A Study on the effect of listing of chemicals in Annex III to the Rotterdam Convention

Final Report (Contract No: ENV/07.0201/512.723161/ETU/A.3

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Executive summary

The Rotterdam Convention was created in response to growing concerns around the use of specific named chemicals, and the potential risks to human health and the environment. The aims of the Convention centre around shared responsibility for the trade of such chemicals, and a need for information exchange on the safe use and management between ratified Parties for chemicals listed in Annex III and other chemicals subject to the Convention. This is the 'prior informed consent' (PIC) procedure, which requires a manufacturer/distributor of a chemical named within the Rotterdam Convention to seek permission from the competent authority of the receiving country prior to supply of goods.

The Rotterdam Convention also includes a process for addition of new chemicals into Annex III as needed. Once notice of a ban or a severe restriction of a chemical is given by ratified Parties from two specified regions, the substance is taken into consideration for addition to Annex III. Then, scientific experts discuss these chemicals annually at the Chemical Review Committee (CRC) meetings and develop recommendations to the ratified Parties, who meet every two years at the Conference of the Parties (COP) meeting to vote on whether a given chemical should be added to the Convention. In order for the chemical to be added a unanimous vote is required by the Parties.

Concerns have also been raised by the Parties of the Convention that named chemicals have now been discussed at multiple COP meetings without resolution. This is an issue which hampers the effectiveness of the Convention in its objective of ensuring that all those chemicals that require further control are added to the Convention. The main objections to listing have been around socio-economic effects of listing a chemical. The Rotterdam Convention's ultimate aim is not the phase-out of named chemicals, but rather enhanced information sharing on the risks and suitable control measures for all Parties. However a small number of Parties are concerned that listing may lead to reduced production of the chemical in question, resulting in supply shortages and/or price increases. The concern therefore has been that the end-users of these chemicals, particularly for developing nations or nations in transition, may be unfairly disadvantaged.

At COP-7 (2015), an intersessional working group was launched specifically to look at the effectiveness of the Convention and issues hindering the addition of new chemicals to the Annexes. This working group developed what was termed a 'thought starter' paper to look at the main issues around why resolution had not been reached for those chemicals that had been discussed, and the potential options that could be implemented to help improve the effectiveness of the Convention.

The current study aims to support the work of the intersessional working group by exploring whether the objections raised by Parties at successive COPs are valid. The study also reviewed where possible the underlying factors to how and why an impact might occur for the end-user groups (in this case farmers), through the use of case studies. Data has been gathered from a number of sources, primarily data held by FAO on trade of named substances, price, and data on alternatives for named countries. The study has also made use of data from DGD documents to look at number of manufacturers, application of named substances and for pesticides which crops are targeted for use by given chemicals.

The study developed four case studies for the pesticides Alachlor, Aldicarb, Monocrotophos and Parathion, after a selection process designed to identify those named chemicals on Annex III to the Rotterdam Convention with the most complete data-sets needed for case study development. The case studies then reviewed the trends in trade, price and alternatives for a period of time before and after listing in the Rotterdam Convention. These trends were then used against a set of hypothesis, e.g. listing on the Rotterdam Convention causes the price of the named chemical to increase, to assess whether an effect had been witnessed or not. Comment was also provided on cases where results were inconclusive.

The study findings found that for none of the four pesticides, conclusive evidence of an impact of listing could be observed. For three case studies, there was no effect on either price or trade observable in the limited data available, with both continuing broadly in a similar fashion before and after listing. In only one case out of the four developed, were trends identified which suggested a possible impact of listing was witnessed for some countries (increase in price, decrease in trade, switching to alternatives which were also more expensive). It is worth noting that in the case where some impacts of the Convention seem to have occurred, there appeared to be a limited set of alternatives to the named chemical, which meant a lack of market competition and thus more flexibility for price increases.

The study also reviewed the available alternatives for nominated chemicals due for discussion at the next COP meeting due to be held in 2017. Again for chrysotile asbestos, SHPF of Fenthion and for Trichlorfon, multiple alternatives, both chemical and non chemical, exist, suggesting that in the majority of markets there is a good level of competition and flexibility to add these chemicals while continuing to meet the needs of end-users. For SHPF Paraquat, there were more limited chemical alternatives available which were not suitable for all geographic regions. However a large number of non-chemical alternatives were available. In this case the main issue may be around market preference and confidence of farmers in non-chemical alternatives. For the SHPF Paraquat, the findings of the current study suggested care is needed in considering the options further to ensure end-users' needs can be met should a listing be made.

