the data sources used are provided in Sections 3.1 and 3.2.

The outcome of Step 1 was a "long-list" of HHPs identified in the December 2021 Register of Pesticides (Figure 2).

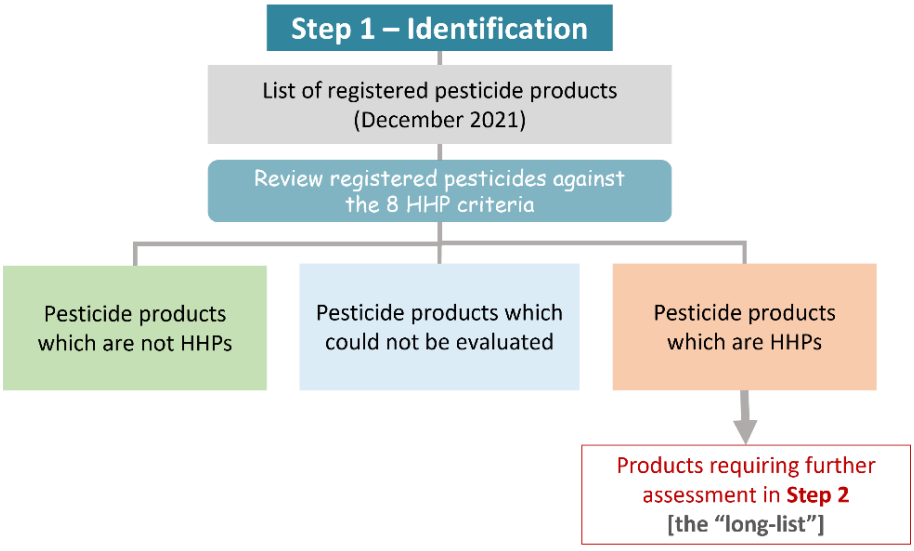

Figure 2 *Summary of the process and outcome of Step-1, to identify the HHPs in the Register of Pesticides in Ghana.*

2.3 Step 2 – Needs and risk assessments

Step 2 in the HHP risk reduction process consisted of three activities:
1. Stocktaking of use of identified HHPs
2. Needs assessment of the identified HHPs
3. Risk assessment of the identified HHPs

These assessments were carried out on the HHPs in the long-list compiled as a result of Step 1.

2.3.1 Stocktaking of use of identified HHPs

There is only limited collection of data on the use of pesticides in Ghana. However, relatively complete statistics are available on the importation and the local formulation of pesticides. Therefore, pesticide importation data for the period 2019 – 2021, available at the EPA, were compiled as a proxy for pesticide use, for all HHPs in the long-list.

These statistics were completed with information obtained from pesticide importers and distributors, as well as from local pesticide formulators.

The result of this stock-taking exercise was a list of HHPs which were expected to be actually in use in Ghana.

2.3.2 Needs assessment of the identified HHPs

The needs assessment consisted of various activities.

As a first step, all registered uses of the long-listed HHPs were compiled from current pesticide labels approved in Ghana. This provided information on the crop-pest combinations for which the use of the HHPs was authorized.

Subsequently, stakeholders (e.g. pesticide importers and distributors, Ministry of Food and Agriculture, agricultural research institutions, grower organizations), were consulted in two stakeholder meetings. They were asked to identify main uses of the HHPs, what type of users are applying these pesticides (e.g. smallholder farmers, large farms, domestic users), and the geographical distribution of their use.

During the stakeholder consultations, the continued needs for the HHPs was also discussed. This included questions about the economic importance of the crop and pest/disease on which the HHPs were used, the efficacy of the HHPs in controlling the pests/diseases, and the availability of alternatives (both pesticides and other pest management options).

2.3.3 Risk assessment of the identified HHPs

The International Code of Conduct on Pesticide Management (FAO/WHO, 2014) stipulates, in its Article 7.5, that: *Prohibition of the importation, distribution, sale and purchase of highly hazardous pesticides may be considered if, based on risk assessment, risk mitigation measures or good marketing practices are insufficient to ensure that the product can be handled without unacceptable risk to humans and the environment.*

This implies that decisions to prohibit the use of a HHP should take into account an assessment of risks and not only of the hazards of these pesticide products.

Therefore, for those HHPs expected to be in use, various risk assessments were conducted. The focus of these assessments was on occupational risks (for applicators and workers) and on dietary risks (for consumers). This was done since the criteria for HHPs primarily concern human health hazards. Furthermore, internationally recognized risk assessment models are available for human health risks which are relevant to

the pesticide use conditions in Ghana. No further environmental risk assessments were conducted as part of the evaluation of the HHPs.

Further details about the risk assessments that were conducted can be found in Chapter 5.

The outcome of Step 2 (Figure 3) was a "short-list" of pesticides in the Register of Pesticides which:

- are HHPs,
- are currently in use in Ghana,
- continue to be needed, and
- pose unacceptable risks to human health

This short-list was the main focus of discussion for the identification of appropriate risk mitigation measures in Step 3.

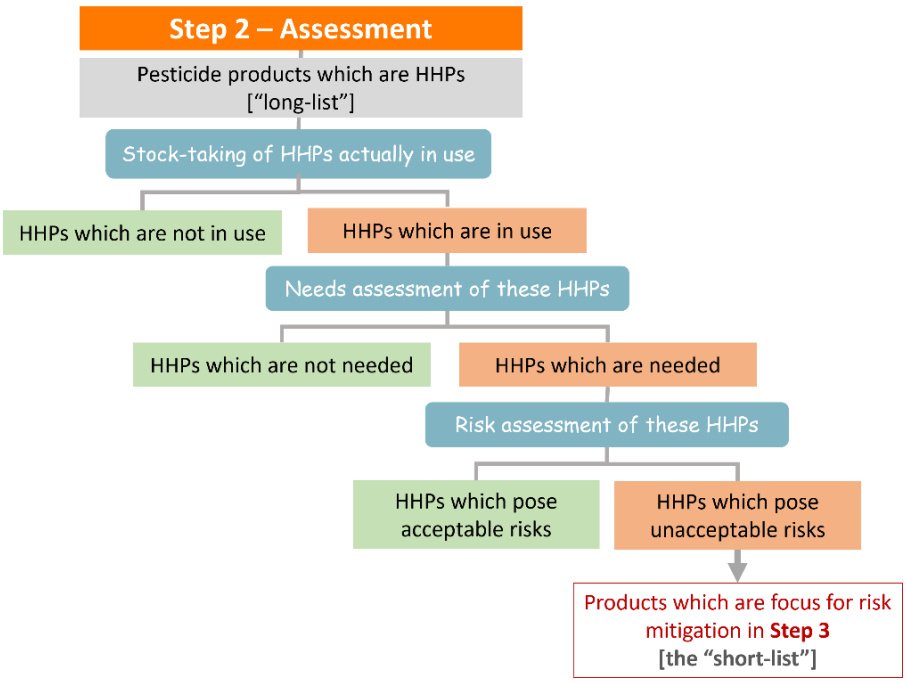

Figure 3 *Summary of the process and outcome of Step-2, to assess needs and risks of the HHPs in the Register of Pesticides in Ghana.*

2.4 Step 3 – Risk mitigation

Risk mitigation measures for the HHPs were initially defined by the EPA-CCMC team on the basis of the results of the different needs and risk assessments. Mitigation measures ranged from "maintain registration" for HHPs that were considered needed and did not pose unacceptable risks, to "immediately cancel registration" for HHPs which posed unacceptable acute risks to human health. Various intermediate risk reduction measures were also proposed (Chapter 6).

Risk mitigation measures were communicated to stakeholders for written comments. Furthermore, two hybrid on-line/in person meetings were organized in which stakeholders were invited to provide further inputs with respect to the current use and future needs of the HHPs, possible lower risk alternatives, as well as their views about the proposed mitigation measures.

The final proposal for risk mitigation measures for all HHPs identified in the long-list was prepared by EPA-CCMC for technical review by the Pesticides Technical Committee (PTC), and final consideration by the EPA Board.

2.5 Time line

The overall time line of the HHP risk reduction activity in Ghana is shown in Figure 4. It shows that the activity was conducted over a period of 16 months, from the initial elaboration of guidance for HHP identification to the final proposal for risk mitigation measures to be submitted to the PTC and EPA Board.

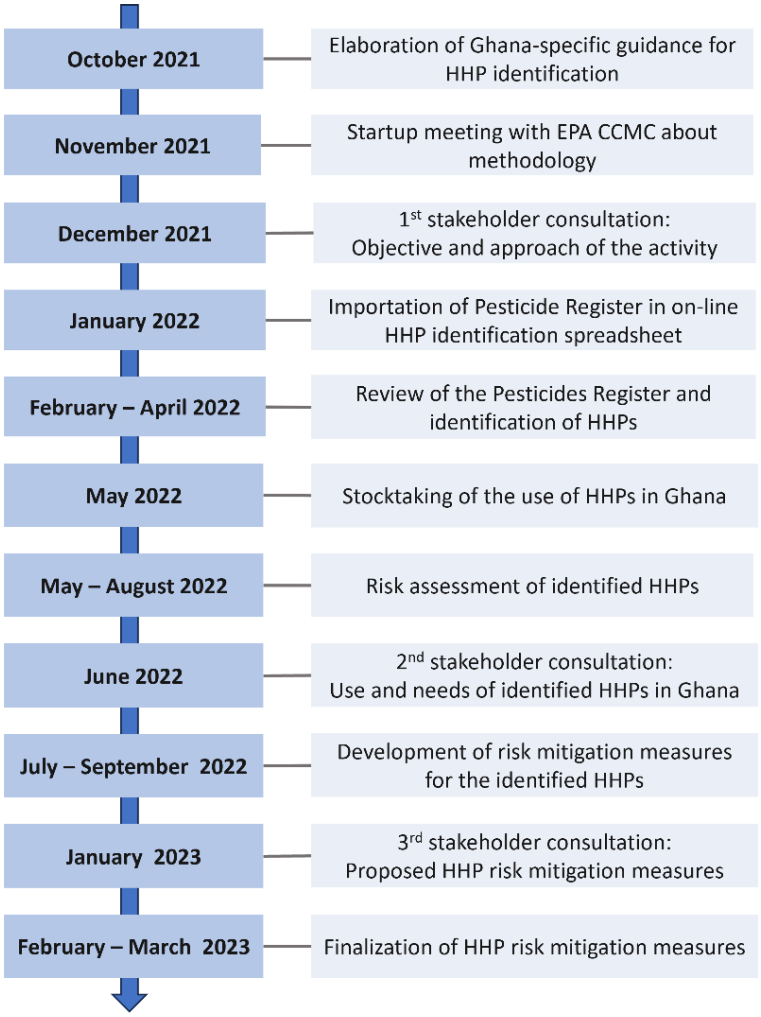

Figure 4 *Timeline of the key activities of the HHP risk reduction activity in Ghana.*

3 Identification of HHPs

3.1 Criteria

The criteria defined by FAO and WHO were applied to identify which of the registered pesticide products in Ghana could be considered HHPs (FAO/WHO, 2016) (Table 1). No additional criteria were applied.

While these criteria are clearly defined, national regulators can interpret them in slightly different ways. Data sources used to decide whether a criterion is met may also vary from one regulator to another.

Table 1 *FAO and WHO criteria for highly hazardous pesticides (HHPs) (FAO/WHO, 2016).*

Criteria	Definition
Highly hazardous pesticides are defined as having one or more of the following characteristics:	
1	Pesticide formulations that meet the criteria of **classes Ia or Ib of the WHO Recommended Classification of Pesticides by Hazard**;
or	
2	Pesticide active ingredients and their formulations that meet the criteria of **carcinogenicity Categories 1A and 1B** of the Globally Harmonized System on Classification and Labelling of Chemicals (**GHS**);
or	
3	Pesticide active ingredients and their formulations that meet the criteria of **mutagenicity Categories 1A and 1B** of the Globally Harmonized System on Classification and Labelling of Chemicals (**GHS**);
or	
4	Pesticide active ingredients and their formulations that meet the criteria of **reproductive toxicity Categories 1A and 1B** of the Globally Harmonized System on Classification and Labelling of Chemicals (**GHS**);
or	
5	Pesticide active ingredients listed by the **Stockholm Convention in its Annexes A and B**, and those meeting all the **criteria in paragraph 1 of Annex D** of the Convention;
or	
6	Pesticide active ingredients and formulations listed by the **Rotterdam Convention in its Annex III**;
or	
7	Pesticides listed under the **Montreal Protocol**;
or	
8	Pesticide active ingredients and formulations that have shown a **high incidence of severe or irreversible adverse effects** on human health or the environment.

In this assessment, the FAO/WHO criteria for HHPs were interpreted in the following manner:

Criterion 1, WHO classification Ia and Ib, is based on the acute oral and dermal LD_{50} values of a pesticide formulation and not of the active ingredient. In principle, acute LD_{50} values of the formulated pesticide products are available in the pesticide registration dossiers that were submitted to the EPA. However, extracting those data from the dossiers was considered too time-consuming for the current HHP assessment. Instead, LD_{50} values of the active ingredients were obtained from reputable data sources (Section 3.2) and the LD_{50} values of the formulated products were then calculated using the formulas provided in the WHO Recommended Classification (WHO, 2020)

Criterion 5 (Stockholm Convention, 2019; Annex D) was interpreted in a less restrictive manner than originally intended. Paragraph 1 of Annex D of the Stockholm Convention sets out the screening criteria to list a chemical in its Annexes A, B or C, i.e. for a chemical to be considered a persistent organic pollutant (POP) under the Convention. The criteria in Annex D refer to the persistence, bio-accumulation potential, potential for long-range environmental transport, and adverse effects of the chemical. All four of these criteria should be met for a pesticide to be considered a POP. However, it was argued that the potential for

long-range transport, though relevant for a global instrument like the Stockholm Convention, is less relevant to the national situation in Ghana. Pesticides that meet the other three criteria of Annex D can be considered persistent, bio-accumulative and toxic and may therefore pose a high risk within the country. Consequently, it was decided that if these three Annex D criteria were met, the pesticide would be considered a HHP, even if the potential for long-range transport was not confirmed.

All other HHP criteria were applied strictly as defined by FAO and WHO.

3.2 Data sources

Independent, internationally reputable, data sources were consulted to evaluate whether or not a pesticide product would meet the HHP criteria. Since a single data source did not have information on all pesticides, various data sources were chosen. In first instance the primary source was checked; only if no information was available in the primary source, one or more secondary sources were consulted. The data sources and order of consultation for each of the HHP criteria are listed in Table 2.

Table 2 *Data sources that were used to verify whether HHP criteria were met, as well as the order of consultation.*

Criteria	Applicable to	Data source and order of consultation (1 = primary source; 2 = secondary source; etc.)	Reference [1]
1. WHO hazard classes Ia and Ib	Formulated products, calculated on the basis of the LD_{50} of the active ingredient (a.i) and its concentration in the registered formulation	*Acute oral LD_{50} values:*	
		1. WHO recommended classification of pesticides by hazard	WHO (2020)
		2. Pesticide Properties Database (PPDB); Veterinary Substances Database (VSDB); Bio-Pesticides Database (BPDB)	Lewis *et al.* (2016)
		3. PubChem	PubChem (undated)
		Acute dermal LD_{50} values:	
		1. Pesticide Properties Database (PPDB); Veterinary Substances Database (VSDB); Bio-Pesticides Database (BPDB)	Lewis *et al.* (2016)
		2. PubChem	PubChem (undated)
2, 3 & 4. GHS categories 1A and 1B for (2) carcinogenicity, (3) germ cell mutagenicity & (4) reproductive toxicity	Active ingredients, with the exception of formulations with an a.i. concentration < 0.1%, for which the GHS does not require hazard classification	1. European Chemicals Agency (ECHA) – C&L Inventory	ECHA (undated)
		2. OECD – eChem Portal (Classification Search)	OECD (undated)
		3. PubChem	PubChem (undated)
5. Stockholm Convention Annex A & B	Active ingredients	1. Stockholm Convention	Stockholm Convention (2019)
Stockholm Convention Annex D (See Appendix … for detailed guidance on how this criterion was applied)		1. Pesticide Properties Database (PPDB); Veterinary Substances Database (VSDB); Bio-Pesticides Database (BPDB) – for persistence, bioaccumulation and aquatic toxicity data 1. European Chemicals Agency (ECHA) – C&L Inventory – for human toxicity data	Lewis *et al.* (2016) ECHA (undated)
6. Rotterdam Convention Annex III	Active ingredients or formulations (as defined by the Convention)	1. Rotterdam Convention	Rotterdam Convention (2019)
7. Montreal Protocol	Active ingredients	1. Montreal Protocol	UNEP (2019)
8. Severe or irreversible effects	Formulated products	National environmental or residue monitoring data; poison centre data; reported incidents (as available)	

[1] Full references and URLs of the data sources are provided in the References chapter.

The criteria listed in Annex D of the Stockholm Convention (2019) are not always very specific. They are sometimes qualitative and open for different interpretations. Even though these criteria are used by the POPs Review Committee to evaluate chemicals and propose listing under the Convention, no specific guidance on how to apply these criteria is available. Therefore, to ensure that this HHP criterion was applied in a consistent and transparent manner, specific guidance was developed for the current HHP review activity (Annex 1). The guidance refers to Stockholm Convention Annex D criteria for persistence, bioaccumulation and adverse effects; the potential for long-range environmental transport was not included in the HHP assessment, as explained in Section 3.1.

3.3 Outcome

The Register of Pesticides of December 2021 comprised of 932 pesticide products containing 230 active ingredients.

No evaluation against the HHP criteria was feasible for 46 products, or 4.9% of the total number registered. In some cases, these products were biopesticides containing microbials to which the HHP criteria are not applicable. In other cases, no data could be found in the selected data sources for one or more of the criteria.

A total of 88 pesticide products were identified as meeting one or more of the HHP criteria (Table 3), or 9.4% of the registered products. These HHP products contained 22 different active ingredients, or 9.6% of the total number of active ingredients registered.

In some cases, not all formulations of a given active ingredient were considered to be a HHP, but only those exceeding a specific concentration. For instance, many rodenticides are not a HHP when formulated as very low concentration baits, but they are when marketed in higher concentrations. In such cases, only the latter products were included in the long-list of HHPs.