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1. Introduction

1.1 Background to the project and policy area

Policy context

Introduction to the Rotterdam Convention

The use of hazardous chemicals presents an inherent risk to both people and the environment, requiring suitable risk management controls to ensure their safe trade and use. Where such chemicals are used globally, the level of understanding of the risks and controls in place can vary widely meaning that in some cases the level of risk may become unacceptable. Such has been the concern, particularly for developing nations or nations in transition where infrastructure to manage hazardous chemicals may be weaker, that globally steps have been taken to proactively manage these issues. This culminated in the creation of the Rotterdam Convention[1] in 2004 which aims to improve the controls around the movement of named hazardous chemicals and severely hazardous pesticide formulations (SHPFs) across political borders using the prior informed consent (PIC) procedure. The Rotterdam Convention also aims to engage and promote the exchange of information on safe use and risk management for named hazardous chemicals and SHPFs.

At European level, the PIC procedure is regulated under Regulation (EU) 649/2012[2] and managed by the European Chemicals Agency (ECHA) as the institution responsible for the administrative and technical tasks related to the Regulation.

The Convention involves chemicals which are used for industrial use and pesticides, including SHPF that have been banned or severely restricted due to health or environmental reasons by Parties to the Convention and which have been notified by Parties to be included in the PIC procedure.

The Convention has set specific rules for international trade in hazardous chemicals and imposes a number of obligations on Parties with respect to the listed chemicals, namely in its articles 10 and 11.

The Convention currently has 154 Parties. As well as the European Union and its Member States this includes many developing countries and economies in transition.

To date a total of 46 chemicals are listed in Annex III (32 pesticides and 14 industrial chemicals), and four chemicals are recommended for listing in Annex III, which will be considered for discussion in the next Conference of the Parties (COP) meeting.

Procedural elements of the Rotterdam Convention

Annex II to the Convention specifies the criteria for listing banned or severely restricted chemicals in Annex III. The Chemical Review Committee to the Rotterdam Convention verifies whether final regulatory action is taken as a consequence of a risk evaluation. This review considers whether the final regulatory action provides a sufficiently broad basis to merit listing of the chemical in Annex III. It also takes into consideration whether the listing would lead to a significant decrease in the quantity of the chemical used and reduction of risk for human health or the environment. Intentional misuse is not in itself an adequate reason to list a chemical.

Annex IV establishes the information and criteria for listing SHPF in Annex III. Information requirements comprise besides others the existence of handling or application restrictions in other States; information on incidents, risk and hazard evaluations; and indications on the extent of use, alternative pest-control practices, and other information. Criteria comprise the reliability of the evidence for incidence; the relevance to other States with similar climate, conditions and use patterns; the existence of handling/application restrictions technologies or techniques not reasonably or widely applied in States lacking the necessary infrastructure; and the significance of the reported effects in relation to the quantity used.

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[1] http://www.pic.int/

[2] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:201:0060:0106:en:PDF

The chemicals included in Annex III are chemicals that are subjected to the PIC procedure. The procedure consists of the following:

1. Two notifications for a chemical from two PIC regions meeting the information requirement of the Convention.

2. In case of SHPF a proposal from a developing country or a countries with an economies in transition meeting, as per the information required in Annex IV.

3. A draft Decision Guidance Document (DGD) prepared by the Chemical Review Committee.

New pesticides may be added to Annex III during the regular COP meetings, if consensus is reached between Parties.

The COP meets every two years and is responsible for the decisions about amendments to the Convention as well as the addition of chemicals to Annex III.

The Chemical Review Committee is a subsidiary body of the COP that meets each year. Its members review notifications and proposals from Parties as well as developing recommendations to the COP on the inclusion of chemicals upon Annex III.

Failure to reach consensus on addition of chemicals to Annex III

At the latest COP to the Rotterdam Convention (COP-7) in May 2015[3], Parties failed to reach consensus on the listing of the following four chemicals:

- Chrysotile asbestos;
- Certain severely hazardous pesticide formulations containing Paraquat;
- Trichlorfon; and
- Certain severely hazardous pesticide formulations containing Fenthion.

For chrysotile asbestos and pesticides containing Paraquat, the lack of consensus has already occurred several times. In all cases the block was caused by the negative vote of a small number of Parties or even only one Party. The arguments brought forward are in principle not relevant under the Convention as they are not related to human health and the environment, but focus on economics and aspects of availability, such as:

- Reduction of production, leading to reduced supply and/or to higher prices;
- Lack of availability of alternatives in developing countries; and
- Higher prices of alternatives.

A key challenge observed to hamper the procedures under the PIC procedure is the fact that individual Parties do not apply the Convention criteria when establishing their position. This undermines the functioning of the Convention and its objectives by severely hampering the listing of chemicals that are still internationally traded. Improving the effectiveness of the Convention is hence considered a priority issue by the European Commission.

In 2008, COP-4 discussed a number of options to ensure continued effectiveness of the Convention[4] in the context of some chemicals having been discussed for a protracted amount of time for inclusion in Annex III (e.g. for chrysotile asbestos during the third, fourth, fifth and sixth Convention meetings) and no consensus has been reached. However, the members present were unable to agree on any approach. At COP-7, Parties again failed to reach consensus on the listing of four chemicals, due to an individual Party or a small number of Parties having blocked listing. Furthermore a decision was adopted at COP-7 in 2015[5] on Intersessional work on the process of listing chemicals in Annex III to the Convention. According to this decision an intersessional working group shall identify the reasons for and against listing, and shall develop further options

[3] http://www.pic.int/TheConvention/ConferenceoftheParties/Meetings/COP7/Overview/tabid/4252/language/en-US/Default.aspx
[4] UNEP/FAO/RC/COP.4/12 and UNEP/FAO/RC/COP.4/13
[5] RC-7/5

for improving the effectiveness of the process as well as proposals for enabling improved information flows that support the PIC procedure for those chemicals.

Background to the project

The current study has been commissioned to assess the issues raised and discussed by the Parties at successive COPs. This relates to the objections made for addition of substances to Annex III of the Convention on socio-economic grounds. While the economic aspects are outside of the scope for criteria on whether a chemical or SHPF should be added to Annex III, they do have genuine ramifications for end-users and industry sectors where these named chemicals are used. To help assess whether these objections are valid and require greater scrutiny, the project explores the socio-economic aspects of adding a chemical to Annex III through the use of example case studies. This approach has included the development of an economic assessment for potential impacts, and data gathering supported by the Food and Agriculture Organization of the United Nations (FAO) to draw in the necessary data to flesh out the case studies.

Alongside the case study body of work, two additional tasks have been conducted. Firstly for those nominated substances targeted for discussion at COP-8, an assessment has been made to look at the available alternative substances on the market and whether it would be possible for end-users to make use of such alternatives if there were any impacts upon prices or availability of the nominated chemicals at the point of adding them to Annex III. Secondly the study makes use of the discussions of the COP and the Intersessional working group created at COP-7 to look at the wider issues affecting the continued effectiveness of the Convention and what options suggested thus far could be adopted. This includes a logical assessment of the options to look at their advantages, drawbacks and potential unexpected side effects if they were to be implemented.

1.2 Objectives of the study

Based on the objections raised by Parties at successive COPs and the concerns raised by Parties around the continued effectiveness of the Convention the current study has the following main objectives:

- To understand what are the impacts of the listing of a pesticide in Annex III to the Convention on the development of the pesticide market in developing countries and countries with economies in transition related to the listed pesticides and its respective alternatives;
- What alternatives exist for the chemicals that are expected to be considered by COP-8;
- Review of the options to ensure the continued effectiveness of the Convention for those chemicals where the COP fails to reach consensus on the listing although all criteria relevant under the Convention are met; and
- Recommendations on a way forward.

1.3 Acknowledgements

The Authors would like to thank and acknowledge the support of the Food and Agriculture Organisation (FAO) for provision of key data which has been used in the current study. In particular the work conducted by the FAO in contact with regional offices to gather key economic data.

2. Methodological approach

2.1 Overview of the methodological approach

Development of hypothesis for testing

The objections raised by the Parties at successive COPs for not adding chemicals to Annex III of the Rotterdam Convention largely focusses on socio-economic issues. The basis of this argument is two-fold; firstly that the addition of a named chemical or SPHF to Annex III of the Convention could lead to reduced production of that SPHF or chemical, possibly leading to supply shortages and higher prices adversely affecting particular user groups such as farmers. This would be of particularly high concern where food security issues arose or the economic viability of the sector was damaged. Reduced supply would have the impact of requiring end users to purchase alternatives which may be more expensive or less effective, or the possibility of not using any chemical/SHPF which could affect yield of final goods directly. For SHPFs, this again raises the issue of food security and protection of the farming sector.