Table 3 *Long-list of Highly Hazardous Pesticides (HHPs) identified in the Register of Pesticides of Ghana of December 2021 (The complete list of HHP pesticide products is provided in Annex 2).*

Active ingredient [1]	Type [2]	HHP criteria that were met (and associated *hazard statement*)	Number of products
Aluminium phosphide (≥ 56% formulations)	Fum	▪ WHO Class Ib – *highly hazardous*	2
Magnesium phosphide (≥ 56% formulations)	Fum	▪ WHO Class Ib – *highly hazardous*	1
Anthraquinone (all formulations)	BR	▪ Carcinogen Category 1B – *may cause cancer*	2
Brodifacoum (≥98% formulation)	R	▪ WHO Class Ib – *highly hazardous* ▪ Reproductive toxicant Category 1A – *may damage the unborn child*	1
Bromadiolone (≥2.5% formulation)	R	▪ WHO class Ib – *highly hazardous* ▪ Reproductive toxicant Category 1A – *may damage the unborn child*	1
Chromium trioxide + arsenic pentoxide (all formulations)	WP	▪ WHO Class Ib – *highly hazardous* ▪ Carcinogen Category 1A – *may cause cancer* ▪ Germ cell mutagen Category 1B – *may cause genetic effects*	1
Carbofuran (all formulations)	I, N	▪ Rotterdam Convention Annex III	7
Fenvalerate (all formulations)	I	▪ Stockholm Convention Annex D	6
Lufenuron (all formulations)	I	▪ Stockholm Convention Annex D	2
Methomyl (≥50% formulation)	I	▪ WHO Class Ib – *highly hazardous*	1
Oxamyl (≥24% formulation)	I, N	▪ WHO Class Ib – *highly hazardous*	2
Thiacloprid (all formulations)	I	▪ Reproductive toxicant Category 1B – *may damage fertility; may damage the unborn child*	1

Active ingredient [1]	Type [2]	HHP criteria that were met (and associated *hazard statement*)	Number of products
Boric acid (all formulations)	AM, I	▪ Reproductive toxicant Category 1B – *may damage fertility; may damage the unborn child*	1
Carbendazim (all formulations)	F	▪ Germ cell mutagen Category 1B – *may cause genetic defects* ▪ Reproductive toxicant Category 1B – *may damage fertility; may damage the unborn child*	10
Cyproconazole (all formulations)	F	▪ Reproduction toxicant Category 1B – *may damage the unborn child*	1
Dimethomorph (all formulations)	F	▪ Reproduction toxicant Category 1B – *may damage fertility*	8
Mancozeb (all formulations)	F	▪ Reproduction toxicant category 1B – *may damage the unborn child*	30
Propiconazole (all formulations)	F	▪ Reproduction toxicant category 1B – *may damage the unborn child*	1
Triadimenol (all formulations)	F	▪ Reproductive toxicant category 1B – *may damage fertility; may damage the unborn child*	1
Glufosinate-ammonium (all formulations)	H	▪ Reproductive toxicant category 1B – *may damage fertility; may damage the unborn child*	5
Haloxyfop-methyl (all formulations)	H	▪ WHO Class IB – *highly hazardous*	4

[1] In some cases, only products containing an active ingredient exceeding a certain concentration were considered to be a HHP. The concentrations mentioned in this table are those listed in the Ghana Register of Pesticides; they are not necessarily the concentration limit of what constitutes a HHP for that active ingredient.

[2] Pesticide type: AM = anti-microbial; BR = bird repellent; F = fungicide; Fum = fumigant; H = herbicide; I = insecticide; n = nematicide; R = rodenticide; WP = wood preservative.

Many of the active ingredients identified as HHPs are represented by only one or a few registered products. However, for some active ingredients a considerable number of products was registered, including carbendazim, carbofuran, dimethomorph and mancozeb.

The HHP criterion that was most often met was the GHS reproductive toxicant Category 1B (associated hazard statements: may damage fertility and/or may damage the unborn child) (Figure 5). This was followed by WHO Class Ib (associated hazard statement: highly hazardous).

No pesticides in the Ghana register were listed in Stockholm Convention Annex A or B, which are persistent organic pollutants (POPs) destined for elimination or restriction, respectively. Since Ghana is a Party to the Stockholm Convention, it follows the provisions of that convention.

No pesticides met HHP 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*. This criterion generally needs to be evaluated against local information. However, no reports or data were obtained about effects on human health or the environment observed in Ghana. This does not exclude that such effects may have occurred, but reports describing them were not available at the time of the HHP scan.

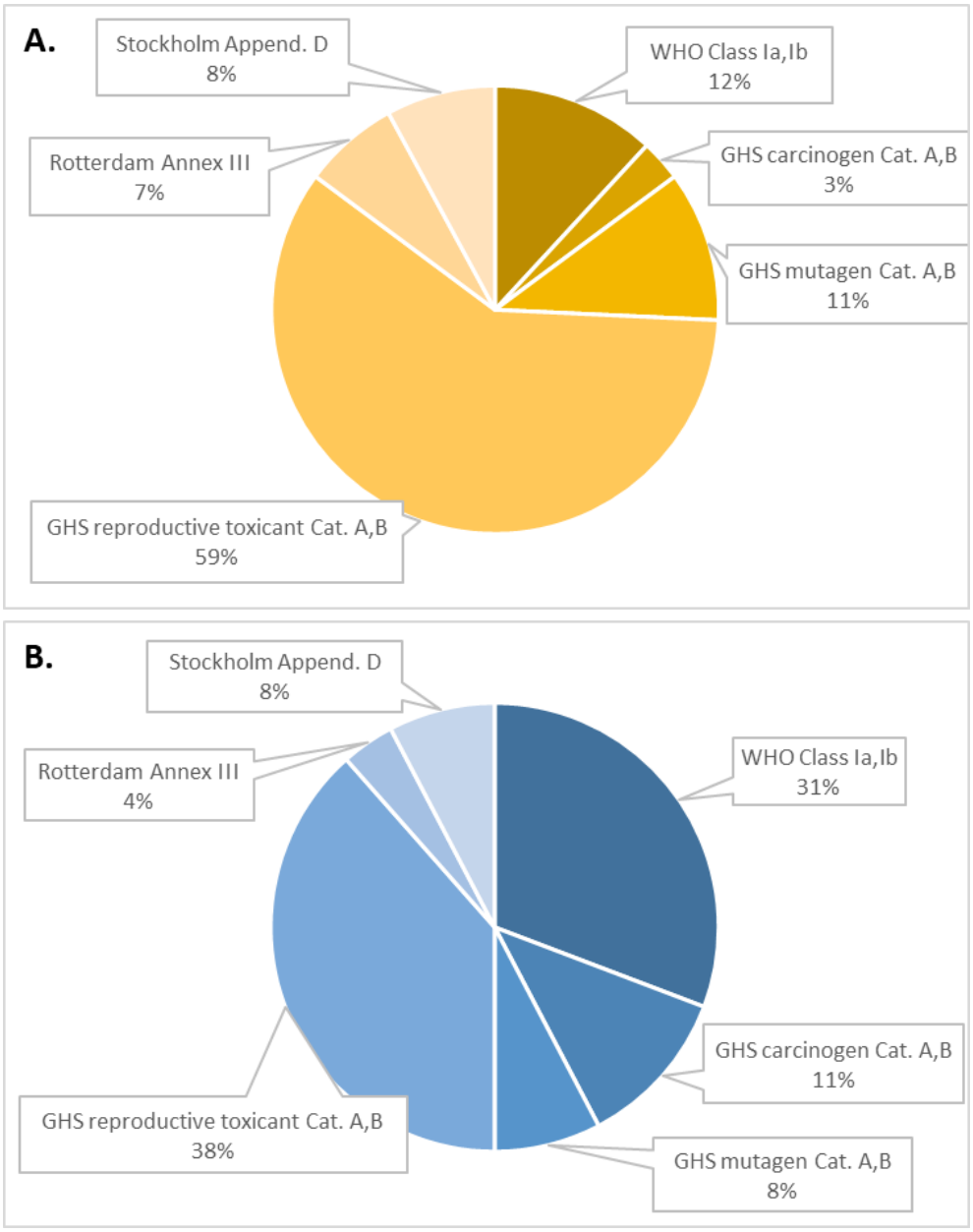

Figure 5 *Relative importance of the HHP criteria for the identified HHPs in Ghana. A. percentage of the HHP products that met the various criteria (n=87 product); B. percentage of the HHP active ingredients that met the various criteria (n=22 a.i.).*

4 Needs assessment

4.1 Stocktaking

For all HHPs in the long-list (Section 3.3, Table 3) pesticide importation data were compiled for the period 2019 – 2021. These statistics were completed with information obtained from pesticide importers and distributors, as well as from local pesticide formulators.

Since no pesticide use statistics are collected in Ghana, and few pesticides are exported from Ghana, these importation and local formulation data were expected to provide a reasonable estimate for pesticides use in the country.

Table 4 summarizes the results of this stocktaking exercise. The table provides the total pesticide imports and formulation for the period January 2019 – December 2021.

HHP products containing seven active ingredients were not imported or locally formulated in recent years. Apart from the fumigant magnesium phosphide, which is used by the Ghana Cocoa Board, apparently there is no current market for products with the other six active ingredients. Furthermore, products containing three other active ingredients were imported/formulated in only relatively small quantities (less than 10,000 kg per year).

On the other hand, pesticide products containing 4 active ingredients were imported/formulated in quantities exceeding on average 40,000 kg per year: the insecticides/nematicides carbofuran and fenvalerate, and the fungicides dimethomorph and mancozeb. The latter fungicide was used in large quantities, averaging 400,000 kg per year.

The other HHPs were estimated to be used in intermediate quantities.

Table 4 *Highly Hazardous Pesticides (HHPs) imported or locally formulated in Ghana, over the period 2019 – 2021. Quantities are of formulated pesticide products.*

Active ingredient	Total quantity imported or formulated (kg or L)	Remarks
Aluminium phosphide (≥ 56% formulations)	12,000	
Magnesium phosphide (≥ 56% formulations)	0	The Ghana Cocoa Board still has a large stock
Anthraquinone (all formulations)	0	Some recent but limited (unquantified) imports were reported
Brodifacoum (≥98% formulation)	0	
Bromadiolone (≥2.5% formulation)	0	
Chromium trioxide + arsenic pentoxide (all formulations)	20,000	Product apparently only used by one farm
Carbofuran (all formulations)	224,000	
Fenvalerate (all formulations)	133,000	
Lufenuron (all formulations)	12,700	
Methomyl (≥50% formulation)	27,800	

Active ingredient	Total quantity imported or formulated (kg or L)	Remarks
Oxamyl (≥24% formulation)	0	
Thiacloprid (all formulations)	400	
Boric acid (all formulations)	0	There may be industrial uses as antimicrobial or antiseptic, but this is not quantified
Carbendazim (all formulations)	28,700	
Cyproconazole (all formulations)	0	
Dimethomorph (all formulations)	434,300	
Mancozeb (all formulations)	1,200,700	
Propiconazole (all formulations)	4,800	
Triadimenol (all formulations)	10,000	
Glufosinate-ammonium (all formulations)	2,000	
Haloxyfop-methyl (all formulations)	40,000	

4.2 Uses and alternatives

All registered uses of the long-listed HHPs were compiled from current pesticide labels approved in Ghana. This provided information on the crop-pest combinations for which the use of the HHPs was authorized (Table 5).

Key stakeholders were then consulted in stakeholder meetings to discuss continued needs for the identified HHPs as well as possible alternatives. Stakeholders were provided with so-called HHP Information Cards, which summarized the information for all identified HHPs at the time of the meetings. The latest version of these cards is provided in Annex 5.

The outcome of this part of the needs assessment are summarized in Table 5.

Most of the listed alternatives were synthetic pesticides expected to pose lower health and environmental risks. Relatively few biopesticides have been registered in Ghana. Other pest management approaches, such as IPM, resistant crop varieties or cultural methods were proposed only rarely by stakeholders, possibly due to the fact that relevant institutions for such alternatives were not present during the consultations.

Table 5 *Registered uses of the identified HHPs, alternatives registered in Ghana, as well as remarks about the continued needs for these pesticides.*

Active ingredient	Registered uses	Registered non-HHP alternatives	Remarks
Aluminium phosphide (≥ 56% formulations)	– Fumigant to control pests in stored agricultural products (e.g. cereals, tobacco, processed food) – Use is currently restricted to trained, large-scale users	– Pirimiphos-methyl, deltamethrin, pyrethrum	Hermetic grain storage bags for small scale storage are available in Ghana, but are expensive
Magnesium phosphide (≥ 56% formulations)	– Fumigant to control pests in stored agricultural products – Use is currently restricted to trained, large-scale users		Controlled use by the Ghana Cocoa Board in their large stores.
Anthraquinone (all formulations)	– Bird repellent on rice	– Methyl anthranilate	
Brodifacoum (≥98% formulation)	– Rodenticide for the control of rats and mice	– Several baits with a very low concentration of brodifacoum are registered	This concentrated formulation was likely intended for the local formulation of rodent baits
Bromadiolone (≥2.5% formulation)	– Rodenticide for the control of rats and mice	– One bait with a very low concentration of brodifacoum are registered	This concentrated formulation was likely intended for the local formulation of rodent baits
Chromium trioxide + arsenic pentoxide (all formulations)	– Insecticide used as wood preservative	– Other pesticides for wood treatment are currently registered which are not HHPs, though some may also pose high human health and environmental risks. – US-EPA has identified alternative, lower risk, wood treatment options	Mainly used to treat wooden poles
Carbofuran (all formulations)	Insecticide, nematicide for the control of: – insect pests in rice, vegetables, oil palm, maize, sugarcane, cotton, groundnut – Nematodes in rice, vegetables, maize, sweetpotato, sunflower		Not many low risk nematicides or insecticides against soil insects are currently registered
Fenvalerate (all formulations)	Insecticide for control of: – pests in vegetables, fruits – bollworm, cotton stainer, stalkborers in cotton, maize, sorghum – Aphids, mites, weevils in cocoa	– Active isomer esfenvalerate may be registered. – Many broad-spectrum insecticides are registered	
Lufenuron (all formulations)	Insecticide for the control of: – podborers, bollworm, beet armyworm, leafmoths in kidney bean, tomato, cabbage – cabbage caterpillar in cabbage	– Teflubenzuron	
Methomyl (≥50% formulation)	– Insecticide for the control of army worm, aphids, whiteflies in cereals, vegetables, fruit trees	– Many alternative lower-risk insecticides are registered	Need to assess IPM options since there is a high risk of resistance development in the listed pests if reliance on single insecticides.
Oxamyl (≥24% formulation)	– Insecticide and nematicide for the control of nematodes and soil insects		Not many nematicides are registered in Ghana.
Thiacloprid (all formulations)	Insecticide for the control of: – insect pests in cotton – fall armyworm in maize	– Many other contact/systemic insecticides registered	
Boric acid (all formulations)	– Insecticide for the control of ants, bugs and roaches – Uses as antimicrobial or antiseptic	– Several alternatives for control of public health pests are registered – Other disinfectants are registered	

Active ingredient	Registered uses	Registered non-HHP alternatives	Remarks
Carbendazim (all formulations)	Fungicide for the control of: – rice blast, Rice sheath blight in rice – Botrytis, Sclerotinia, blue mould in vegetables, fruits, rubber – leafspot, leaf mould, stem rot, powdery mildew, leaf blight, scab in vegetables – Anthracnose and downy mildew in vegetables, fruits, coffee – leafspot, leaf mould, stem rot in rubber, mango – late leaf spot, peanut rust in groundnut – fungi and algae as additive to paint	– Several fungicides are registered for control of most of the listed diseases.	
Cyproconazole (all formulations)	– Fungicide for control of diseases in maize, rice, groundnut and vegetables	– Difenoconazole, tebuconazole	
Dimethomorph (all formulations)	Fungicide for the control of: – Black pod disease in cocoa – Late blight in sweetpotato, tomato – Downy mildew and early blight in cucumber	– Black pod disease in cocoa: copper hydroxide, metalaxyl, pyraclostrobin, – Blights and mildew in vegetables: many registered fungicides	Part of black pod disease resistance management in cocoa
Mancozeb (all formulations)	– Fungicide for the control of a wide variety of diseases in vegetables, fruits, ornamentals, soybean, groundnut, coffee, banana, plantain, tubers, rice, cereals, tobacco	– Several alternative fungicides are registered	Mancozeb is an effective and cheap broad-spectrum fungicide, and therefore very widely used
Propiconazole (all formulations)	– Fungicide to control diseases in rice, pineapple	– Difenoconazole, tebuconazole	
Triadimenol (all formulations)	– Fungicide for the control of early blight, late blight, tomato leaf spot in vegetables, field crops, ornamentals	– Various fungicides active against blights are registered	
Glufosinate-ammonium (all formulations)	– Herbicide for the control of annual and perennial grasses and broadleaf weeds in vegetables, cereals, fruits, rubber, fallow land	– Several broad-spectrum herbicides currently registered, such as ametryn, 2,4-D, glyphosate, nicosulfuron and others.	
Haloxyfop-methyl (all formulations)	– Herbicide for the control of annual and perennial grasses in vegetables, watermelon, groundnut, soybean, pineapple, cotton, legumes, non-crop land	– Several herbicides are registered to control grassy weeds.	

5 Risk assessment

5.1 Occupational risks

5.1.1 Method

The main occupational risks of a pesticide are those for the applicator (when applying the pesticide) and the worker (when harvesting or otherwise handling the treated crop).

Occupational risks of using a HHP in Ghana were evaluated using the OPEX Tool of the European Food Safety Authority (EFSA, 2022b; version 0.3.22). The tool is developed to provide estimates of the non-dietary exposure for operators, workers, residents and bystanders, related to the use of plant protection products (EFSA, 2022a).

Occupational risk assessments were conducted for the HHPs in the long-list that were in actual use (Table 4) and for which exposure scenarios were available in the EFSA OPEX Tool. No exposure scenarios, and therefore no occupational risk assessments, were conducted for the fumigants, rodenticides, the antimicrobial and the bird repellent.

Relevant pesticide application scenario data were identified from the list of registered uses which was compiled in Section 4.2 (Table 5).

Application techniques
All risk assessment were conducted for hand-held pesticide application equipment (e.g. backpack sprayers), which are most commonly used in Ghana. If crops were also grown on large commercial farms in Ghana, the risk resulting from vehicle-mounted sprayers was also assessed.

Crop
It is crop structure that determines to a large extent the exposure risk of operators and workers. For each of the HHPs, one or more representative crop groups were chosen from the registered uses. If such a crop was included in the OPEX Tool pick-list of crops, and hand-held sprayers available as application technique, that crop was evaluated.

If the exact crop group for which the HHP was registered in Ghana was not available in the OPEX Tool, a crop group was chosen that had a structure which came closest to the crop in Ghana; and had an associated application technique relevant for Ghana. If available application techniques in the Tool did not correspond with the conditions in Ghana, a different crop was chosen with a similar structure to the crop in Ghana but which included the relevant application techniques.

Application rate
The highest registered application rates for the selected crops were used for the occupational risk assessment.

Volume of water
Whenever available on the pesticide label, the minimum and maximum volume of water for preparing the spray dilution was used in the OPEX Tool.

In absence of this information, a minimum volume of water of 100 L/ha and a maximum volume of water of 300 L/ha was used as a default. This range of volumes can be expected with hand-held spray equipment in Ghana.

Dermal absorption
Dermal absorption determines to a large extent the penetration of the pesticide through the skin. Usually dermal absorption of a pesticide formulation is presented as a value for the concentrated formulation (used for mixing and loading) and a value for the diluted formulation (spray dilution used for application).

If available, dermal absorption values included in EFSA Lists of Endpoints (LoEP) for the same or similar pesticide formulations as the HHPs in Ghana were used. In absence of relevant product specific dermal absorption values in the EFSA LoEP, the default values for dermal absorption were used according to EFSA Guidance (EFSA, 2017).

A more detailed description of the use of dermal absorption values in the occupational risk assessments of the HHPs is provided in Annex 3.