To assess these concerns a socio-economic analysis was developed. However due to the global nature of the Convention and likely local/regional impacts for named chemicals, a full socio-economic impact assessment would be complex and likely exacerbated by the level of data requirements needed to support such a study. On that basis an alternative approach has been developed. This involves deriving a set of hypotheses which will be tested, followed by the development of case studies based on named chemicals already added to Annex III to assess the impacts based on the before and after situation for addition to Annex III of the Convention.

On that basis the following hypotheses were developed to cover the objections raised by Parties at successive COP meetings:

- Listing leads to a decrease in production and/or the number of manufacturers of the substance.
- Listing reduces traded volume.
- Listing inflates prices.
- Listing leads to a reduction in use volumes of the substance.
- Listing leads to substitution of the substance with alternatives[6].

Development of scope boundaries

In order to develop case studies to review and assess the hypotheses developed, it has also been necessary to define scope boundaries. These boundaries keep the focus of each case study upon the possible outcomes whilst also noting the complexity of supply chains and outside effects which could make the conclusions more difficult to clearly define. The objections raised by Parties at successive COPs have largely related to the agricultural sector with particular concerns around the potential impacts upon the farming sector. For this reason the agricultural sector has been made the key focus of the case studies to look at import of pesticides (both named substances under Annex III and alternatives), crop production, and potential issues with the efficacy of pesticides and target pests.

Indirect impacts upon chemical manufacturers and distributors (including of SHPFs) who supply goods into a given ratified nation have been ruled outside the scope of the current study. This has been on the basis that the Rotterdam Convention only affects transboundary movement of named chemicals, and on that basis the manufacturers and distributors of these named goods would have both domestic and international trade. This would make it more difficult to assess the impacts of adding chemicals to Annex III based on the data available. Therefore it was agreed to keep the focus of the case study on the direct impacts on the agricultural sector.

[6] Note that this substitution may be indicated by factors such as increased trade, inflating prices and an increased use of alternatives. Hence, a sub-hypothesis could be formulated that listing leads to increased trade, inflating prices and an increased use of alternatives.

Assessment of data needs for case study development

Data needs matrix

Following the development of hypotheses and scope boundaries a 'data needs' matrix was developed to fully document what information was needed to help develop the case studies. An example of this matrix is provided in Figure 2.1. The matrix was designed to gather both quantitative information which could be used in the economic assessment but also qualitative information to help provide case studies with a full understanding and complete picture of what is happening on a regional/national basis.

Table 2.1 Data needs matrix

Pesticide	Reason for listing Note 1	Type of chemical Note 2	Production – number and volume Note 3	Production – distribution Note 4	Use – application and volume Note 5	Use – distribution Note 6	Market players Note 7	Comments/ sources of data
Tributyl tin compounds								
Alachlor								
Aldicarb								
Endosulfan								
Azinphos-methyl								
Methamidophos								

Note 1: HH – human health; Env – environment; Note 2: H- herbicide; I – insecticide; F – fungicide; Note 3 – number of manufacturing countries and market size; Note 4 – geographical distribution of manufacturing: OECD; DC – developing countries; OECD+DC; Note 5: information on application of the pesticide (types of crops) and quantities; Note 6 - geographical distribution of use: OECD; DC – developing countries; OECD+DC; Note 7 – information on the market players – number (low/medium/high), size (small, medium, large, multinational) and type (research or generic) of manufacturing companies.

Sources of data used

The data needs matrix was used to help detail the nature of the information needed, as well as to help define from where information could be drawn. This literature gathering phase was also supported by data provided by the FAO based on their own survey of ratified Parties and data on pesticide usage. The following key sources have been screened for information, with details on general findings regarding their relevance also included in the bullet points below:

- Decision guidance documents for substances listed in Annex III of the Convention provide a range of mostly qualitative information, such as trade names, formulation types, main uses, manufacturers. However, these are available only for when the respective chemical is first listed (i.e. no time series data) and may not be comprehensive.
- Websites, statistic portals and publications from relevant international organisations (FAOstat, UN trade data, Organisation for Economic Cooperation and Development (OECD), World Bank, World Health Organization (WHO), Eurostat, CEPALSTAT, AFRISTAT) were searched. These sources provide quantitative time series data, particularly trade data, but generally the product classifications used are on higher levels, i.e. data is often available for an aggregation of several chemicals including a substance on the draft list. For instance, publicly available FAOstat pesticide trade data covers only some substances on the draft list and these are mostly aggregated with other substances e.g. Monocrotophos aggregated with fluoroacetamide and phosphamidon, captafol aggregated with Methamidophos, or Parathion and Parathion-methyl.
- Websites, statistic portals and publications from government bodies of selected countries were searched. The selection of countries was based on expected likeliness of data availability, coverage of countries from various world regions including regions hosting countries opposed to

the listing of certain proposed chemicals in Annex III of the Rotterdam Convention (such as Sudan, Guatemala and India) and language (expected likeliness of availability of information in a language spoken by the project team, i.e. English, French or Spanish). Data was discovered for USA, UK and India (including tonnages of goods imported and price per tonne). Further countries searched without result were Egypt, Sudan, South Africa, China, Mexico, Honduras and Guatemala.

- Keyword searches were conducted on Google (in English, French and Spanish), using a wide range of text strings addressing all data categories specified in the data needs matrix, in general and in combination with specific countries or regions. These searches revealed patchy additional information (e.g. application rates, and target crops and pests), typically from NGO reports, trade associations and other publications.
- Electronic sources like Pesticides Action Network (PAN) and some governmental institutions (e.g. Environmental Protection Agency (EPA) (USA), National Registration Authority for Agricultural and Veterinary Chemicals (Australia), Institut du Sahel (INSAH), Central Insecticides Board and Registration Committee of India, Directorate of Plant protection, Quarantine & Storage of India or Pest Management Regulatory Agency of Canada) were considered. Furthermore, the International Programme of Chemical Safety (Inchem) website was used. This website contains trade names of some alternative substances. Central Insecticides Board and Registration Committee of India contains a list of major uses of pesticides, which contained some of the identified alternative substances. The Directorate of Plant Protection, Quarantine & Storage of India contained data on demand, production, consumption, imports and prices of some alternative substances. National Registration Authority for Agricultural and Veterinary Chemicals (Australia) and Pest Management Regulatory Agency of Canada contain alternatives, pests, crops and trade names. The EPA documents contain crops and pests where some alternatives are used. The INSAH website contains information about alternatives used as well as trade names.
- The ECHA database on the PIC procedure (export notifications) was also consulted. Institutions such as the European Commission have supported the study with information on export quantities in tonnes of chemicals subject to the PIC procedure as well as with information on the use of chrysotile asbestos by developing countries such Vietnam, South Africa and Brazil.
- Desk research conducted allowed to identify producers of the substances. Producers of alternatives, NGOs, and FAO regional offices were contacted directly (in written format and via phone) in order to collect information on markets, close data gaps, and obtain actual information on production countries, user countries, annual production, prices and application (tonnes/ha). The information received from companies contains user regions (African countries) for various alternatives identified as well as annual production, prices and application (tonnes/ha) for products in India. Furthermore, the FAO supported the study with data on import quantities in tonnes and values (US$) of some developing countries for the period 2008-2015.
- Additionally, data on prices for some alternatives was identified for the USA and India from the United States Department of Agriculture National Agricultural Service (USDA NASS) and the Directorate of Plant Protection Quarantine & Storage of India.

Scoping analysis for identification of target chemicals

During the early discussion with the European Commission, concerns were raised regarding the availability of data needed to populate the data needs matrix for the development of case studies. It was agreed that data availability was critical to the success of the whole study. On that basis a two-step approach was adopted. Firstly a review of the named chemicals in Annex III was conducted to develop a preliminary set of 14 chemical substances which had been added to the Rotterdam Convention at different points in time. These substances are presented in Table 2.1. Subsequently a data gathering and literature search was conducted to gather information necessary to populate the data needs matrix.

The second step was then to review the completed data matrix to assess which substances had the most complete data-sets needed for development of case studies. This sub-set was then taken forward to full case study development while the remaining substances were filtered out from the process. Those named chemicals shown in bold within Table 2.1 had the most complete sets of data, and were therefore selected for the next stage in the process. A summary of the key data identified for each substance is given in Section 3.1.