Acceptable Operator Exposure Level
The level of exposure estimated with the EFSA OPEX Tool was compared with the Acceptable Operator Exposure Level (AOEL). The operator or worker risk of a HHP was considered unacceptable whenever the exposure exceeded the AOEL. Values for the AOEL were obtained from EFSA Lists of Endpoints (LoEP) for each of the active ingredients that were evaluated.

5.1.2 Outcome

The outcome of the occupational risk assessments, for different application scenarios relevant for Ghana, is summarized in Table 6.

Both worker and operator risks were unacceptable for carbendazim, glufosinate-ammonium and methomyl, for all evaluated application scenarios and even when full personal protective equipment (PPE) would be used. Therefore, these HHPs can not be expected to be used with acceptable risk under Ghanaian conditions of use.

For various HHPs, occupational risks were only acceptable if operators and/or workers will wear considerable PPE (overall, gloves, face shield or mask). This was the case for carbofuran, haloxyfop-methyl, and certain scenarios with mancozeb and propiconazole.

In several cases, either an overall or basic workwear (long-sleeved pants and shirt) should be worn to ensure that the HHP can be applied with acceptable risk: dimethomorph, certain mancozeb or propiconazole scenarios, thiacloprid and thiadimenol.

None of the HHPs could be applied with acceptable risk without at least basic workwear being used by applicators and workers.

Table 6 *Results of the occupational risk assessments of HHPs in actual use in Ghana, using the EFSA OPEX Tool.*

Active ingredient	Application scenario				Risk assessment	
	Reference crop in Ghana [2]	**Crop group in OPEX [1]**	**Rate (g a.i./ha)**	**Equipment**	**Operator**	**Worker**
Carbendazim	Vegetables, sweetpotato, rice	Low vegetables	1000	Hand-held, backpack	No acceptable risk, even with full PPE	No acceptable risk, even if hands, arms, body and legs are covered
	Rice, maize	Field crops		Tractor		
Carbofuran	Vegetables, rice	Low vegetables	75	Hand-held broadcast application of dry granules	Risk acceptable only if PPE is used. *Mixing/loading:* overall, gloves, face mask (FFP2 or similar). *Application:* overall, gloves	Not applicable (pesticide applied to soil)
	Oil palm,	Oil fruits				
	Rice, maize	Field crops		Tractor broadcast application of dry granules		
Dimethomorph	Vegetables	Low vegetables	108	Hand-held, backpack, tractor	Risk acceptable only if PPE is used. *Mixing/loading:* overall *Application:* overall	Risk acceptable with basic workwear
	Cocoa	Orchards		Hand-held, backpack		
Glufosinate-ammonium	Vegetables	Low vegetables	900	Hand-held, backpack	No acceptable risk, even with full PPE	No acceptable risk, even if hands, arms, body and legs are covered
	Fruit trees, banana, rubber	Orchards				
	--	Bare ground (pre-emergence)				No applicable
Haloxyfop-methyl	Vegetables, groundnut	Low vegetables	260	Hand-held, backpack	Risk acceptable only if PPE is used. *Mixing/loading:* overall, gloves, face shield. *Application:* overall, gloves	No acceptable risk, even if hands, arms, body and legs are covered
	Cotton	High ornamentals			Risk acceptable only if PPE is used. *Mixing/loading:* overall, gloves. *Application:* overall, gloves	
	--	Bare ground (pre-emergence)				
Mancozeb	Vegetables, sweetpotato	Low vegetables	3200	Hand-held	No acceptable risk, even with full PPE	Risk acceptable only if hands, arms, body and legs are covered
	Vegetables, sweetpotato			Backpack	Risk acceptable only when wearing overall, gloves	
	Fruit trees, plantain, banana	Orchards		Hand-held, backpack	Risk acceptable only when wearing overall	No acceptable risk, even with full PPE
	Ornamentals, coffee	High ornamentals		Hand-held	No acceptable risk, even with full PPE	No acceptable risk, even with full PPE
	Ornamentals, coffee			Backpack	Risk acceptable only when wearing overall, gloves	
	Cereals, rice, soybean	Field crops		Tractor	No acceptable risk, even with full PPE	Risk acceptable only if hands, arms, body and legs are covered

Active ingredient	Application scenario				Risk assessment	
	Reference crop in Ghana [2]	Crop group in OPEX [1]	Rate (g a.i./ha)	Equipment	Operator	Worker
Methomyl	Vegetables, sweetpotato, groundnut	Low vegetables	2000	Hand-held, backpack, tractor	No acceptable risk, even with full PPE	No acceptable risk, even if hands, arms, body and legs are covered
	Fruit trees	Orchards				
	Rice, maize	Field crops		Tractor		
Propiconazole	Pineapple	Low berries	100	Hand-held, backpack	Risk acceptable when wearing overall	Risk acceptable with basic workwear
	Sugarcane	Cane fruit/high berries		Hand-held, backpack, tractor		Risk acceptable only if hands, arms, body and legs are covered
	Rice	Field crops		Tractor	Risk acceptable with basic workwear	Risk acceptable with basic workwear
Thiacloprid	Cotton	High ornamentals	36	Hand-held, backpack	Risk acceptable when wearing overall or workwear	Risk acceptable only if arms, body and legs covered
	Maize	High vegetables				
	Vegetables	Low vegetables				
	Maize	Field crops		Tractor		Risk acceptable with basic workwear
Triadimenol	Vegetables	Low vegetables	9	Hand-held, backpack	Risk acceptable when wearing overall or workwear	Risk acceptable with basic workwear
	Fruit trees	Orchards				
	Ornamentals	High ornamentals				

1 Reference crops in Ghana were selected from the registered uses of the HHPs on authorized labels.

2 Crop groups in OPEX are the corresponding crop groups in the EFSA OPEX model that were used for the risk assessment.

5.2 Dietary risks

5.2.1 Method

Pesticides applied on food crops may leave residues that are ingested by consumers of the food commodity. Such dietary risks were assessed for all HHPs that had acceptable occupational risk scenarios (Section 5.1). HHPs showing unacceptable occupational risks were generally not assessed for dietary risks since their use in Ghana is likely to be discontinued.

The International Estimated Daily Intake (IEDI) model (GEMS/Food, 2020) was used to estimate dietary risks (17 cluster diet, version 04a, dd 30 October 2020). This model estimates chronic (life-long) dietary exposure to residues of chemicals in food. It has been developed by the Global Environment Monitoring System / Food Contamination Monitoring and Assessment Programme (GEMS/Food), implemented by the World Health Organization and used by the Codex Alimentarius.

Because no national diet was available for Ghana, the GEMS/Food regional cluster diet G03 was used, which covers parts of West Africa and includes Ghana.

The risk assessments were conducted using maximum residue limits (MRLs) as a proxy for worst case residue levels of the HHPs in food commodities. The primary source for MRL values was the Codex Pesticides Residues in Food Online Database (Codex Alimentarius, 2022). If no Codex MRLs were available, Australian or Brazilian MRLs were used as alternative. These countries were chosen since they include agro-ecological zones that are similar to the ones found in Ghana.

Dietary risks were estimated for all commodities combined on which the HHP had been authorized for use in Ghana (Section 4.2). Corresponding agricultural commodities were then chosen in the IEDI model. The highest level commodity in the model was generally chosen in each relevant commodity group, to ensure that it would encompass all food products within a given commodity. Even though the labels in Ghana generally only listed the use of the pesticide on crops, the dietary risk assessment also included residues on animal commodities. This was done since pesticide-treated crop parts could also be fed to animals.

Consumer risk was considered unacceptable if the dietary intake of the HHP exceeded the Acceptable Daily Intake (ADI). ADI values were obtained from the Codex Pesticides Residues in Food Online Database (Codex Alimentarius, 2022).

5.2.2 Outcome

The outcome of the dietary risk assessments is summarized in Table 7. The details of these assessments are provided in Annex 4.

The assessments that were conducted, using MRLs as proxy for pesticide residue levels, result in a Theoretical Maximum Daily Intake (TMDI). It is generally recognized that the TMDI provides a significant overestimation of normally expected residue intakes, unless the pesticide is greatly overdosed when compared to recommended application rates.

Furthermore, since pesticide labels in Ghana often indicate that a pesticide can be used on a very broad crop group (e.g. “vegetables”, “fruit trees”), the dietary risk assessment had to assume that all possible commodities within such a crop group would contain residues of that pesticide. In reality, it may be that fewer crops within a broad crop group are treated with the pesticide in Ghana. In such a case, residue levels would likely be lower, and so would the dietary risk. However, since authorized uses on the labels were many, the estimated residue intake was relatively high.

The results for five of the eight evaluated active ingredients (dimethomorph, methomyl, propiconazole, thiacloprid and triadimenol) indicate that the total residue intake are well below the acceptable daily intakes (ADI) applied by the Codex Alimentarius. It is therefore unlikely that using these pesticides on the registered crops will result in unacceptable consumer risks.

The dietary risk assessments of two active ingredients (carbendazim and mancozeb) were borderline below and above the ADI, respectively. A dietary risk cannot be excluded, but more specific data on measured residues and the exact crops that are treated with these pesticides in Ghana is needed to be more certain.

The evaluation of haloxyfop-methyl resulted in a large exceedance of the ADI, suggesting an actual risk for consumers if this herbicide is applied in Ghana.

In many cases, MRLs for some of the commodities could not be obtained from the sources that were used in this assessment (i.e. Codex Alimentarius, Australia, Brazil). Generally, this was only for a few commodities, and it is not likely that this data gap would have significantly changed the outcome of the risk assessment.

In three cases, MRLs were missing for 50% of the crop commodities. In the case of haloxyfop-methyl, additional MRLs would further increase the residue intake and would make the dietary risk even more unacceptable. For thiacloprid and triadimenol, the estimated dietary risk was only 1% of the ADI; one or two additional MRLs would have increased the total residue intake, but is unlikely to have changed the overall outcome significantly.

MRLs were generally only available for half of the animal commodities. However, since in the diet G03, applicable to Ghana, the consumption of animal food commodities is only 6% of the total food consumption, this shortage of MRLs for animal commodities is unlikely to have changed the outcome of the risk assessment in a substantial way.

Table 7 *Results of the dietary risk assessments of selected HHPs, using the GEMS/Food IEDI model for regional cluster diet G03 (for more details, see Annex 4).*

Active ingredient	ADI Codex (mg/kg bw/day)	Number of crops or crop groups on Ghanaian approved labels	% crop commodities with representative MRLs	% animal commodities with representative MRLs	Pesticide residue intake as % ADI
Carbendazim	0.03	7	94%	30%	90%
Dimethomorph	0.2	5	89%	50%	3%
Haloxyfop-methyl	0.0007	12	50%	50%	790%
Mancozeb	0.03	32	95%	50%	120%
Methomyl	0.02	9	100%	50%	10%
Propiconazole	0.07	4	100%	50%	1%
Thiacloprid	0.01	2	50%	50%	1%
Triadimenol	0.03	4	50%	50%	1%

6 Risk mitigation

6.1 Method

Risk mitigation measures for the HHPs were initially identified by the EPA-CCMC team on the basis of the results of the different needs and risk assessments carried out in the previous chapters. The measures were then communicated to stakeholders for written comments. Furthermore, two meetings were organized in which stakeholders were invited to provide further inputs with respect to the current use and future needs of the HHPs, possible lower risk alternatives, as well as their views about the proposed mitigation measures. Proposals were modified, whenever provided data or argumentation justified this. Nonetheless, the final proposals for the risk mitigation measures were those of EPA-CCMC only.

The starting point for discussion on risk mitigation measures was the outcome of the assessments conducted in staps 1 and 2, which are schematically summarized in Figure 6.

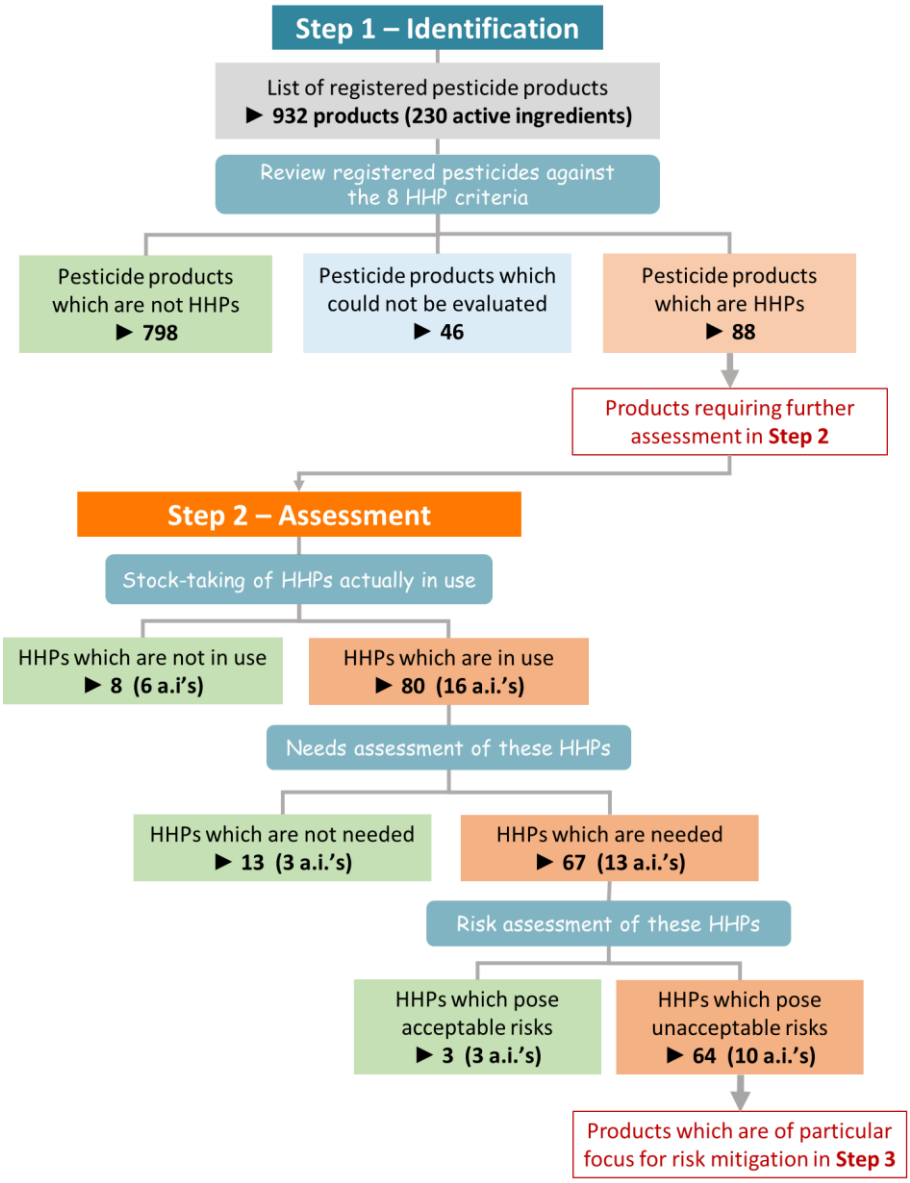

Figure 6 *Schematic summary of the outcomes of Step-1 and Step-2.*

In principle, the overall rationale as summarized in Table 8 was then followed to propose regulatory and risk mitigation measures for the identified HHPs.

The measure *"cancel registration"* means that the registration should be immediately cancelled, either because the HHP was not in recent use, or because it poses high acute health risks.

The measure *"phase-out registration"* means that the HHP will be phased-out progressively during a limited period of time (suggested 2 – 3 years). Phasing out of a HHP is generally proposed when considerable quantities of the pesticide are still in use, health risks are not acute, and alternatives need to be phased in.

The measure *"restrict registration"* means that the HHPs will remain registered only for a limited number of uses, for specific users only (authorised) and ensuring appropriate PPE or other protective measures. Registration may also be temporary, i.e. limited in time, to allow alternatives to be phased in.

The measure *"maintain registration"* means that the HP can continue to be used in Ghana, although use limitations or additional risk mitigation measures may be required.

The additional activity "*develop a road-map*" was recommended for HHPs that were used in large quantities, need to be phased out, but for which sufficient alternatives were not yet available. The road map should describe the development and phase-in of alternatives and the phase-out of the HHP in more detail.

Table 8 *Rationale for proposing regulatory and risk mitigation measures for HHPs identified in the Register of Pesticides of Ghana.*

Situation	Proposed measure
1. HHP was not in use in Ghana	
1.1 No essential needs were identified	► Cancel registration
1.2 Some essential (future) needs were identified	
1.2.1 Operator, worker and consumer risks are acceptable	► Maintain registration
1.2.2 Operator and/or worker and/or consumer risks are unacceptable	
1.2.2.1 Alternatives are available	► Cancel registration
1.2.2.2 Alternatives are not available	► Phase out registration and identify/develop alternatives. In the mean time, restrict to essential uses only
1.2.3 No risk assessment was conducted (or only qualitative)	
1.2.3.1 Alternatives are available	► Cancel registration
1.2.3.2 Alternatives are not available	► Phase out registration and identify/develop alternatives. In the mean time, restrict to essential uses only
2. HHP was in use in Ghana	
2.1 HHP is assumed to be needed	
2.1.1 Operator, worker and consumer risks are acceptable	► Maintain registration
2.1.2 Operator and/or worker and/or consumer risks are unacceptable	
1.2.2.1 Alternatives are available	► Cancel or phase out registration
1.2.2.2 Alternatives are not available	► Restrict registration to essential uses only, and impose strict risk mitigation measures ► Develop a road map towards phase-out
2.1.3 No risk assessment was conducted (or only qualitative)	
1.2.2.1 Alternatives are available	► Cancel or phase out registration
1.2.2.2 Alternatives are not available	► Restrict registration to essential uses only, and impose strict risk mitigation measures ► Develop a road map towards phase-out

6.2 Proposed risk mitigation measures

The proposed risk mitigation measures for all HHPs are summarized in Table 9.

For HHP products containing three active ingredients (aluminium phosphide, propiconazole and triadimenol), the current registrations were proposed to be maintained. Aluminium phosphide is a restricted use fumigant in Ghana and was recommended to remain so, though with stricter enforcement. The risk assessments of propiconazole and triadimenol did not result in unacceptable occupational and dietary risks if standard precautionary measures are taken.

The use of HHP products containing four active ingredients (dimethomorph, magnesium phosphide, mancozeb and thiacloprid) was recommended to be restricted. Restrictions proposed are generally a limitation of the number of uses/users of the pesticide to be authorized in Ghana. Stricter use of PPE was also recommended for these products.

The phase out was recommended of HHP products containing another five active ingredients (carbofuran, chromium trioxide + arsenic pentoxide, glufosinate-ammonium and lufenuron). These pesticides were still used in considerable quantities but would either require some time to phase-in alternatives and/or could be used with acceptable acute occupational risks with basic PPE.

The registrations of HHP products with the remaining 10 active ingredients were recommended to be cancelled immediately. These were products that were currently not used in Ghana or posed a high acute toxicity to pesticide applicators and workers.