Table 2.2 Scoping set of chemicals for preliminary assessment

Chemicals listed in Annex III before entry into force of the Rotterdam Convention	Chemicals listed in Annex III after entry into force of the Rotterdam Convention	Chemicals already considered by COP but no decision taken so far	Chemicals recommended by CRC for listing in Annex III
Monocrotophos	Azinphos-methyl	Trichlorfon	Carbofuran
Parathion	Alachlor	Fenthion	Carbosulfan
	Aldicarb	Paraquat	
	Methamidophos	Chrysotile asbestos	
	Tributyltin (TBT)		
	Endosulfan		

*Chemicals in bold selected for full case study development.

2.2 Development of case studies

For each of the four selected case study substances, six sections have been developed, each covering one of the six hypotheses defined previously. This structure is outlined in more detail in the case study chapter, in Section 3.2.

Each section presents the available information which has been identified during the assessment of data needs. Data is generally presented per country and where possible aggregated to analyse international developments. All hypotheses are formulated to reflect changes induced by listing in Annex III of the Rotterdam Convention, so where data is available before and after listing, it is analysed with regards to any significant changes in trends around the time of listing in the direction predicted by the respective hypothesis. This means that it is not just levels of imports, prices etc. that are compared, but growth rates are also analysed to reveal changes in trends over time. Where data is available only before or only after listing, it does not allow to compare trends before and after listing, but it is still presented and analysed where useful. For instance, if a substance is already no longer used in a country before listing, then listing cannot affect its subsequent use. The trend after listing may also still suggest a rejection of the hypothesis if it is contrary to the trend predicted by the hypothesis (e.g. increasing trade volume after listing).

Data has been analysed and/or visualised in several ways:

- Average trade prices have been calculated from trade volume and value;
- Nominal prices have been converted to real prices to account for the impact of inflation;
- Growth rates and compound annual growth rates (CAGR)[7] for periods before and after listing have been calculated to reveal the change of trends (i.e. decreasing or increasing growth rates) rather than just levels;
- Indices have been calculated which normalise the values to the value at the year of listing[8] to focus on the development relative to the year of listing rather than absolute levels; and

[7] The compound annual growth rate (CAGR) is the mean annual growth rate over a specified period of time longer than one year. In other words, it reflects how much a metric has changed on average each year. It thus allows firstly an assessment of the overall change of the metric over a longer period of time regardless of the fluctuation inbetween and secondly to compare the rate of change between different periods of different lengths of time. It is used here to compare the change of key metrics such as import quantities, use quantities and prices between different periods before and after listing of the substance, in order to assess whether there appears to be a break in trend of the evolution of the metric around the time of listing.

[8] The indexes are calculated as follows: [Index value year x] = 100 * [Value year x] / [value year of listing].

- Data has been plotted to visualise trends.

Where further sources have been used to manipulate the data, it has been stated in the analysis.

As there can be a large number of alternatives to a substance, in some cases the detail of analysis in the analysis of substances is lower than the full analysis for the case study substances itself as stated above.

2.3 Uncertainty and limitations

Data gaps and limitations

Manufacturing data (names, countries, numbers and capacity of manufacturers, production data) consists mainly of information for single points in time. Quantitative data such as capacity and production volume (or value) is generally rare. Capacity and production data is available for India from the Pesticides Manufacturers & Formulators Association of India (PMFAOI) for 1999-2003, but it is restricted only to that time frame, which often does not overlap with the listing of the respective chemical in Annex III of the Convention. It is available for the following substances (date of listing in brackets where applicable): Monocrotophos (draft in 2002, final in 2004), Parathion (2004), Endosulfan (2011), Fenthion, Paraquat.

Information on certain user countries is able to be extracted from WHO or NGO publications. For example, quantities used by country and crop have been found for the USA and the UK for a range of crops and years, and it can be expected that such data could be found for other developed countries. However, use data has generally not been identified for developing countries (with the exception of India 2001-2006 from a WHO report) and thus geographic coverage across all relevant regions cannot be achieved with the available data.

The only price data set identified comes from the US Department of Agriculture and covers selected years and substances. Trade data is the main source for information on prices for other countries and substances, but considerable gaps remain. Comtrade (UN) provides global trade data for tributyltin (TBT) since 2012. The other chemicals from the draft list, as well as TBT before 2012, are covered only in aggregation with other substances. India trade data is available for 2006-2015 for Parathion and Parathion methyl, Endosulfan and Fenthion. As mentioned above, FAOstat pesticide trade data is available but covers only some substances on the draft list and these are mostly aggregated with other substances.

In order to improve the FAOstat pesticide trade data needed in support of this project, FAO’s Secretariat of the Rotterdam Convention sent 116 questionnaires to national statistical organisations. At the time of writing, 34 responses have been received including Excel files, extracts from publications as well as trade files from customs offices, with nine countries providing aggregated data under 3808 HS code. More responses are expected in the near future. As only provisional information is available at the time of writing, this data has not been analysed in detail yet for inclusion in this report.

Export data (quantities in tonnes) for EU countries from the ECHA database on the PIC procedure includes information on most relevant substances, but in no case overlaps with the year of listing. I.e. for the relevant substances there is information only related to the period before the listing of the substances, with one exception, a single data point of marginally small values for Parathion after listing. Additionally, a change in exports from Europe alone is not sufficient to conclude that import of the substance in question has changed similarly in the destination countries, as imports from other countries may compensate for any changes in imports from Europe. This information is thus not sufficient to assess any changes in trade after the listing of any of the substances.

Regarding data on alternatives, publicly available data on import and export of alternatives was highly limited. Even after intensive research in publicly available sources [e.g. Comtrade, FAOstat, UN trade data, Organisation for Economic Cooperation and Development (OECD), World Bank, World Health Organization (WHO), Eurostat, CEPALSTAT, AFRISTAT] the only data that could be identified and used for this report are the following:

1) Data provided by the European Commission on export notifications for all years before and after listing of the substance as available.

2) Data on import to developing countries and economies in transition as provided by FAO.

3) Export and import data from India for some alternatives.

It is also important to highlight the differences in how regulation is applied. Within the European Union the management of pesticides is done on a ‘per substance’ basis. This includes an assessment of the active pesticide ingredient to grant permission for use within pesticide products. A ban on a pesticidal active substance or failure to grant a licence for use means that substance cannot be used within the European Union. Conversely the USA regulates substances on a ‘per application’ basis. This means that if a given pesticidal application is identified as being of concern the specific application can be restricted or banned, but the substance can continue to be manufactured and used for other applications. This difference, while subtle, may have consequences for cost impacts, particularly on manufacturers who either have to cease production entirely, or are able to continue production but for a more limited set of applications.

Note that in combination with use data, trade data could in theory also be used to calculate production, or in combination with production data to calculate usage. Furthermore, higher level data aggregated for various substances could be used in specific cases as proxy for substance-specific information.

In conclusion, data availability varies widely across substances on the draft list for analysis, but there is generally a lack of comprehensive time series data covering relevant years and countries. Particular gaps exist for developing countries. For instance, for Africa and Central America no quantitative data at all has been identified with the exception of high level aggregates. India is the only country for which data on production, trade and use (at least of specific substances in specific years) has been identified. A summary of data gaps is provided in Table 2.1. Considering that for no substance and country comprehensive data on all required categories (production, use and prices) appears to be available, a full cost-benefit using a cost model is unlikely to be possible or suitable.

Table 2.3 Overview of data gaps

Information category	Data gaps
Trade names and mixtures	Well covered.
Production countries and volumes	Manufacturing capacity and production volume not available on individual substance level and/or as time series over a sufficient period of time for most countries and substances. Names and number and countries available only for specific points in time.
Names, number and capacity of manufacturers	
Dose and application, crop, pest	Well covered, though dose is often not available for every crop and only available for some countries.
Quantities used, user countries	Quantities used by country and crop not available for developing countries except India, i.e. not available for Africa or Latin America.
Prices and distribution market players	Price data: pending further data to be received from FAO.

Screening of the preliminary results from the survey conducted by FAO’s Secretariat of the Rotterdam Convention suggests that provision of the finalised results will improve the data situation significantly. The preliminary data covers years ranging from 2008 to 2015 and includes imports in terms of weight and value for all substances of the draft list of chemicals for analysis except Endosulfan, which will allow for the calculation of average import prices and the analysis of import levels over time. Regions covered include Africa, Latin America, South and South-Eastern Asia, Eastern and South-Eastern Europe and the Middle East. The data is comprehensive but some gaps are likely to remain, i.e. the data does not cover every substance for every country and every year mentioned above. Therefore, the conclusion that a full cost-benefit analysis using a cost model is unlikely to be possible or suitable remains valid.

Regarding chemical alternatives and non-chemical alternatives, the main data gaps were about prices and producer countries. Furthermore, some alternatives were known to be used only in developed countries.