For pesticide products containing two active ingredients, carbofuran and mancozeb, it was recommended to develop a road map towards phase out of all or many of their uses. A road map was recommended given the large quantities of current uses of these pesticides and the lack of sufficient immediate low risk alternatives. The road maps should describe the activities needed to develop and phase-in alternatives, register low-risk pesticides and create awareness and knowledge with the HHP users. A provisional outline of such a road map is provided in Annex 7.

The mitigation measures were discussed with key stakeholders and their comments and suggestions have been taken into account whenever pertinent and feasible. Nevertheless, the final proposals listed in Table 9 are those of the pesticide team at EPA-CCMC. They were subsequently submitted to the Pesticides Technical Committee (PTC) for comments and final consideration and approval of the proposed mitigation measures by the EPA Board.

Table 9 *Summary of the proposed risk mitigation measures for the HHPs identified in Ghana*

Active ingredient	Reason why HHP	Number of registered products	Recent use	Proposed measure	Justification
Aluminium phosphide	WHO Class Ib – *highly hazardous (inhalation)*	2	Moderate	**Maintain restricted registration**	▪ Fumigant with very high acute toxicity. ▪ Its use is currently restricted to trained, large-scale users. ▪ Stricter enforcement of the current restricted use may be needed (e.g. no authorization of imports for retail sales).
Anthraquinone	Carcinogen category 1B – *may cause cancer*	2	Very limited	**Cancel registration**	▪ Application of a carcinogenic pesticide on a major food crop, quite shortly before harvest, is not acceptable. ▪ Since only very limited imports have been recorded, and an alternative bird repellent is registered, use in Ghana is not considered essential.
Boric acid	Reproductive toxicant Category 1B – *may damage fertility; may damage the unborn child*	1	None	**Cancel registration** (as a pesticide)	▪ Current registration has expired. ▪ Since no imports have been recorded, use in Ghana is not considered essential. ▪ Sufficient lower risk alternatives are available.
Brodifacoum (only for the ≥98% formulation)	WHO Class Ib – *highly hazardous* Reproductive toxicant Category 1A – *may damage the unborn child*	1	None	**Cancel registration**	▪ Concentrated brodifacoum has a high acute toxicity and is a reproductive toxicant. ▪ Use of low concentration baits containing brodifacoum remains possible.
Bromadiolone (only for the 2.5% formulation)	WHO Class Ib – *highly hazardous* Reproductive toxicant Category 1A – *may damage the unborn child*	1	None	**Cancel registration**	▪ Concentrated brodifacoum has a high acute toxicity and is a reproductive toxicant. ▪ Use of low concentration baits containing brodifacoum remains possible.
Carbendazim	Germ cell mutagen Category 1B – *may cause genetic defects* Reproductive toxicant Category 1B – *may damage fertility; may damage the unborn child*	10	Moderate	**Cancel registration** (use-up time for existing stocks)	▪ No acceptable occupational risk scenarios were identified, therefore it is unlikely that carbendazim can be used with acceptable risk in Ghana. ▪ No essential needs were identified by stakeholders.
Carbofuran	Rotterdam Convention Annex III	7	Important	**Phase-out registration** (develop road map)	▪ Acceptable operator scenarios were identified only if PPE was used. ▪ Large quantities of carbofuran have been imported, indicating a need for its use. ▪ Not many low risk nematicides or insecticides against soil insects are currently registered, and will need to be identified. ▪ Since listing of carbofuran in Annex III of the Rotterdam Convention was due to both human health risks and a wide range of environmental risks, progressive phase out of carbofuran in Ghana is proposed. ▪ As an initial risk reduction step, use of carbofuran should be restricted to licenced operators and registration for general use should be cancelled. ▪ Due to the current large use of carbofuran in Ghana, a more detailed roadmap for phase-out will subsequently need to be developed.

Active ingredient	Reason why HHP	Number of registered products	Recent use	Proposed measure	Justification
Chromium trioxide + arsenic pentoxide (in combination with copper oxide)	WHO Class Ib – *highly hazardous* Carcinogen Category 1A – *may cause cancer* Germ cell mutagen Category 1B – *may cause genetic effects*	1	Limited	**Phase-out registration**	▪ Wood preservative used by one farm. ▪ US-EPA concluded that chromated arsenicals pose cancer and non-cancer health risks of concern to workers in wood treatment facilities; their use as a wood treatment is highly restricted in the USA. ▪ In view of both the acute and chronic hazards of this pesticide, use with acceptable risks to operators in Ghana is unlikely. ▪ Pesticide industry and wood processing companies to be invited to propose alternative, lower risk, wood treatment options.
Cyproconazole	Reproduction toxicant Category 1B – *may damage the unborn child*	1	None	**Cancel registration**	▪ Since no imports have been recorded, use in Ghana is not considered essential. ▪ Several lower risk alternatives available.
Dimethomorph	Reproduction toxicant Category 1B – *may damage fertility*	8	Important	**Restrict registration**	▪ Restrict registration to use in cocoa only, as part of black pod disease resistance management (essential use). ▪ PPE should be required for handling and application.
Fenvalerate	Stockholm Convention Annex D	6	Important	**Cancel registration** (use-up time for existing stocks)	▪ Fenvalerate can be replaced by its active isomer esfenvalerate, which does not meet Annex D criteria and is therefore not an HHP.
Glufosinate-ammonium	Reproductive toxicant Category 1B – *may damage fertility; may damage the unborn child*	5	Limited	**Phase-out registration**	▪ No acceptable occupational risk scenarios were identified; it is therefore unlikely that glufosinate-ammonium can be used with acceptable risk in Ghana. ▪ Glufosinate-ammonium is an HHP on the basis of chronic hazards. Phase-out of the registration during a limited time period is therefore acceptable.
Haloxyfop-methyl	WHO Class Ib – *highly hazardous*	4	Moderate	**Cancel registration** (use-up time for existing stocks)	▪ Operator risks were only acceptable with full PPE, and no acceptable worker risk scenarios were identified. It is therefore unlikely that haloxyfop-methyl can be used with acceptable risk in Ghana in harvestable crops. ▪ Dietary risks were highly unacceptable. ▪ Haloxyfop-methyl could in principle be replaced by haloxyfop-P-methyl, which is the herbicidally active R-isomer of haloxyfop-methyl. It is less acutely toxic, and not an HHP. However, dietary risks would remain unacceptable also for haloxyfop-P-methyl, so this particular substitution is not recommended. ▪ Several alternative herbicides with similar modes of action are currently registered in Ghana. ▪ Haloxyfop-methyl is HHP on the basis of acute hazards. Cancellation of the pesticide should therefore be immediate.
Lufenuron	Stockholm Convention Annex D	2	Moderate	**Phase-out registration**	▪ Lufenuron is listed as HHP due to its high persistence in the environment and its bioaccumulation potential. ▪ Phase-out of the registration during a limited time period is therefore acceptable.

Active ingredient	Reason why HHP	Number of registered products	Recent use	Proposed measure	Justification
Magnesium phosphide (≥56% formulation)	WHO Class Ib – *highly hazardous*	1	Limited	**Restrict registration**	▪ Fumigant with very high acute toxicity. ▪ Mainly used by the Ghana Cocoa Board. ▪ All registrations of use by smallholder farmers to be discontinued. ▪ Only to be authorized for use by trained (licenced) pesticide applicators in large scale stores of grain companies, wood processing companies, cocoa processing companies and the Ghana Cocoa Board.
Mancozeb	Reproductive toxicant Category 1B – *may damage the unborn child*	30	Important	**Restrict registration** (develop road map)	▪ Occupational risks were acceptable only in a few cases, with basic PPE. ▪ Dietary risks were borderline unacceptable, using the worst case assessment. ▪ Large quantities of mancozeb are being imported, indicating a need for this fungicide. ▪ Continued use of mancozeb for some uses may be possible with proper risk mitigation measures in place. ▪ Due to the current large use of mancozeb in Ghana, a more detailed roadmap to reduce reliance on mancozeb will need to be developed.
Methomyl	WHO Class Ib – *highly hazardous*	1	Moderate	**Cancel registration** (use-up time for existing stocks)	▪ No acceptable occupational risk scenarios were identified; therefore methomyl can likely not be used with acceptable risk in Ghana. ▪ Methomyl was identified as HHP on the basis of its high acute toxicity. Cancellation of registration should therefore be immediate.
Oxamyl	WHO Class Ib – *highly hazardous*	2	None	**Cancel registration**	▪ Very high acute toxicity. ▪ Since no imports have been recorded, use in Ghana is not considered essential. ▪ Oxamyl was identified as HHP on the basis of its high acute toxicity. Cancellation of registration should therefore be immediate.
Propiconazole	Reproductive toxicant Category 1B – *may damage the unborn child*	1	Limited	**Maintain registration** (additional risk mitigation)	▪ Occupational risks were acceptable with basic workwear. ▪ Dietary risks were acceptable. ▪ Appropriate PPE should be required on the label.
Thiacloprid	Reproductive toxicant Category 1B – *may damage fertility, may damage the unborn child*	1	Very limited	**Restrict registration**	▪ For hand-held and backpack sprayers (generally used in cotton and maize in Ghana) operator risks are only acceptable if basic workwear is worn (overalls or long-sleeved short and long pants), and worker risks are acceptable only if arms, body and legs covered. ▪ Most cotton and maize farmers in Ghana will use basic workwear when spraying a pesticide and harvesting their crop. ▪ Use of appropriate PPE should be prominently indicated on the pesticide label and enforced during use. Only uses where PPE use can be realistically expected should be registered.
Triadimenol	Reproductive toxicant Category 1B – *may damage fertility, may damage the unborn child*	1	Moderate	**Maintain registration** (additional risk mitigation)	▪ Occupational risks were acceptable with basic workwear. ▪ Dietary risks were acceptable. ▪ Appropriate PPE should be required on the label.

7 Conclusions and recommendations

Highly Hazardous Pesticides are of particular concern because of the serious adverse effects they can cause to human health and the environment. For that reason, the Ghana Environmental Protection Agency, in collaboration with Wageningen Environmental Research, reviewed all HHPs in its pesticides register.

The systematic approach recommended by FAO and WHO was followed to (1) identify HHPs, (2) assess their needs, risks and alternatives, and (3) define appropriate risk mitigation measures.

Of the 932 pesticide products registered in Ghana as at December 2021, a total of 88 pesticide products were identified as meeting one or more of the HHP criteria, or 9.3% of the registered products.

For all of these pesticide products risk mitigation measures were proposed.

On the basis of this study, the following recommendation are made:

- to consider the risk mitigation measures proposed in this Section 6.2, with the aim to minimize the risks posed by the use of HHPs in Ghana.
- to develop priority road maps towards phase out of carbofuran and mancozeb, in collaboration with all relevant stakeholders, based on the outline provided in Annex 7.
- to include the FAO/WHO HHP criteria in the hazard and risk assessments of each new pesticide product submitted for registration in Ghana.
- to include and/or strengthen environmental risk assessment, not part of the current HHP evaluation, in the evaluation of each new pesticide product submitted for registration in Ghana.
- for those HHPs for which the use was proposed to be continued (with or without further restrictions), to monitor their use and impact on human health and the environment.
- for those HHPs for which the use was proposed to be continued, to further promote and engage in research on alternatives including biological control and IPM
- for those HHPs for which the use was proposed to be continued, to strengthen advice about the need for and proper use of PPE and other risk reduction measures.

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Annex 1 Evaluating criteria in Annex D of the Stockholm Convention

Introduction
The Stockholm Convention Annex D lists the screening criteria used to identify a persistent organic pollutant (POP): persistence, bioaccumulation, toxicity and long-range transport. For the Ghana HHP scan, only the first three criteria were used, and long-range transport was omitted, because a POP which is not transported over long distances would still pose an environmental and health hazard in Ghana.

Because the Stockholm Convention does not provide quantitative criteria for toxicity, the European Union toxicity criteria for persistent, bioaccumulative and toxic (PBT) chemicals were used. These are: **A**) aquatic toxicity endpoint NOEC or EC_{10} < 0.01 mg/L, **B**) GHS reproductive toxicant Category 1A, 1B and 2[1] and **C**) GHS STOT RE Category 1 or 2.

Order of entering the criteria
It is in theory not necessary to fill in *all* the Stockholm Annex D criteria in the HHP spreadsheet. A pesticide is only indicated as a Persistent Organic Pollutant (POP) if it is persistent *and* bio-accumulative *and* potentially toxic. So if evaluation of the bio-accumulation criteria indicates that the substance is NOT bio-accumulative, it is not necessary to assess the toxicity and persistence criteria because the substance will not be a POP. This more efficient strategy for using the spreadsheet, depicted in Figure 7, was used to review the pesticides in the Ghana register. If the reviewer ended up in a green box, the evaluation was ended, since there was no need to assess the remaining criteria.

Figure 7 provides the steps of the evaluation, which are briefly explained below. Pesticide properties needed for the evaluation were taken from the Pesticide Properties Database (PPDB) (Lewis *et al.*, 2016). Annex 6 presents the choices available in the PPDB for each of the three POP screening criteria and provides a proposal for which property to select and justification of this choice

Bioaccumulation
Parameters to be checked in the PPDB:
- Aquatic bioconcentration factor (BCF aquatic)
- Aquatic bioaccumulation factor (BAF aquatic)
- Octanol-water partition coefficient (log K_{ow} or log P)

i. Select the BCF (or BAF) from the PPDB and enter this value (in L/kg) in the relevant cell in the spreadsheet, tab "Active Ingredient list" (section: B5. Stockholm Convention).

ii. If the BCF (or BAF) is not available select the Log P at pH 7, 20°C from the PPDB and enter this value in the relevant cell in the spreadsheet, tab "Active Ingredient list" (section: B5. Stockholm Convention).

The pesticide is considered bio-accumulative if the BCF or the BAF > 5000 L/kg and/or the Log P > 5 ➜ Continue with the toxicity evaluation.

If the BCF or the BAF ≤ 5000 L/kg and the Log P ≤ 5, the pesticide is not bio-accumulative and therefore not a POP ➜ Stop the evaluation.

[1] Note that checking reproductive toxicant Category 1A and 1B is already covered under HHP criteria No. 4

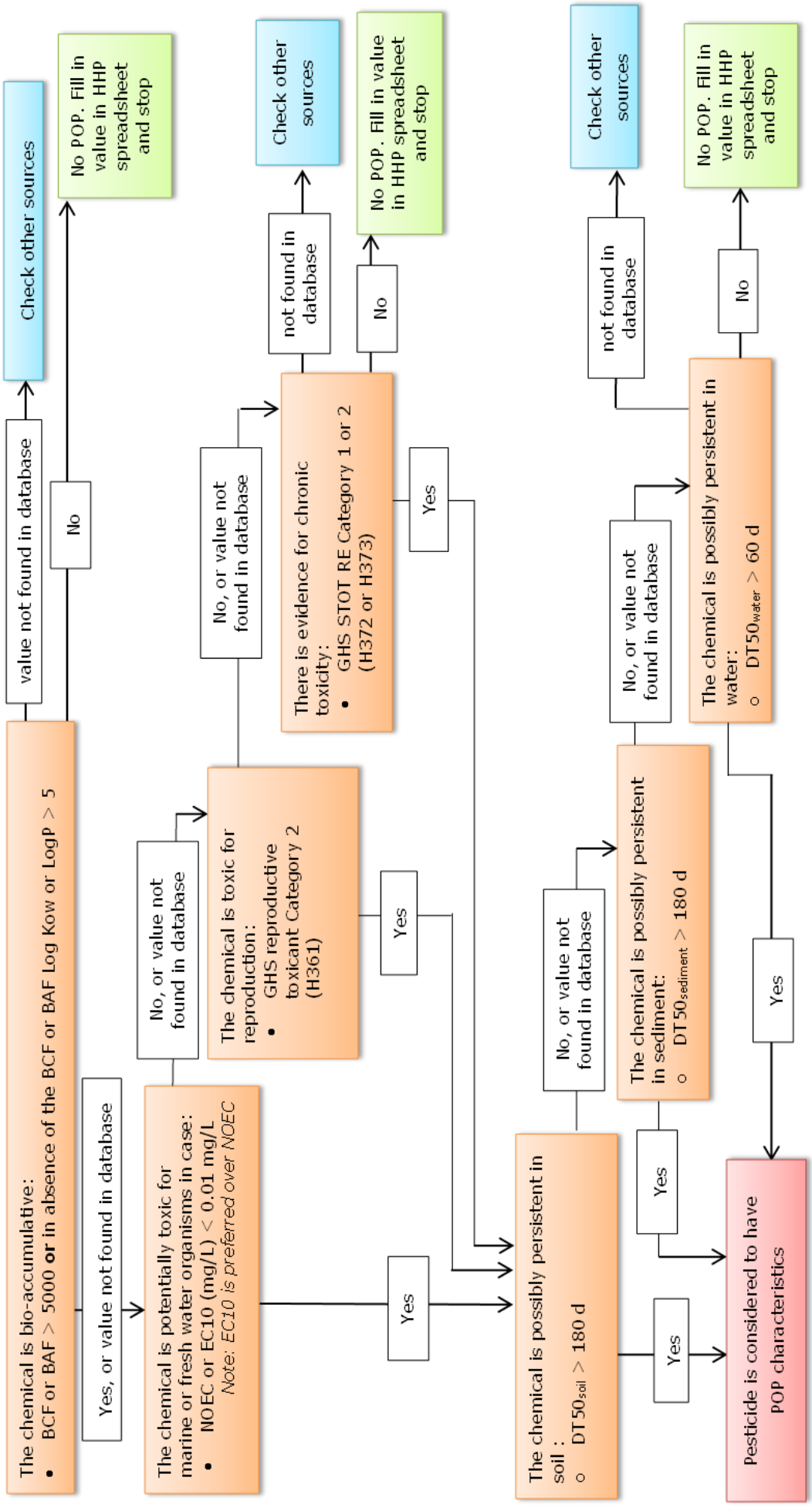

Figure 7 *Efficient strategy for checking the POP criteria as part of a Highly Hazardous Pesticides scan in Ghana*

Toxicity

Parameters to be checked in the PPDB:

- Aquatic toxicity:
  - EC_{10} or NOEC for aquatic organisms (mg/L): fish, aquatic invertebrates, aquatic crustaceans
  - If no EC_{10} or NOECs are available: chronic LC_{50} (21 or 28 day; mg/L) for aquatic organisms: fish, aquatic invertebrates, aquatic crustaceans
- GHS reproductive toxicity (Repr. 2)
- GHS Specific target organ toxicity – repeated exposure (STOT RE)

Aquatic toxicity

i. Select the lowest value of the EC_{10} or NOEC of the pesticide (EC_{10} is preferred) of fish, aquatic invertebrates or aquatic crustaceans
   - Enter this value in the relevant cell in the spreadsheet, tab "Active Ingredient list" (section: B5. Stockholm Convention).

ii. If no EC_{10} or NOEC values are available, select the chronic LC_{50} of fish, aquatic invertebrates, or aquatic crustaceans, but only if it is clear that the LC_{50} was determined in a chronic (21 d or 28 d) study
   - Enter this value in the relevant cell in the spreadsheet, tab "Active Ingredient list" (section: B5. Stockholm Convention).

The pesticide is toxic if the NOEC or EC_{10} or chronic LC_{50} of one of the aquatic organisms (lowest value) < 0.01 mg/L ➔ Continue with the persistence evaluation

If NOEC and EC_{10} (and chronic LC_{50}) of all the aquatic organisms ≥ 0.01 mg/L, the pesticide is not toxic to aquatic organisms ➔ Continue with the reproductive toxicity evaluation

Reproductive toxicity

Use the GHS classification as determined by the European Chemicals Agency (ECHA, undated).

i. If the pesticide is classified as Repr. 2 (H361) in the C&L inventory
   - In the relevant cell in the spreadsheet, tab "Active Ingredient list" (section: B5. Stockholm Convention): select '*Yes: ECHA*' from picklist

ii. If the pesticide is NOT classified as Repr. 2 (H361) in the C&L inventory
   - In the relevant cell in the spreadsheet, tab "Active Ingredient list" (section: B5. Stockholm Convention): select *'No'* from picklist

The pesticide is considered toxic if classified as Repr. 2 ➔ Continue with the persistence evaluation

If the pesticides is not classified as Repr. 2 ➔ Continue with the specific target organ toxicity evaluation

Specific organ target toxicity – repeated exposure (STOT-RE)

Use the GHS classification as determined by the European Chemicals Agency (ECHA, undated).

i. If the pesticide is classified as STOT RE 1 (H322) or STOT RE 2 (H373) in the C&L inventory;
   - In the relevant cell in the HHP identification spreadsheet, tab "Active Ingredient list" (section: B5. Stockholm Convention): 'select *Yes: ECHA*' from picklist

ii. If the pesticides is NOT classified as STOT RE 1 (H372) or STOT RE 2 (H373) in the C&L inventory;
   - In the relevant cell in the HHP identification spreadsheet, tab "Active Ingredient list" (section: B5. Stockholm Convention): 'select *'No'* from picklist

The pesticide is considered toxic if classified as STOT RE 1 or STOT RE 2 ➔ Continue with the persistence evaluation

If the pesticides is not classified as STOT RE 1 or STOT RE 2 ➔ the pesticide is not considered toxic and therefore not a POP ➔ Stop the evaluation.

Persistence

Parameters to be checked in the PPDB:

- Persistence in soil – $DT_{50,soil}$ (days)
- Persistence in sediment – $DT_{50,sediment}$ (days)
- Persistence in water - $DT_{50,water}$ (days)

Persistence in soil

i. Select from the PPDB the DT_{50} lab at 20°C
   - Enter this value in the relevant cell in the spreadsheet, tab "Active Ingredient list" (section: B5. Stockholm Convention)

The pesticide is considered to be persistent in the soil if the $DT_{50\ lab,soil}$ at 20°C >180 d ➔ Stop the evaluation: the pesticide can be considered a POP

If the $DT_{50\ lab,soil} \leq$ 180 days, the pesticide is not persistent in soil ➔ Continue the evaluation of sediment persistence.

Persistence in sediment

i. Select the DT_{50} of total the water-sediment system given in the PPDB.
   - Enter this value in the relevant cell in the spreadsheet, tab "Active Ingredient list" (section: B5. Stockholm Convention)

The pesticide is considered to be persistent in the sediment if the DT_{50} of total water-sediment system > 180 d ➔ Stop the evaluation: the pesticide can be considered a POP.

If the DT_{50} sediment ≤ 180 days, the pesticide is not persistent in sediment ➔ Continue the evaluation of water persistence.

Persistence in water

The decision making flow chart below (Figure 8) can be used to check the persistence of the pesticide in water.

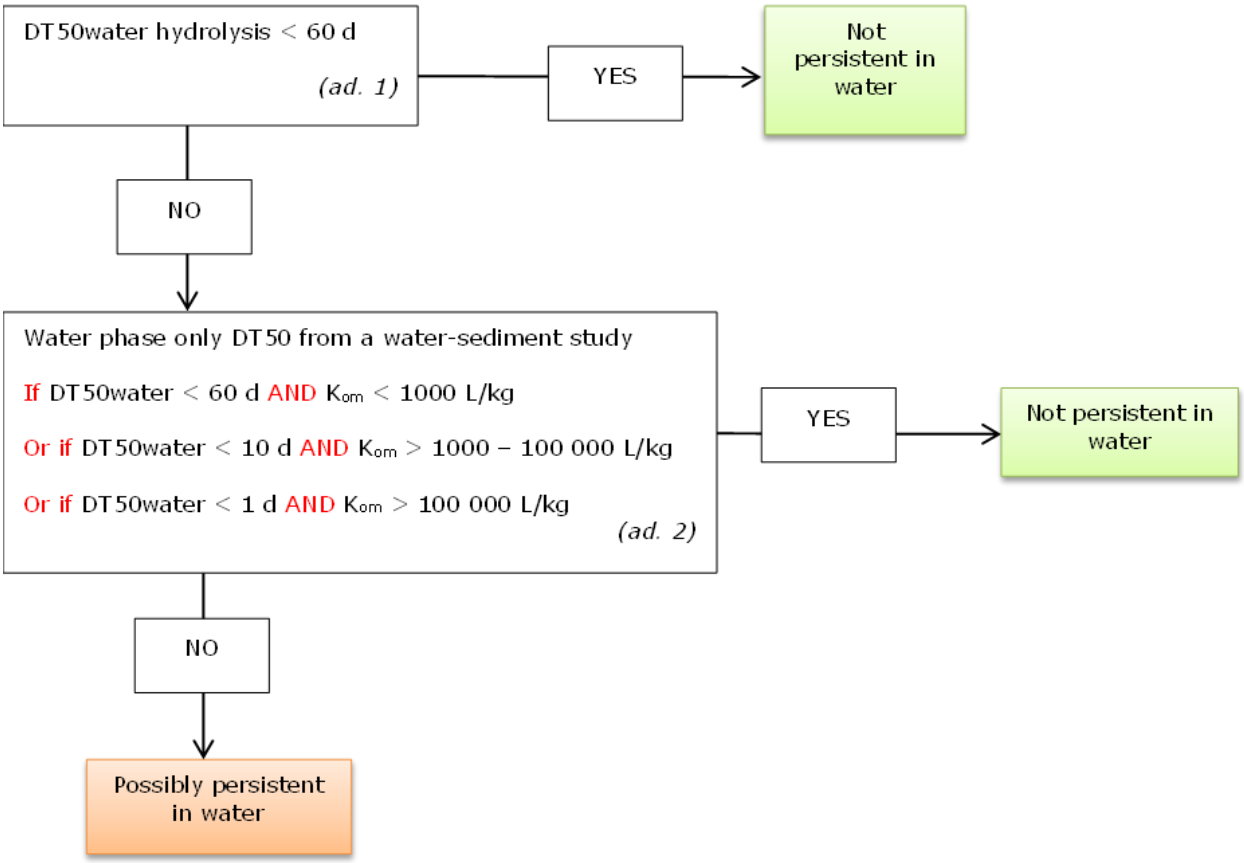

Figure 8 *Decision making flow chart on persistence of the pesticide in water. Ad. 1 and ad. 2 refer to additional information found in Annex 6.*

Step by step guidance persistence in water
The checks and steps specified below need to be followed in the order they are given in order to reach the conclusion on persistence in water.

Check 1: $DT_{50water}$ hydrolysis < 60 d?
Step 1: select from the PPDB the aqueous hydrolysis half-life at pH 7 and the aqueous hydrolysis half-life at pH 9 and check if they are measured at temperatures at 20 °C. If both half-lives are measured at 20 °C proceed to Step 3; if not proceed with Step 2. If values of hydrolysis half-lives are not given in de PPDB proceed to Check 2.

Step 2: Calculate the half-lives back to half-lives at 20 °C:

Step 2a: Calculate the degradation rate, *k*, from the DegT50 as follows:

$$k = \frac{\ln 2}{DegT50} \qquad \text{Eq. 1}$$

where:
DegT50 = Degradation half-life (d)
k = Transformation rate (d^{-1})

Step 2b: Calculate the degradation rate, *k*, at 20 °C (293.15 K):

$$k(T) = k(T_{ref})exp\left[\frac{E}{R}\left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right] \qquad \textit{Eq. 2}$$

where:

T =	Temperature at which the DegT50 was reported (K)
T_{ref} =	Reference temperature (K) (293.15)
k =	Transformation rate (d^{-1})
E =	75000 J mol^{-1} = recommended value for the molar Arrhenius activation energy
R =	8.3144 J mol^{-1} K^{-1} = recommended value for the universal gas constant

Step 2c: Calculate the degradation half-life (DegT50) at 20 °C:

$$DegT50 = \frac{Ln\,2}{k} \qquad \textit{Eq. 3}$$

Step 3: Select the maximum from the two $DegT_{50}$ values at pH 7 and pH 9 and both at 20 °C

Step 4: Is the maximum value < 60 days?

No: proceed to Check 2

Yes: chemical is NOT persistent in water – enter this $DegT_{50}$ value in the spreadsheet

Check 2: is the water phase only half-life from a water-sediment study < 60 d?

Step 1: select from the PPDB the water phase only half-live from a water-sediment study.

Step 2: select from the PPDB the value for the K_{oc} of soil (in L/kg)

Step 3: Calculate the K_{om} in L/kg using the value of the K_{oc} of soil (in L/kg) using Eq. 4.

$$K_{om} = K_{oc}/1.724 \qquad \textit{Eq. 4}$$

Step 4a: $DT_{50water}$ < 60 d AND K_{om} < 1000 L/kg?

No: proceed to *Step 4b*

Yes: chemical is NOT persistent in water – enter the value of the $DT_{50water}$ in the spreadsheet

Step 4b: $DT_{50\ water}$ < 10 d AND K_{om} > 1000 – 100 000 L/kg?

No: proceed to *Step 4c*

Yes: chemical is NOT persistent in water – enter the value of the $DT_{50water}$ in the spreadsheet

Step 4c: $DT_{50\ water}$ < 1 d AND K_{om} > 100 000 L/kg

No: chemical is very likely persistent in water: fill in the value of the $DT_{50water}$ in the spreadsheet; in case this value is < 60 days, fill in a value of 100 days.

Yes: chemical is NOT persistent in water – enter the value of the $DT_{50water}$ in the spreadsheet

Annex 2 Pesticide products identified as HHP

The following pesticide products were identified as HHP in the Register of Pesticides (Ghana EPA, 2021)

Active ingredient	Product no. (in Register)	Product name
Aluminium-phosphide	• A1c.4 • A1c.5	• Phostoxin Bag • Temaphos
Anthraquinone	• B6.1 • A1a.112	• AV 5055 • Seed Power 44 WS
Boric acid	• B1a.7	• Harris Famous Roach Powder
Brodifacoum	• B7.7	• Vertox (>98%)
Bromadiolone	• B7.6	• Super Guard
Carbendazim	• A2.10 • A2.13 • A2.30 • A2.31 • B2.17 • B2.23 • B2.46 • B9.3 • A2.1 • A2.40 *	• Callet 50 WP • Carinho WP • Goldazim WP • Guardian Xtra WP • Fungitect • Kabendazim 50WP • Sun-Dazim • Fungipol 237 • Acticide EPW • Mandazim WP
Carbofuran	• A1a.61 • A1a.91 • A7.2 • B1.20 • B1.63 • B1.73 • B5.1	• Furadan 3G • Nemaran 3GR • Carbodan 3G • Altifura 3G • Furabak 3% G • J-Furan 3G • Fulan 3%
Chromium trioxide + Arsenic pentoxide	• B1.94	• Nako Protecta CCA
Cyproconazole	• B2.24	• Kingstar WG
Dimethomorph	• A2.59 • B2.35 • A2.9 • A2.7 • B2.32 • A2.54 • A2.45 • B2.14	• Sun-Vege • Pilarxanil Sky • Cabrio Duo • Banjo Forte 400SC • Orvego • Sphinx Star 480WDG • Qualico 46WP • Forum R
Fenvalerate	• A1b.8 • A1a.121 • A1a.122 • A1a.136 • A1a.60 • A1a.7	• Suncombi 30EC • Sumeco 20 EC • Sumico 20 EC • Verate 200 EC • Frankofen 20 EC • Agricombi 40EC
Gufosinate ammomium	• A3.180 • A3.25 • B3.168 • B3.209 • B3.71	• Sunphosate Ultra SL • Bastnate 200 SL • ParaForce Super • Sunglusate 100SL • Eagrowpunch
Haloxyfop-methyl	• A3.98 • B3.112 • B3.145 • B3.230	• Hero Super 108 EC • Hadop • Loxy Crown • Veggie Force
Lufenuron	• A1a.108 • B1.32	• Ronfos 550 EC • Blaze
Magnesium phosphide	• A1c.3	• Degesch Plate

Active ingredient	Product no. (in Register)	Product name
Mancozeb	• A2.16 • A2.20 • A2.21 • A2.26 • A2.33 • A2.34 • A2.36 • A2.38 • A2.46 • A2.57 • A2.68 • A2.8 • B2.15 • B2.20 • B2.26 • B2.28 • B2.31 • B2.56 • B2.7 • B2.41 • A2.40 * • A2.18 • A2.39 • A2.66 • B2.19 • B2.25 • B2.45 • B2.52 • B2.8 • B2.22	• Conti-Zeb • Damazeb 80WP • Dizcozeb 80 WP • Foko 80WP • Ivory 80WP • Kabazeb 80 WP • Kilazeb 80 WP • Manco-care • Rainmancoz 80WP • Suncozeb 80WP • Zeb-care 80 WP • Benco 80 WP • Frankozeb 80 WP • Grancozeb 80 WP • Kinzeb • Megazeb • Omnizeb 80 WP • Waaf-cozeb 80 WP • Bonzeb • Skope 370 WP • Mandazim WP • Cuprofix 30 Disperss • Mancozan Super WP • Victory 72 WP • Glofert-cure • KingVictory • Sun-Cotala WP • Topcare • Bon Victory WP • Invess-cure
Methomyl	• B1.112	• Strongcare 50 WP
Oxamyl	• B5.2	• Nématode Master 24 SL
Propiconazole	• A2.44	• Prozole 250 EC
Thiacloprid	• A1a.15	• Belt Expert 480SC
Triadimenol	• A2.51	• Shavit F 715 WP

* identical product containing two HHP active ingredients.

Annex 3 Dermal absorption in the EFSA OPEX Tool

Insight in the extent to which the skin absorbs an active ingredient and/or formulation after exposure is important for calculation of systemic exposure.

Usually the dermal absorption of a pesticide formulation is presented as a value for the concentrated formulation (used for mixing and loading) and a value for the diluted formulation (spray dilution used for application). In general, the percentage dermal absorption from a diluted product is in many cases higher than from a concentrated product.

Dermal absorption values for the concentrated and diluted pesticide product are often provided in the List of Endpoint (LoEP) of EFSA Conclusions on pesticides.

In the absence of such data, default values for dermal absorption as used in the EU are described in an EFSA guidance report (EFSA, 2017 – see Table 10).

Table 10 *Default values to be used in the absence of experimental data (EFSA, 2017).*

Formulation category	Concentration status	Default value
Organic solvent-based [(a)] or other [(b)]	Concentrate	25%
	Dilution	70%
Water-based/dispersed [(c)] or solid [(d)]	Concentrate	10%
	Dilution	50%

(a): Formulation types: emulsifiable concentrate (EC), emulsion, oil in water (EW), suspo-emulsion (SE), dispersible concentrate (DC), oil miscible liquids (OL/OF), oil-based suspension concentrates (OD), emulsion for seed treatment (ES), microemulsion (ME).

(b) Formulation types: bait concentrate (CB), capsule suspension (CS), gel for direct application (GEL/GD), bait, ready for use (RB), mixture of capsule suspension and suspension concentrate (ZC), seed coated with a pesticide (PS), experimental solution of active substances in solvent (AI).

(c): Formulation types: soluble concentrate (SL), suspension concentrate (SC), flowable concentrate for seed treatment (FS), flowable (FL) (=SC).

(d): Formulation types: wettable powder (WP), water-dispersible granules (WG/WDG), water-soluble granules (SG), water-soluble powder (SP), powder for dry seed treatment (DS).

For the occupational risk assessments of the HHPs in Ghana, using the EFSA OPEX Tool, the following approach was used:

Dermal absorption of the concentrate (product)
Dermal absorption values from the EFSA Lists of Endpoint are product specific. The concentration of active ingredient of the product for which the dermal absorption values are determined might deviate from the concentration of active ingredient of the Ghana HHP product.

The following logic for choosing a dermal absorption value for the concentrated products was used:

i. In absence of the product specific dermal absorption values in the EFSA LoEP, default values from the table above were used.
ii. If product specific dermal absorption values were available in the EFSA LoEP:
    a. If the concentration of the a.i. in the product from Ghana is within 20% of the concentration of the product in the LoEP (i.e. similar): the value in the LoEP was used.
    b. If the concentration of the a.i. in the product from Ghana is more than 20% higher than the concentration of the product in the LoEP: the highest value between the relevant default or the value in the LoEP was used.
    c. If the concentration of the a.i. in the product from Ghana is more than 20% lower than the concentration of the product in the LoEP: the lowest value between the relevant default or the value in the LoEP was used.

Dermal absorption of the dilution

i. In case absorption data of dilutions were available, and the concentration of active ingredient in the dilution was known, these absorption values were entered in the table "Absorption of the Active Substance" on the page Active Substances of the OPEX Tool.
ii. In case absorption data for the dilution were available from the EFSA LoEP, but without specifying the dilution concentration:
    a. The table under i. was left empty for the dilutions; but
    b. The dermal absorption of the dilution was entered on the page "Intended Use" of the OPEX Tool.
iii. In case absorption data for the dilution were not available at all:
    a. The table under i. was left empty for the dilutions; but
    b. The EFSA default value for dermal absorption of the dilution was entered on the page "Intended Use" of the OPEX Tool.

Annex 4 Dietary risk assessments

The tables below show the crops or crop groups that were listed on the labels of the registered HHPs and the associated commodity groups used in the IEDI model. The highest level commodity group was used for each crop listed on the label. If more crops or crop groups were listed on the label within the same IEDI commodity group, the highest level commodity was used within that commodity group.

Examples:

1. Crop listed on the labels = cocoa: associated IEDI commodity = *Cacao bean, raw (incl roasted, incl powder, incl butter, incl paste, incl nes products)*
2. Crop listed on the labels = vegetables: associated IEDI commodity = all vegetable commodities (since the pesticide is authorized to be used on "vegetables"); i.e.: *Bulb vegetables; Brassica; Fruiting vegetables, cucurbits; Fruiting vegetables, other than cucurbits; Leafy vegetables; Legume vegetables; Root and tuber vegetables; Stalk and stem vegetables*
3. Crop listed on the labels = cucumber:
   a. If no higher level crop is listed on the labels: commodity group used = *Cucumber, raw*
   b. If one or more higher level crop are also listed on the labels (e.g. cucurbits): commodity group used = *cucurbits, raw* (the highest level commodity was used for the risk assessment)
   c. If a very generic crop group was also listed on the labels, of which the specific crop was part (e.g. both cucumber and vegetables listed): commodity group used = example a. plus all other vegetable commodities (see example 2.)

Animal commodities were also included in the dietary risk assessment, since treated crops may be used as animal food, and fish can be exposed to pesticides applied in Ghana.

Maximum Residue Limits are those listed in the Codex Alimentarius, except when indicated otherwise. If MRLs were available for all commodities in a given commodity group, these individual MRLs were used in the IEDI model. On the other hand, if MRLs were not available in the Codex for all commodities in a commodity group, the highest MRL within that group was used to represent the whole commodity group.

Carbendazim

CODEX ADI = 0.03 mg/kg bw/day

Residue definition: Sum of benomyl, carbendazim and thiophanate-methyl, expressed as carbendazim

Crops or crop groups on Ghanaian labels	Commodity group and code in IEDI model	MRL (mg/kg)	MRL source: commodity [1]
Mango	FI 0030 Group of Assorted (Sub)Tropical fruits, inedible peel, raw (incl processed)	5	COD: mango
Fruits	*All the above fruit commodity groups, plus:*		
	FC 0001 Group of Citrus fruit, raw (incl citrus fruit juice, incl kumquat commodities)	1	COD: oranges, sweet, sour (including Orange-like hybrids)
	FP 0009 Group of Pome fruits, raw (incl. apple juice, incl apple cider)	3	COD: pome fruits (group)
	FS 0012 Group of Stone fruits, raw (incl dried plums, incl dried apricots)	2	COD: apricot, peach
	FB 0018 Group of Berries and other small fruits, raw (incl processed)	1	COD: berries and other small fruits
	FT 0026 Group of Assorted (sub) tropical fruits, edible peel, raw (incl processed)	--	*Not available in used sources*
Vegetables	VA 0035 Group of Bulb vegetables, raw	0.01	AUS: garlic
	VB 0040 Group of Brassica vegetables (excl Brassica leafy vegetables), raw	0.5	COD: Brussels sprouts
	VC 0045 Group of Fruiting vegetables, cucurbits, raw	0.5	COD: squash, summer
	VO 0050 Group of Fruiting vegetables other than cucurbits, raw, (incl processed commodities, excl dried chilli peppers)	2	COD: peppers, chili
	VL 0053 Group of Leafy vegetables, raw	5	COD: lettuce
	VP 0060 Group of Legume vegetables, raw	0.5	COD: Common bean (pods and/or immature seeds)
	VD 2065 Group of Pulses, raw (incl processed)	0.5	COD: beans (dry), soya bean (dry)
	VR 2070 Group of Root and tuber vegetables, raw (incl processed)	0.2	COD: carrot
	VS 0078 Group of Stalk and stem vegetables, raw	0.2	COD: asparagus
Rice	GC 2088 Subgroup of rice cereals	2	COD: rice, husked
Groundnut	SO 0698 Peanuts, nutmeat, raw (incl roasted, incl oil, incl butter)	0.1	COD: peanut
Coffee	SB 0716 Coffee bean raw (incl roasted, incl instant coffee, incl substitutes)	0.1	COD: coffee beans
	Animal commodities (codes: 030, 031, 032, 033, 036, 037, 038, 039, 040, 041, 042, honey)	0.05	COD: edible offal (mammalian); milk and milk products; poultry meat; poultry, eggs.

[1] COD = Codex MRL; BRA = Brazilian MRL; AUS = Australian MRL.

Dimethomorph

CODEX ADI = 0.2 mg/kg bw/day

Crops or crop groups on Ghanaian labels	Commodity group and code in IEDI model	MRL (mg/kg)	MRL source: commodity [1]
Vegetables	009 Bulb vegetables	0.5	AUS: onions
	010 Brassica	6	COD: cabbage
	013 Leafy vegetables	30	COD: spinach
	014 Legume vegetables	0.15	COD: peas
	017 Stalk and stem vegetables	15	COD: celery
Cucumber	011 Fruiting vegetables, cucurbits	0.05	COD: fruiting vegetables, cucurbits
Tomato	012 Fruiting vegetables, other than cucurbits	1.5	COD: fruiting vegetables other than cucurbits
Potato	016 Root and tuber vegetables	0.05	COD: potato
Cocoa	SB 0715 Cacao bean, raw (incl roasted, incl powder, incl butter, incl paste, incl nes products)	--	*Not available in used sources*
	Animal commodities (codes: 030, 031, 032, 033, 036, 037, 038, 039, 040, 041, 042, honey)	0.01	COD: meat from mammals; edible offal (mammalian); milk and milk products; poultry meat; poultry, edible offal of; eggs.

[1] COD = Codex MRL; BRA = Brazilian MRL; AUS = Australian MRL.

Haloxyfop-methyl

CODEX ADI = 0.0007 mg/kg bw/day

Residue definition: Sum of haloxyfop (including haloxyfop-P), its esters and its conjugates expressed as haloxyfop)

Crops or crop groups on Ghanaian labels	Commodity group and code in IEDI model	MRL (mg/kg)	MRL source: commodity [1]
Pineapple	FI 0353 Pineapple, raw (incl canned pineapple, incl pineapple juice, incl dried pineapple)	--	*Not available in used sources*
Vegetables	011 Fruiting vegetables, cucurbits	--	*Not available in used sources*
	012 Fruiting vegetables, other than cucurbits	--	*Not available in used sources*
	013 Leafy vegetables	0.5	AUS: leafy vegetables
	016 Root and tuber vegetables	--	*Not available in used sources*
	017 Stalk and stem vegetables	--	*Not available in used sources*
Onions, shallot	VA 0035 Group of Bulb vegetables, raw	0.2	COD: Onions
Cabbage	VB 0040 Group of Brassica vegetables (excl Brassica leafy vegetables), raw	--	*Not available in used sources*
Sweet potato	VR 0508 Sweet potato, raw (incl dried)	--	*Not available in used sources*
Watermelon	VC 0432 Watermelon, raw	--	*Not available in used sources*
Pulses, Soyabean	VD 0070 Group of Pulses, raw (incl processed)	3	COD: beans (dry)
Legumes	VP 0060 Group of Legume vegetables, raw	0.7	COD: peas (pods and succulent seeds)
Groundnut	SO 0697 Peanuts, nutmeat, raw (incl roasted, incl oil, incl butter)	0.05	AUS: groundnut
Cotton	SO 0691 Cotton seed, raw (incl oil)	0.7	COD: cotton
	Animal commodities (codes: 030, 031, 032, 033, 036, 037, 038, 039, 040, 041, 042, honey)	0.5	COD: meat from mammals
		2	COD: edible offal (mammalian);
		7	COD: milk and milk products
		0.7	COD: poultry meat
		0.7	COD: poultry, edible offal of
		0.1	COD: eggs

[1] COD = Codex MRL; BRA = Brazilian MRL; AUS = Australian MRL.

Mancozeb

CODEX ADI = 0.2 mg/kg bw/day

ADI and MRLs for total dithiocarbamates: mancozeb, maneb, metiram and zineb

Crops or crop groups on Ghanaian labels	Commodity group and code in IEDI model	MRL (mg/kg)	MRL source: commodity [1]
Avocado, Banana, Plantain, Mango, Papaya, Pineapple	FI 2021 Group of Assorted (Sub)Tropical fruits, inedible peel, raw (incl processed)	5	COD: papaya
Citrus	FC 0001 Group of Citrus fruit, raw (incl citrus fruit juice, incl kumquat commodities)	10	COD: mandarins
Fruits	*All the above fruit commodity groups, plus:*		
	FP 0009 Group of Pome fruits, raw (incl. apple juice, incl apple cider)	5	COD: pome fruits
	FS 0012 Group of Stone fruits, raw (incl dried plums, incl dried apricots)	7	COD: stone fruits
	FB 0018 Group of Berries and other small fruits, raw (incl processed)	10	COD: currents, black, red, white
	FT 2012 Subgroup of Assorted (sub) tropical fruits - edible peel - large, raw (incl processed)	--	*Not available in used sources*
	009 Bulb vegetables:		
Onions	-- Onions, dry, raw	0.5	COD: onion (bulb)
Garlic	VA 0381 Garlic, raw	0.5	COD: garlic
Leek	VA 0384 Leek, raw	0.5	COD: leek
--	-- Onions, green, raw	10	COD: spring onion
Cabbage	VB 0040 Group of Brassica vegetables (excl Brassica leafy vegetables), raw	5	COD: cabbages, head
	011 Fruiting vegetables, cucurbits:		
Cucumber	VC 0424 Cucumber, raw	2	COD: cucumber
--	VC 0425 Gherkin, raw	2	COD: cucumber
--	VC 0431 Squash, Summer (Courgette, Marrow, Zucchetti, Zucchini), raw	1	COD: Squash, summer
Melons	VC 0046 Melons, except watermelon, raw (Cantaloupe)	0.5	COD: Melon, except watermelon
--	VC 0429 Pumpkins, raw	0.2	COD: Pumpkins
--	VC 0432 Watermelon, raw	2	COD: Watermelon
Okra, tomato, garden eggs	Group of Fruiting vegetables other than cucurbits, raw, (incl processed commodities, excl dried chilli peppers)	2	COD: tomato
Lettuce crops	VL 0053 Group of Leafy vegetables, raw	15	COD: Kale
Soybean	VD 0070 Group of Pulses, raw (incl processed)	2	AUS: beans
Potato, sweet potato, tuber crops	VR 0075 Group of Root and tuber vegetables, raw (incl processed)	1	COD: carrot
Vegetables	*All the above vegetable commodity groups, plus:*		
	VP 0060 Group of Legume vegetables, raw	2	AUS: peas
	VS 0078 Group of Stalk and stem vegetables, raw	0.1	COD: asparagus
Cereals, rice	GC 0080 Group of Cereal grains, raw, (incl processed) (incl sweet corn)	1	COD: wheat, barley
Field crops	GS 0659 Sugar cane, raw (incl sugar, incl molasses)	0.1	BRA: sugar cane
Cashew	TN 0295 Cashew nuts, nutmeat	3	BRA: cashew
Peanut, groundnut	SO 0697 Peanuts, nutmeat, raw (incl roasted, incl oil, incl butter)	0.1	COD: peanut
Coffee	SB 0716 Coffee bean raw (incl roasted, incl instant coffee, incl substitutes)	0.3	BRA: coffee
	Animal commodities (codes: 030, 031, 032, 033, 036, 037, 038, 039, 040, 041, 042, honey)	0.05	COD: meat from mammals
		0.1	COD: edible offal (mammalian);
		0.05	COD: milk and milk products
		0.1	COD: poultry meat
		0.1	COD: poultry, edible offal of
		0.05	COD: eggs

[1] COD = Codex MRL; BRA = Brazilian MRL; AUS = Australian MRL.

Methomyl

CODEX ADI = 0.02 mg/kg bw/day

Residue definition: Sum of methomyl and thiodicarb, expressed as methomyl

Crops or crop groups on Ghanaian labels	Commodity group and code in IEDI model	MRL (mg/kg)	MRL source: commodity [1]
Fruit trees	FC 0001 Group of Citrus fruit, raw (incl citrus fruit juice, incl kumquat commodities)	1	COD: citrus
	FP 0009 Group of Pome fruits, raw (incl. apple juice, incl apple cider)	0.3	COD: pear, apple
	FS 0012 Group of Stone fruits, raw (incl dried plums, incl dried apricots)	1	COD: plums, including fresh prunes
	FT 0026 Group of Assorted (sub) tropical fruits, edible peel, raw (incl processed)	0.015	BRA: acerola (Barbados cherry)
	FI 0030 Group of Assorted (Sub)Tropical fruits, inedible peel, raw (incl processed)	0.2	AUS: dragon fruit
Cowpea	VD 2065 Group of Pulses, raw (incl processed)	0.2	COD: soya bean (dry)
Yam, potato	VR 2070 Group of Root and tuber vegetables, raw (incl processed)	0.02	COD: potato
Vegetables	*All the above vegetable commodity groups, plus:*		
	VA 0035 Group of Bulb vegetables, raw	0.2	COD: onions
	VB 0040 Group of Brassica vegetables (excl Brassica leafy vegetables), raw	2	AUS: Brassica vegetables
	VC 0045 Group of Fruiting vegetables, cucurbits, raw	0.1	COD: cucurbits
	VO 0050 Group of Fruiting vegetables other than cucurbits, raw, (incl processed commodities, excl dried chilli peppers)	1	COD: tomato
	VL 0053 Leafy vegetables	0.2	COD: lettuce
	VP 0060 Group of Legume vegetables, raw	5	COD: Peas (pods and succulent seeds)
	VS 0078 Group of Stalk and stem vegetables, raw	2	COD: asparagus
Rice	GC 2088 Subgroup of rice cereals	0.2	BRA: rice
Maize	GC 2091 Subgroup of Maize Cereals	0.02	COD: maize
Groundnut	SO 0698 Peanuts, nutmeat, raw (incl roasted, incl oil, incl butter)	0.05	BRA: peanut
Cotton	SO 0691 Cotton seed, raw (incl oil)	0.2	COD: Cotton seed
	Animal commodities (codes: 030, 031, 032, 033, 036, 037, 038, 039, 040, 041, 042, honey)	0.02	COD: meat from mammals; edible offal (mammalian); milk and milk products; poultry meat; poultry, edible offal of; eggs.

[1] COD = Codex MRL; BRA = Brazilian MRL; AUS = Australian MRL.

Propiconazole

CODEX ADI = 0.07 mg/kg bw/day

Residue definition: Propiconazole plus all metabolites convertible to 2,4-dichloro-benzoic acid, expressed as propiconazole

Crops or crop groups on Ghanaian labels	Commodity group and code in IEDI model	MRL (mg/kg)	MRL source: commodity [1]
Pineapple	FI 0353 Pineapple, raw (incl canned pineapple, incl pineapple juice, incl dried pineapple)	2	COD: pineapple
Banana	FI 0327 Banana, raw (incl plantains) (incl dried)	0.1	COD: banana
Rice	GC 2088 Subgroup of rice cereals	0.1	BRA: rice
Sugarcane	GS 0659 Sugar cane, raw (incl sugar, incl molasses)	0.02	COD: sugarcane
	Animal commodities (codes: 030, 031, 032, 033, 036, 037, 038, 039, 040, 041, 042, honey)	0.01	COD: meat from mammals
		0.01	COD: mammalian fats
		0.5	COD: edible offal (mammalian);
		0.01	COD: milk and milk products
		0.01	COD: poultry meat
		0.01	COD: eggs

[1] COD = Codex MRL; BRA = Brazilian MRL; AUS = Australian MRL.

Thiacloprid

CODEX ADI = 0.01 mg/kg bw/day

Crops or crop groups on Ghanaian labels	Commodity group and code in IEDI model	MRL (mg/kg)	MRL source: commodity [1]
Maize	GC 2091 Subgroup of Maize Cereals	--	*Not available in used sources*
Cotton	SO 0691 Cotton seed, raw (incl oil)	0.02	COD: Cotton seed
	Animal commodities (codes: 030, 031, 032, 033, 036, 037, 038, 039, 040, 041, 042, honey)	0.1	COD: meat from mammals
		0.5	COD: edible offal (mammalian);
		0.05	COD: milk and milk products
		0.02	COD: poultry meat
		0.02	COD: poultry, edible offal of
		0.02	COD: eggs

[1] COD = Codex MRL; BRA = Brazilian MRL; AUS = Australian MRL.

Triadimenol

CODEX ADI = 0.03 mg/kg bw/day

Residue definition: Sum of triadimefon and triadimenol

Crops or crop groups on Ghanaian labels	Commodity group and code in IEDI model	MRL (mg/kg)	MRL source: commodity [1]
Citrus	FC 0001 Group of Citrus fruit, raw (incl citrus fruit juice, incl kumquat commodities)	--	*Not available in used sources*
Mango	FI 0345 Mango, raw (incl canned mango, incl mango juice)	--	*Not available in used sources*
Tomato	VO 2045 Subgroup of tomatoes, raw (incl processed) (Lycopersicum spp. Only)	1	COD: Fruiting vegetables other than cucurbits (group)
Eggplant	VO 2046 Subgroup of eggplants	1	COD: Fruiting vegetables other than cucurbits (group)
	Animal commodities (codes: 030, 031, 032, 033, 036, 037, 038, 039, 040, 041, 042, honey)	0.02	COD: meat from mammals
		0.01	COD: edible offal (mammalian);
		0.01	COD: milk and milk products
		0.01	COD: poultry meat
		0.01	COD: poultry, edible offal of
		0.01	COD: eggs

[1] COD = Codex MRL; BRA = Brazilian MRL; AUS = Australian MRL.

Annex 5 HHP information cards

An information summary card was elaborated for each of the highly hazardous pesticides identified as such in the EPA Pesticides Register. Different versions of the cards were used to inform stakeholders about the HHPs under review.

Aluminium phosphide			**HHP info card**
Active ingredient:	Aluminium phosphide ≥ 2.2% formulations		
Reason:	WHO Class Ib – highly hazardous (inhalation)		
Number of registered products:	2	2019 – 2021 imports: (all formulations)	12,000 kg
Registered crops & pests:	*Fumigant* Stored agricultural products (e.g. cereals, tobacco, processed food)		
Needs assessment:	Much used fumigant mainly for large-scale grain storage. Rapid action; does not leave residues in the commodity.		
Risk assessments:	Operator & worker risks:	Not conducted: no appropriate risk assessment model for fumigants	
	Dietary risks:	Not conducted: no residues expected; no MRLs	
Alternatives:	Registered pesticides:	Pirimiphos-methyl; Deltamethrin; Pyrethrum	
	Need to develop alternative pest management strategies?	Yes; e.g. hermetic grain storage bags for small scale storage	
Proposed risk mitigation:	**Maintain restricted registration** Justification: – Fumigant with very high acute toxicity – Its use is currently restricted to trained, large-scale users – Stricter enforcement of the current restricted use may be needed (e.g. no authorization of imports for retail sales)		

Anthraquinone			**HHP info card**
Active ingredient:	Anthraquinone All formulations		
Reason:	Carcinogen category 1B – *may cause cancer*		
Number of registered products:	2	2019 – 2021 imports: (all formulations)	0 but apparently some limited (unquantified) imports recently
Registered crops & pests:	Bird repellent; mainly used on rice when seeds are ripening		
Needs assessment:	Very limited imports, so apparently no great need		
Risk assessments:	Operator & worker risks:	Not conducted	
	Dietary risks:	Not conducted; no Codex MRLs have been established for this pesticide	
Alternatives:	Registered pesticides:	Methyl anthranilate	
	Need to develop alternative pest management strategies?	No	
Proposed risk mitigation:	**Cancel registration** Justification: – Application of a carcinogenic pesticide on a major food crop, quite shortly before harvest, is not acceptable. – Since only very limited imports have been recorded, and an alternative bird repellent is registered, use in Ghana is not considered essential.		

Boric acid			**HHP info card**
Active ingredient:	Boric acid All formulations		
Reason:	Reproductive toxicant 1B – *may damage fertility; may damage the unborn child*		
Number of registered products:	1	2019 – 2021 imports: (all formulations)	0
Registered crops & pests:	*Insecticide, antimicrobial, antiseptic* Insecticide for the control of ants, bugs and roaches		
Needs assessment:	Not imported: apparently no great need Possible industrial uses, but not quantified		
Risk assessments:	Operator & worker risks:	Not conducted	
	Dietary risks:	Not conducted	
Alternatives:	Registered pesticides:	Several alternatives for control of public health pests are registered Other disinfectants registered	
	Need to develop alternative pest management strategies?	No	
Proposed risk mitigation:	**Cancel registration** (as a pesticide) Justification: – Current registration has expired – Since no imports have been recorded, use in Ghana is not considered essential. – Sufficient lower risk alternatives are available.		

Brodifacoum			**HHP info card**
Active ingredient:	Brodifacoum only for the ≥98% formulation		
Reason:	WHO class Ib – *highly hazardous* Reproductive toxicant 1A – *may damage the unborn child*		
Number of registered products:	1	2019 – 2021 imports: (all formulations)	0
Registered crops & pests:	*Rodenticide* Rodenticide for the control of rats and mice		
Needs assessment:	Not imported: apparently no great need. It appears that this concentrated product was intended for local formulation of baits.		
Risk assessments:	Operator & worker risks	Not conducted	
	Dietary risks	Not conducted	
Alternatives:	Registered pesticides	Several baits with a very low concentration of brodifacoum are registered; these are not HHPs	
	Need to develop alternative pest management strategies?		
Proposed risk mitigation:	Current registration has expired: **No renewal of registration** Justification: – Concentrated brodifacoum has a high acute toxicity and is a reproductive toxicant. – Use of low concentration baits containing brodifacoum remains possible.		

Bromadiolone			**HHP info card**
Active ingredient:	Bromadiolone Only for the 2.5% formulation		
Reason:	WHO class Ib – *highly hazardous* Reproductive toxicant 1B – *may damage the unborn child*		
Number of registered products:	1	2019 – 2021 imports: (all formulations)	0
Registered crops & pests:	*Rodenticide* Rodenticide for the control of rats and mice. It appears that this concentrated product was intended for local formulation of baits.		
Risk assessments:	Operator & worker risks	Not conducted	
	Dietary risks	Not conducted	
Alternatives:	Registered pesticides	One bait with a very low concentration of bromadiolone is registered; this is not a HHP	
	Need to develop alternative pest management strategies?		
Proposed risk mitigation:	**Cancel registration** Justification: – Concentrated bromadiolone has a high acute toxicity and is a reproductive toxicant. – Use of low concentration baits containing bromadiolone remains possible.		

Carbendazim			**HHP info card**
Active ingredient:	Carbendazim All formulations		
Reason:	▪ Germ cell mutagen category 1B – *may cause genetic defects* ▪ Reproductive toxicant category 1B – *may damage fertility; may damage the unborn child*		
Number of registered products:	10	2019 – 2021 imports:	28,700 kg
Registered crops & pests:	*Fungicide* Rice blast, Rice sheath blight *in:* rice Botrytis, Sclerotinia, blue mould *in:* vegetables, fruits, rubber Leafspot, leaf mould, stem rot, powdery mildew, leaf blight, scab *in:* vegetables Anthracnose and downy mildew in: vegetables, fruits, coffee Leafspot, leaf mould, stem rot *in:* rubber, mango Late leaf spot, peanut rust *in:* groundnut Fungi and algae *in:* additive to paint		
Needs assessment:	Moderate imports		
Risk assessments:	Operator & worker risks	@ 1000 g a.i./ha with hand-held or backpack sprayers in low vegetables, or tractor spraying in field crops. Operator: no acceptable risk, even with full PPE Worker (e.g. harvesting): no acceptable risk, even with full PPE	
	Dietary risks	Registration on 7 crops or crop groups Representative MRLs available for 94% of all crop commodities Total residue intake = 90% of ADI (=acceptable risk)	
Alternatives:	Registered pesticides	Several fungicides are registered for control of most of the listed diseases.	
	Need to develop alternative pest management strategies?	Possibly	
Proposed risk mitigation:	**Cancel registration** Justification: – No acceptable occupational risk scenarios were identified, therefore it is unlikely that carbendazim can be used with acceptable risk in Ghana. – Use-up time for existing stocks … months		

Carbofuran			**HHP info card**
Active ingredient:	Carbofuran All formulations		
Reason:	Rotterdam Convention Annex III		
Number of registered products:	7	2019 – 2021 imports: (all formulations)	224,000 kg
Registered crops & pests:	*Insecticide, Nematicide* Insect pests *in:* rice, vegetables, oil palm, maize, sugarcane, cotton, groundnut Nematodes *in:* rice, vegetables, maize, sweet potato, sunflower		
Needs assessment:	Large quantity imported		
Risk assessments:	Operator & worker risks	@ 75 g a.i./ha with hand-held broadcast application of dry granules in low vegetables or oil fruits, or tractor broadcast application of granules in field crops. Operator: acceptable risk only if PPE is used: mixing/loading = overall, gloves, FFP2 or similar face mask. Application = overall, gloves Worker: not applicable	
	Dietary risks	Dietary risk assessment was not possible because very few representative MRLs are still established	
Alternatives:	Registered pesticides	Not many low risk nematicides or insecticides against soil insects are currently registered	
	Need to develop alternative pest management strategies?	Yes, especially for smallholder users	
Proposed risk mitigation:	**Phase-out registration** Justification: – Acceptable operator scenarios were identified if PPE was used. – Since listing of carbofuran in Annex III of the Rotterdam Convention was due to both human health risks and a wide range of environmental risks, progressive phase out of carbofuran in Ghana is proposed. – Large quantities of carbofuran have been imported, indicating a need for its use. – Not many low risk nematicides or insecticides against soil insects are currently registered, and will need to be identified. – As an initial risk reduction step, use of carbofuran will be restricted to licenced operators and registration for general use will be cancelled. – Due to the current large use of carbofuran in Ghana, a more detailed roadmap for phase-out will subsequently need to be developed.		

Chromium trioxide + arsenic pentoxide			**HHP info card**
Active ingredient:	Chromium trioxide + arsenic pentoxide (in combination with copper oxide) All formulations		
Reason:	WHO class Ib – *highly hazardous* Carcinogen category 1A – *may cause cancer* Germ cell category mutagen 1B – *may cause genetic effects*		
Number of registered products:	1	2019 – 2021 imports: (all formulations)	20,000 kg
Registered crops & pests:	*Insecticide* Wood preservative; used to treat wooden poles		
Needs assessment:	Pesticide product apparently only used by one farm		
Risk assessments:	Operator & worker risks	No appropriate risk assessment model available	
	Dietary risks	No appropriate risk assessment model available No food being treated	
Alternatives:	Registered pesticides	Other pesticides for wood treatment are currently registered, which are not HHPs, though some may also pose high human health and environmental risks.	
	Need to develop alternative pest management strategies?	US-EPA has identified alternative wood treatment options	
Proposed risk mitigation:	**Phase-out registration** Justification: – US-EPA concluded that chromated arsenicals pose cancer and non-cancer health risks of concern to workers in wood treatment facilities; their use as a wood treatment is highly restricted in the USA. – In view of both the acute and chronic hazards of this pesticide, use with acceptable risks to operators in Ghana is unlikely. – Pesticide industry and wood processing companies to be invited to propose alternative, lower risk, wood treatment options – Registration of this pesticide to be phased-out by …		

Cyproconazole			**HHP info card**
Active ingredient:	Cyproconazole All formulations		
Reason:	Reproduction toxicant category 1B – *may damage the unborn child*		
Number of registered products:	1	2019 – 2021 imports: (all formulations)	0
Registered crops & pests:	*Fungicide* Diseases in maize, rice, groundnut and vegetables		
Needs assessment:	Not imported: apparently no great need No specific diseases mentioned in the registration		
Risk assessments:	Operator & worker risks	Not conducted	
	Dietary risks	Not conducted	
Alternatives:	Registered pesticides	difenoconazole, tebuconazole	
	Need to develop alternative pest management strategies?	No	
Proposed risk mitigation:	**Cancel registration** Justification: – Since no imports have been recorded, use in Ghana is not considered essential. – Several lower risk alternatives available.		

Dimethomorph			**HHP info card**
Active ingredient:	Dimethomorph All formulations		
Reason:	Reproduction toxicant category 1B – *may damage fertility*		
Number of registered products:	8	2019 – 2021 imports: (all formulations)	434,300 kg
Registered crops & pests:	*Fungicide* Black pod disease *in:* cocoa Late blight *in:* potato, tomato Downy mildew and early blight *in:* cucumber		
Needs assessment:	Large quantity imported.		
Risk assessments:	Operator & worker risks	@ 108 g a.i./ha with hand-held or backpack sprayers in low vegetables or orchards, and tractor sprayers in low vegetables. Operator: risk acceptable only if PPE is used: mixing/loading = overall; application = overall Worker (e.g. harvesting): risk acceptable with basic workwear	
	Dietary risks	Registration on 5 crops or crop groups Representative MRLs available for 89% of crop commodities Total residue intake = 3% of ADI (= acceptable)	
Alternatives:	Registered pesticides	Black pod disease in cocoa: copper hydroxide, metalaxyl, pyraclostrobin, Blights and mildew in vegetables: many	
	Need to develop alternative pest management strategies?	Research in cocoa conducted/ongoing in Ghana	
Proposed risk mitigation:	**Restrict registration** Justification: – Restrict registration to use in cocoa only, as part of black pod disease resistance management (essential use) – PPE required for handling and application		

Fenvalerate			**HHP info card**
Active ingredient:	Fenvalerate All formulations		
Reason:	Stockholm Convention Annex D		
Number of registered products:	6	2019 – 2021 imports: (all formulations)	133,000 kg
Registered crops & pests:	*Insecticide* Insect pests *in:* vegetables, fruits Bollworm, cotton stainer, stalkborers *in:* cotton, maize, sorghum Aphids, mites, weevils *in:* cocoa		
Needs assessment	Large quantity imported, so apparent need for this type of broad spectrum and quick acting insecticide		
Risk assessments:	Operator & worker risks	Not conducted: HHP for environmental reasons	
	Dietary risks	Not conducted: HHP for environmental reasons	
Alternatives:	Registered pesticides	Many broad-spectrum insecticides registered.	
	Need to develop alternative pest management strategies?	No	
Proposed risk mitigation:	**Cancel registration** Justification: – Fenvalerate can be replaced by its active isomer esfenvalerate, which does not meet Annex D criteria and is therefore not an HHP – Use-up time for existing stocks … months		

Glufosinate-ammonium			**HHP info card**
Active ingredient:	Glufosinate-ammonium All formulations		
Reason:	Reproductive toxicant category 1B – *may damage fertility; may damage the unborn child*		
Number of registered products:	5	2019 – 2021 imports:	2,000 kg
Registered crops & pests:	*Herbicide* Annual and perennial grasses and broadleaf weeds *in:* vegetables, cereals, fruits, rubber, fallow land		
Needs assessment:	Small quantity imported annually		
Risk assessments:	Operator & worker risks	@ 900 g a.i./ha with hand-held or backpack sprayers in low vegetables, orchards or on bare ground Operator: no acceptable risk, even with full PPE Worker (harvesting): no acceptable risk, even with full PPE	
	Dietary risks	Not conducted, since no acceptable operator & worker scenarios were identified.	
Alternatives:	Registered pesticides	Several broad-spectrum herbicides currently registered, such as ametryn, 2,4-D, glyphosate, nicosulfuron and others.	
	Need to develop alternative pest management strategies?		
Proposed risk mitigation:	**Phase-out registration** Justification: – No acceptable occupational risk scenarios were identified, it is therefore unlikely that glufosinate-ammonium can be used with acceptable risk in Ghana. – Glufosinate-ammonium is an HHP on the basis of chronic hazards. Phase-out of the registration during a limited time period is therefore acceptable. – Registration of this pesticide to be phased-out by …		

Haloxyfop-methyl				**HHP info card**
Active ingredient:	Haloxyfop-methyl All formulations			
Reason:	WHO Class IB – *highly hazardous*			
Number of registered products:	4	2019 – 2021 imports:	40,000 kg	
Registered crops & pests:	*Herbicide* Annual and perennial grasses *in:* vegetables, watermelon, groundnut, soybean, pineapple, cotton, legumes, non-crop land			
Needs assessment:	Moderate quantity imported annually			
Risk assessments:	Operator & worker risks	@ 260 g a.i./ha with hand-held or backpack sprayers in low vegetables, high ornamentals or on bare ground Operator: Risk acceptable only with PPE: mixing/loading = overall, gloves, face shield; application = overall, gloves Worker (e.g. harvesting): no acceptable risk, even with full PPE		
	Dietary risks	Registration on 12 crops or crop groups Representative MRLs available for 50% of crop commodities Total residue intake = 790% of ADI (= risk not acceptable)		
Alternatives:	Registered pesticides	Several herbicides are currently registered to control grassy weeds.		
	Need to develop alternative pest management strategies?			
Proposed risk mitigation:	**Cancel registration** Justification: – Operator risks were only acceptable with full PPE, and no acceptable worker risk scenarios were identified. It is therefore unlikely that haloxyfop-methyl can be used with acceptable risk in Ghana in harvestable crops. – Dietary risks were highly unacceptable. – Haloxyfop-methyl could in principle be replaced by haloxyfop-P-methyl, which is the herbicidally active R-isomer of haloxyfop-methyl. It is less acutely toxic, and not an HHP. However, dietary risks would remain unacceptable also for haloxyfop-P-methyl, so this particular substitution is not recommended. – Several alternative herbicides with similar modes of action are currently registered in Ghana. – Haloxyfop-methyl is HHP on the basis of acute hazards. Cancellation of the pesticide should therefore be immediate. – Use-up time for existing stocks … months			

Lufenuron				**HHP info card**
Active ingredient:	Lufenuron All formulations			
Reason:	Stockholm Convention Annex D			
Number of registered products:	2	2019 – 2021 imports: (all formulations)	12,700 kg	
Registered crops & pests:	*Insecticide* Podborers, bollworm, beet armyworm, leafmoths in: kidney bean, tomato, cabbage Cabbage caterpillar *in:* cabbage			
Needs assessment:	Moderate quantity imported annually No essential uses identified			
Risk assessments:	Operator & worker risks	Not conducted: HHP for environmental reasons		
	Dietary risks	Not conducted: HHP for environmental reasons		
Alternatives:	Registered pesticides	Other benzoyl-urea insect growth regulators registered are: teflubenzuron		
	Need to develop alternative pest management strategies?			
Proposed risk mitigation:	**Phase out registration** Justification: – Lufenuron is listed as HHP due to its high persistence in the environment and its bioaccumulation potential. – Phase-out of the registration during a limited time period is therefore acceptable. – Registration of this pesticide to be phased-out by …			

Magnesium phosphide			**HHP info card**
Active ingredient:	Magnesium phosphide ≥56% formulation		
Reason:	WHO class IB – *highly hazardous*		
Number of registered products:	1	2019 – 2021 imports: (all formulations)	0 kg
Registered crops & pests:	*Fumigant*		
Needs assessment	Not imported However, the Ghana Cocoa Board still has a large stock		
Risk assessments:	Operator & worker risks	Not conducted: no appropriate risk assessment model for fumigants	
	Dietary risks	Not conducted: no residues expected; no MRLs	
Alternatives:	Registered pesticides	See: Aluminium phosphide	
	Need to develop alternative pest management strategies?	Identify alternative management options to control pests of stored cocoa beans	
Proposed risk mitigation:	**Restricted registration** Justification: – Fumigant with very high acute toxicity – All registrations of use by smallholder farmers to be discontinued – Only to be authorized for use by trained (licenced) pesticide applicators in large scale stores of grain companies, wood processing companies, cocoa processing companies and the Ghana Cocoa Board		

Mancozeb			**HHP info card**
Active ingredient:	Mancozeb All formulations		
Reason:	Reproductive toxicant category 1B – *may damage the unborn child*		
Number of registered products:	30	2019 – 2021 imports: (all formulations)	1,200,700 kg
Registered crops & pests:	*Fungicide* Wide variety of diseases *in:* vegetables, fruits, ornamentals, soybean, groundnut, coffee, banana, plantain, tubers, rice, cereals, tobacco		
Needs assessment:	Large quantity imported. Mancozeb is an effective and cheap broad-spectrum fungicide, and therefore very widely used		
Risk assessments:	Operator & worker risks	@ 3200 g a.i./ha with hand-held or knapsack sprayers in low vegetables, high ornamentals or orchards, or tractor sprayers in field crops. Operator: No acceptable risk, even with full PPE, for hand-held sprayer in low vegetables and high ornamentals, and with tractor application in field crops. Risk acceptable if PPE is worn (overall, gloves) for backpack spraying in low vegetables, orchards and high ornamentals. Worker (e.g. harvesting): Risk not acceptable even with PPE in orchards and high ornamentals. Risk acceptable with full PPE in low vegetables and field crops = hands, arms, body and legs covered	
	Dietary risks	Registration on 32 crops or crop groups Representative MRLs available for 95% of crop commodities Total residue intake = 120% of ADI (= borderline unacceptable)	
Alternatives:	Registered pesticides	Several alternative fungicides are registered	
	Need to develop alternative pest management strategies?	Yes	
Proposed risk mitigation:	**Restrict registration** Justification: – Occupational risks were acceptable only in a few cases, with limited PPE. – Dietary risks were borderline unacceptable, using the worst case assessment. – Large quantities of mancozeb are being imported, indicating a need for this fungicide – Continued use of mancozeb for some uses may be possible with proper risk mitigation measures in place. – A more detailed roadmap to reduce reliance on mancozeb will need to be developed.		

Methomyl			**HHP info card**
Active ingredient:	Methomyl ≥50% formulations		
Reason:	WHO Class Ib – *highly hazardous*		
Number of registered products:	1	2019 – 2021 imports: (all formulations)	27,800 kg
Registered crops & pests:	*Insecticide* Army worm, aphids, white fly in: cereals, vegetables, fruit trees		
Needs assessment:	Moderate quantity imported annually Assess whether any essential uses exist in Ghana		
Risk assessments:	Operator & worker risks	@ 2000 g a.i./ha with hand-held or knapsack sprayers, or tractor sprayers, in low vegetables, orchards or field crops. Operator: no acceptable risk, even with full PPE Worker (e.g. harvesting): no acceptable risk, even with full PPE	
	Dietary risks	Registration on 9 crops or crop groups Representative MRLs available for all crop commodities Total residue intake = 10% of ADI (=acceptable risk)	
Alternatives:	Registered pesticides	Many alternative lower-risk insecticides are registered	
	Need to develop alternative pest management strategies?	Assess IPM options since there is a high risk of resistance development in the listed pests if reliance on single insecticides.	
Proposed risk mitigation:	**Cancel registration** Justification: – No acceptable occupational risk scenarios were identified, therefore methomyl can likely not be used with acceptable risk in Ghana. – Methomyl was identified as HHP on the basis of its high acute toxicity. Cancellation of registration should therefore be immediate. – Use-up time for existing stocks … months		

Oxamyl			**HHP info card**
Active ingredient:	Oxamyl ≥24% formulation		
Reason:	WHO Class Ib – *highly hazardous*		
Number of registered products:	2	2019 – 2021 imports: (all formulations)	0 kg
Registered crops & pests:	*Insecticide, nematicide* Control of nematodes and soil insects		
Needs assessment:	Not imported: other nematicides probably more effective or cheaper		
Risk assessments:	Operator & worker risks	Not conducted	
	Dietary risks	Not conducted	
Alternatives:	Registered pesticides	Not many nematicides registered	
	Need to develop alternative pest management strategies?		
Proposed risk mitigation:	**Cancel registration** Justification: – Very high acute toxicity – Since no imports have been recorded, use in Ghana is not considered essential. – Oxamyl was identified as HHP on the basis of its high acute toxicity. Cancellation of registration should therefore be immediate.		

Propiconazole			**HHP info card**
Active ingredient:	Propiconazole All formulations		
Reason:	Reproductive toxicant category 1B – *may damage the unborn child*		
Number of registered products:	1	2019 – 2021 imports: (all formulations)	4,800 kg
Registered crops & pests:	*Fungicide* Diseases *in:* rice, pineapple		
Needs assessment:	Small quantity imported		
Risk assessments:	Operator & worker risks	@100 g a.i./ha hand-held or knapsack sprayers, or tractor sprayers in field crops, low berries and cane fruit/high berries: Operator: acceptable exposure with basic workwear or overall Worker (e.g. harvesting): acceptable exposure with basic workwear in low berries and field crops. Risk acceptable only if hands, arms, body and legs are covered in cane fruit/high berries.	
	Dietary risks	Registration on 4 crops or crop groups Representative MRLs available for all crop commodities Total residue intake = 1% of ADI (= acceptable)	
Alternatives:	Registered pesticides	difenoconazole, tebuconazole	
	Need to develop alternative pest management strategies?		
Proposed risk mitigation:	**Maintain registration** (with risk mitigation) Justification: – Occupational risks were acceptable with basic workwear – Dietary risks were acceptable – Appropriate PPE should be required on the label.		

Thiacloprid			**HHP info card**
Active ingredient:	Thiacloprid All formulations		
Reason:	Reproductive toxicant category 1B – *may damage fertility, may damage the unborn child*		
Number of registered products:	1	2019 – 2021 imports: (all formulations)	400 kg
Registered crops & pests:	*Insecticide* Insect pests *in:* cotton Fall armyworm *in:* maize		
Needs assessment:	Very low quantity imported		
Risk assessments:	Operator & worker risks	@ 36 g a.i./ha with hand-held or knapsack sprayers in high ornamentals or high vegetables (simulating use in cotton or maize) and in low vegetables (simulating use in early maize); same application in field crops with vehicle-mounted sprayers. Operator: hand-held or knapsack sprayers or tractor: Acceptable risk only when wearing workwear (overalls or long-sleeved shirt and long pants) Worker (e.g. harvesting): hand-held equipment: acceptable risk only if arms, body and legs covered; tractor: acceptable risk with basic workwear.	
	Dietary risks	Registration on 2 crops or crop groups Representative MRLs available for 50% of crop commodities Total residue intake = 1% of ADI (= acceptable)	
Alternatives:	Registered pesticides	Many other contact/systemic insecticides registered	
	Need to develop alternative pest management strategies?		
Proposed risk mitigation:	**Restricted registration** Justification: – For hand-held and backpack sprayers (generally used in cotton and maize in Ghana) operator risks are only acceptable if basic workwear is worn (overalls or long-sleeved short and long pants), and worker risks are acceptable only if arms, body and legs covered. – Most cotton and maize farmers in Ghana will use basic workwear when spraying a pesticide and harvesting their crop. – Use of appropriate PPE should be prominently indicated on the pesticide label and enforced during use. Only uses where PPE use can be realistically expected should be registered.		

Triadimenol			HHP info card
Active ingredient:	Triadimenol All formulations		
Reason:	Reproductive toxicant category 1B – *may damage fertility, may damage the unborn child*		
Number of registered products:	1	2019 – 2021 imports: (all formulations)	10,000 kg
Registered crops & pests:	*Fungicide* *Early blight, late blight*, tomato leaf spot *in:* vegetables, field crops, ornamentals		
Needs assessment:	Moderate quantity imported		
Risk assessments:	Operator & worker risks	@ 9 g a.i./ha with hand-held or knapsack sprayers in low vegetables, high ornamentals and orchards. Operator: Acceptable risk if overall is worn Worker (e.g. harvesting): Acceptable risk with basic work wear	
	Dietary risks	Registration on 4 crops or crop groups Representative MRLs available for 50% of crop commodities Total residue intake = 1.1% of ADI	
Alternatives:	Registered pesticides	Various fungicides active against blights are registered	
	Need to develop alternative pest management strategies?	Yes/No - remarks	
Proposed risk mitigation:	Maintain registration (with risk mitigation) Justification: – Occupational risks were acceptable with basic workwear – Dietary risks were acceptable – Require basic workwear or overalls on the label		

Annex 6 Selection of pesticide properties from the PPDB for screening POP criteria

The tables below present the choices available in the PPDB for each of the three POP screening criteria and provide a proposal for which property to select and justification of this choice.

Table 11 *Choices available in the PPDB for each of the three POP screening criteria*

Property for screening POP criteria	Choices in PPDB	
$DT50_{soil}$	DT50 typical (d)	'Typical values' quoted are those given in the general literature and are often a mean of all studies field and laboratory. This is the value normally used in the regulatory modelling studies and is for aerobic conditions.
	DT50 lab at 20°C (d)	DegT50 values of plant protection products in soil at 20°C obtained from laboratory studies
	DT50 field (d)	DegT50 values of plant protection products in soil obtained from field dissipation studies
$DT50_{water}$	Aqueous hydrolysis pH 5 (d)	DT50water for the process of hydrolysis obtained from an aqueous hydrolysis study at pH 5
	Aqueous hydrolysis pH 7 (d)	DT50water for the process of hydrolysis obtained from an aqueous hydrolysis study at pH 7
	Aqueous hydrolysis pH 9 (d)	DT50water for the process of hydrolysis obtained from an aqueous hydrolysis study at pH 9
	Water phase only DT50 (d)	The DT50 of the water phase only obtained from a water-sediment study in the dark (processes of hydrolysis and microbial degradation in the water phase of the water-sediment study only). PDDB
	Water-sediment DT50 (d)	The DT50 of the total water-sediment system obtained from a water-sediment study in the dark (so including processes transformation in water and sediment due to hydrolysis and microbial degradation).
$DT50_{sediment}$	Water-sediment DT50 (d)	The DT50 of the total water-sediment system obtained from a water-sediment study in the dark (so including processes transformation in water and sediment due to hydrolysis and microbial degradation).
BCF	BCF (l/kg)	Bio concentration factor (values up to 5000 l/kg can be obtained with sufficient certainty)
Log Kow	Log P (-)	Log of the Octanol-water partition coefficient at pH 7, 20°C. (can be established with sufficient certainly until values of 6, above 6 is more difficult).

Note that the BAF (Bio accumulation factor) is not given in the PPDB.

Table 12 *Properties to choose from the PPDB and justification of this choice (in case necessary)*

Property for screening POP criteria	Chosen property from PPDB	Justification
$DT50_{soil}$	DT50 lab at 20°C (d)	DT50 lab data are the more precise and repeatable of the various options in the PPDB database, and therefore chosen. DT50field values are very likely not determined according the latest EFSA guidance (EFSA, 2010) and therefore not adequate. This EFSA guidance proposes a procedure that ensures that the DegT50 derived from field dissipation studies reflects the degradation rate within in the soil matrix between 1 – 30 cm depth with sufficient accuracy. This procedure aims at diminishing the influence of other loss processes like volatilisation, photochemical degradation runoff etc. which are significant processes in the top millimetres of the soil matrix. Therefore the estimated DegT50 should not be influenced by these loss processes. This can be reached by a proper design of the field study: i.e. by applying irrigation shortly after pesticide application (EFSA advises 10 mm) of by using the proposed method for kinetic evaluation of the field dissipation study for determining the DegT50field. Most field dissipation studies in the dossiers used for the PPDB are performed before the outcome of the EFSA opinion and it is not very likely that the kinetic evaluations are done according the method advised by EFSA (2010). For the same reason the DT50 typical is not suitable as this is often a mean of all studies both field and laboratory, so based upon inaccurate DegT50field values. *EFSA Panel on Plant Protection Products; Guidance for evaluating laboratory and field dissipation studies to obtain DegT50 values of plant protection products in soil. EFSA Journal 2010;8(12):1936 [67 p]. doi:10.2903/j.efsa.2010.1936*

Property for screening POP criteria	Chosen property from PPDB	Justification
$DT50_{water}$ (hydrolysis)	Aqueous hydrolysis half-life pH 7 (d) Aqueous hydrolysis half-life pH 9 (d)	*ad 1.* Figure 8 Select the longest DegT50 in the pH range from 7 to 9.5 from the available data in the PPDB and calculate this back to a temperature of 20˚C using Eq. 2. It is recommended to assume an Arrhenius activation energy of 65.4 kJ/mol = 65400 J/mol (EFSA, 2007). Calculating the degradation rate, *k*, from the DegT50 is done as follows: $k = \frac{\ln 2}{DegT50}$ *Eq. 1* where: *DegT50* = Degradation half-life (d) *k* = Transformation rate (d^{-1}) $k(T) = k(T_{ref}) exp\left[\frac{E}{R}\left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right]$ *Eq. 2* where: T = Temperature (K) T_{ref} = Reference temperature (K) k = Transformation rate (d^{-1}) E = Molar Arrhenius activation energy ($J\ mol^{-1}$) R = Universal gas constant (≈ 8.3144 $J\ mol^{-1}\ K^{-1}$) *EFSA. 2007. Opinion on a request from EFSA related to the default Q10 value used to describe the temperature effect on transformation rates of pesticides in soil. Scientific Opinion of the Panel on Plant Protection Products and their Residues (PPR-Panel). EFSA Journal 622: 1-32*.

Property for screening POP criteria	Chosen property from PPDB	Justification
$DT50_{water}$ (from water-sediment study; DT50 water phase only)	Water phase only DT50 (d)	*ad 2.* Figure 8 The DT50 of the water phase only obtained from a water-sediment study in the dark (processes of hydrolysis and microbial degradation in the water phase of the water-sediment study only) – according OECD 308. It is not very clear whether a dissipation half-life (i.e. including the process of diffusion to the water layer) is requested or whether a degradation half-life, DegT50 (excluding the process of diffusion to the water layer and only including degradation processes of hydrolysis and microbial degradation in the sediment) is requested. The latest ECHA guidance (https://echa.europa.eu/documents/10162/13632/information_requirements_r11_en.pdf/a8cce23f-a65a-46d2-ac68-92fee1f9e54f; last entered 23 September 2021) gives the following guidance. If the DegT50water from OECD 309 < 60 d, other compartments should be taken into account. OECD 309 data is not given in the PPDB. The DegT50water from OECD 309 is the lumped sum of biodegradation and hydrolysis. The PPDB suggests that the DegT50 water phase only is obtained from water sediment studies (i.e. OECD 308). DegT50 values from the water phase only are obtained from water-sediment study data using inverse modelling. The estimated DT50water is surrounded by uncertainties (Ter Horst and Koelmans, 2016, Honti *et al.*, 2015). Ter Horst and Koelmans (2016) mapped the uncertainty of the estimated DegT50water using artificial experimental datasets. They found that at increasing Koc/Kom values the estimated DegT50water is less reliable for increasing values of the DegT50water. The guidance in box 2 of Figure 8 is based on their results. However, this is a rather rough method based on two types of sediment and a dummy chemical of which parameters DegT50water, DegT50sediment and Kom were varied. However, we needed a pragmatic approach but did wish to take in to account the uncertainties surrounding the DegT50water derived from water-sediment studies. *Honti, M.; Fenner, K. Deriving Persistence Indicators from Regulatory Water-Sediment Studies – Opportunities and Limitations in OECD 308 Data. Environ. Sci. Technol. 2015, 49, 5879-5886. DOI:10.1021/acs.est.5b00788* *Ter Horst, M. M., & Koelmans, A. A. Analyzing the Limitations and the Applicability Domain of Water–Sediment Transformation Tests like OECD 308. Environ. Sci. Technol. 2016, 50(19), 10335-10342.*

Property for screening POP criteria	Chosen property from PPDB	Justification
$DT50_{sediment}$	Water-sediment DT50 (DT50 of the total water-sediment system) (d)	It is not very clear whether a dissipation half-life (i.e. including the process of diffusion to the water layer) is requested or whether a degradation half-life, DegT50 (excluding the process of diffusion to the water layer and only including degradation processes of hydrolysis and microbial degradation in the sediment) is requested. We assume that the DegT50sediment (excluding the process of diffusion to the water layer but including degradation processes of hydrolysis and microbial degradation in the sediment) is requested. It is difficult to separately estimate the DegT50 in the sediment compartment from a water-sediment study (e.g. Ter Horst and Koelmans, 2016, Honti *et al.*, 2015). The DegT50 sediment is not found in the PPDB (there is no adequate test to determine the value of this parameter). The DT50 of total water-sediment system is the only information available and this property can in theory be estimated with sufficient certainty. If the DT50 of the total water-sediment system > 180d it is possible that the pesticide is either rather persistent in water or in the sediment. However, it is also possible that in reality the DegT50water of a chemical is smaller than 60 d and that the DegT50sediment of the same chemical is smaller than 180 d, but that the lumped sum of dissipation half-life in the water-sediment system is larger than 180 d. In the latter case using the criterion DT50system > 180 d is actually too strict. However, given the lack of alternatives, we adopted the criterion that if the DT50 of the total water-sediment system of a chemical > 180 d, the chemical is considered persistent in the sediment. *Honti, M.; Fenner, K. Deriving Persistence Indicators from Regulatory Water-Sediment Studies – Opportunities and Limitations in OECD 308 Data. Environ. Sci. Technol. 2015, 49, 5879-5886. DOI:10.1021/acs.est.5b00788* *Ter Horst, M. M., & Koelmans, A. A. Analyzing the Limitations and the Applicability Domain of Water–Sediment Transformation Tests like OECD 308. Environ. Sci. Technol. 2016, 50(19), 10335-10342.*

Property for screening POP criteria	Chosen property from PPDB	Justification
K_{oc}	KOC (L/kg)	ad 2. Figure 8

A value of the sorption coefficient is needed. In this case the K_{oc} of soil (sediment K_{oc} are generally not available in pesticide registration dossiers and thus not given in the PPDB database) is selected.

K_{om} is needed and can be calculated as follows:

Kom = Koc/1.724 Eq. 4

K_{oc} in the PPDB is very likely the most reliable parameter. Below an explanation is given why we consider Kfoc data from the PPDB to be less reliable.

Problems with the use of $K_{F,oc}$ data

The definition of the K_{oc} is based on a linear sorption isotherm:

$$X = m_{oc} K_{oc} C \quad \text{Eq. 5}$$

where
X is mass of pesticide sorbed per mass of dry soil (mg kg^{-1}),
m_{oc} is mass fraction of organic carbon of the soil (kg kg^{-1}),
K_{oc} is the organic-carbon/water distribution coefficient (L kg^{-1}) and C is the mass concentration in the liquid phase (mg L^{-1}).

The definition of the $K_{F,oc}$ is based on the Freundlich isotherm:

$$X = m_{oc} K_{F,oc} C^{N} \quad \text{Eq. 6}$$

where $K_{F,oc}$ is the Freundlich coefficient for distribution over organic carbon and water (L^{N} kg^{-1} mg^{1-N}) and N is the Freundlich exponent (-).
So whereas the unit of K_{oc} depends only on the unit used for the mass of dry soil (kg) and the volume of liquid (L), the unit of $K_{F,oc}$ is also a function of the unit used for the mass of pesticide (mg) and also of N. This has the consequence that the value of $K_{F,oc}$ depends on the unit used for the mass of pesticide. E.g. the $K_{F,oc}$ value obtained by fitting of data with X expressed in mg kg^{-1} and C expressed in mg L^{-1} will differ from the $K_{F,oc}$ value obtained by fitting of the same data with X expressed in µg kg^{-1} and C expressed in µg L^{-1}. Let us consider the following example to illustrate this.

C (mg L^{-1})	X (mg kg^{-1})
0.001	0.0020
0.01	0.0158
0.1	0.1259
1	1
10	7.4943

These numbers are calculated with Eq. 6 using m_{oc} = 0.01, $K_{F,oc}$ = 100 and N =0.9. So if these values would be fitted back to Eq. 6, a $K_{F,oc}$ value of 100 would have been obtained. Let us now consider a researcher that expresses the same data in µg instead of mg.

C (µg L^{-1})	X (µg kg^{-1})
1	2.0
10	15.8
100	125.9
1000	1000.0
10000	7494.3

Fitting these data to Eq. 6 will give a $K_{F,oc}$ value of 200 instead of 100. This can be easily checked by putting the concentrations of the second table in a spreadsheet and calculating X with Eq. 6 (using $K_{F,oc}$ = 199.526 to get exactly the same result).

Sometimes researchers use also mmol instead of mg (1 mmol is usually about 200 mg). So if a $K_{F,oc}$ value is provided, it is necessary to know in which unit the mass of pesticide is expressed. However, this is not done in the PPDB. (pers.comm. Dr. J.J.T.I. Boesten, WUR)

Property for screening POP criteria	Chosen property from PPDB	Justification
BCF	BCF (L/kg)	Bio concentration factor Values up to 5000 L/kg can be obtained with sufficient certainty. The cut off is 5000 (i.e. establishing that the chemical does not accumulate is fish can be done with sufficient certainty).
Log Kow	Log P (-)	Log of the Octanol-water partition coefficient at pH 7, 20°C. Values up to 6 can be established with sufficient certainty, above 6 is more difficult. The cut off is 5 (i.e. establishing that the chemical does not accumulate is fish can be done with sufficient certainty).

Annex 7 Outline of a road map towards phase-out of a HHP

Roadmap to implement alternatives to the use of the HHP {name…} **in** {crop name …}

Situation analysis
- HHP to be replaced
- Crop(s) in which HHP is used
- Pest(s) against which HHP is used
- Geographical extent of the pest
- Importance of the pest (yield loss)
- Efficacy of the HHP to reduce damage, yield loss, economic loss
- Key stakeholders growing the crop; applying the HHP

Possible alternatives
- Registered biopesticides or low risk synthetic pesticides
- Not yet registered biopesticides or low risk synthetic pesticides
  - Requirements for registration
- Other crop or pest management measures
  - Already used in the country
  - Not yet used in the country but applied elsewhere
- Efficacy of alternative (bio)pesticides or pest management measures
  - Research needs to assess alternatives

Identification of viable options
- Compare alternatives and identify viable options: Use the FAO Pesticide Registration Toolkit – Assessment of Alternatives module {https://www.fao.org/pesticide-registration-toolkit/registration-tools/alternatives/main-steps/4-identify-viable-options/en/}
- Decision of the best option(s) to replace the HHP

Implementation
- Lead actor
- Other actors
- Regulatory actions: e.g. authorization (if any)
- Market actions: e.g. production, importation, distribution (if any)
- Outreach and communication actions
- Training actions: e.g. extension and advisory services
- Fiscal actions: e.g. temporary subsidies or taxes
- Time line

Monitoring implementation

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