For Task 3, analysis on prices of alternatives could not be performed due to the non-availability of this data. Data about prices was only available for some alternatives for India and the USA. Public data sources were consulted but all of them contained aggregated data about pesticides and most of the cases prices were not available. In spite of the fact that import values for developing countries for period 2008-2015 were available, prices could not be calculated from those data due to the value of imports normally including the price of freight, transport and other variables. Another data gap for the alternative substances was producer countries for each individual alternative. Due to this, this topic has been addressed generally in Section 3 through market shares of main pesticide global producers.

For Task 4, data on prices for alternatives was only available for some substances for some country markets (e.g. chrysotile asbestos in South Africa). Other, however still limited, information was available on alternatives more generally. For example, regarding the use of Paraquat in countries including Guatemala, a survey of 11 palm oil growers with a combined total of 364,834 ha found that six of the growers either did not use Paraquat or were ceasing to do so, citing instead other herbicides, mowing, legume cover crops, or manual weeding as alternative methods of weed management. In the case of India, other research has found that cover plants are used to supress weed growth on cowpeas as a non-chemical alternative.

Details of the uncertainty, limitations and understanding case studies

As stated above, due to the complexity of a full socio-economic impact assessment, the case studies had to be limited in scope and adapted to the available data. This results in an important limitation as outlined below.

The applied approach tests six hypotheses, each predicting a change induced by listing a substance in Annex III to the Rotterdam Convention. The validity of each hypothesis is tested on the basis of whether the predicted change can be observed after listing, using a simple set of metrics defined by the data available (e.g. import prices). However, due to the complex interrelations of global chemicals markets, there is a wide range of factors that may influence each of the metrics used (e.g. import prices increase at the time of listing because of a coinciding demand increase on the global market due to an acute pest problem). Hence, there is a significant uncertainty regarding whether any observed changes are in fact caused by listing, and whether changes that could have been caused by listing are not observed because they are masked by other factors.

3. Case studies

3.1 Overview of the analysis of data gathered

This chapter presents the core analysis of impacts of the listing of a pesticide in Annex III to the Convention. First, Section 3.2 provides a preliminary assessment for all substances from the scoping set of chemicals. It outlines the data that has been identified for all substances from the scoping set and presents a focused preliminary data analysis for all substances. Based on the data identified and the preliminary analysis, a subset of four substances is selected for more detailed analysis in case studies. Section 3.2 outlines the structure of these case studies, which are presented in the remaining sections of this chapter.

3.2 Overview of the analysis of data gathered

Data identified

FAO trade data[9] is by far the most comprehensive dataset available. It includes all substances from the scoping set of chemicals for preliminary assessment except Endosulfan. It covers import volume and value from 2008 to 2015 for a wide range of countries.

The FAO dataset also contains information on 13 alternative substances including Abamectin, Chlorpyrifos, chlothianidin, Cypermethrin, Diflubenzuron, Dimethoate, ethoprophos[10], Indoxacarb, Lambda-Cyhalothrin, Malathion, Metolachlor, Spinosad and Thiamethoxam.

Other noteworthy time series data are available for selected countries only. These include usage data from FERA, 2016 (GB/UK), usage and price data from USDA, 2016 (USA), usage data for Monocrotophos in India from WHO, 2009, trade data for India from the Open Government Data Platform (India, 2016a) as well as capacity and production data for India from the Pesticides and Formulators Association of India (PMFAI, 2016). Except for the WHO data, each dataset covers several substances.

An overview of which datasets were available for which country and how the data relates to the time of listing of the respective substance is provided in the table below. A more detailed list of data available for each substance is provided in Appendix A.

Table 3.1 Overview of data identified by substance and data category

Substance	Production	Manufacturers	UK usage (FERA)	US usage (USDA)	US Price (USDA)	FAO trade	India trade	EU Export	Alternatives	other
Monocrotophos		b			b, a	a			EU export quantities before and after listing, import data after listing, India and US prices	India usage (b, a)

[9] This data (import value and quantity in terms of weight of selected substances by country, 2008-2015) was directly submitted by FAO to the Commission for the purpose of discussions in the upcoming Intersessional working group on process for listing of chemicals.
[10] Data for ethoprophos was not considered in this study because this substance was excluded as an alternative based on the criteria of FAO/WHO Joint Meeting on Pesticide Management (JMPM) working group on highly hazardous pesticides (HHP)

Substance	Production	Manufacturers	UK usage (FERA)	US usage (USDA)	US Price (USDA)	FAO trade	India trade	EU Export	Alternatives	other
Parathion		b		b, a		a		a (1 data point)	EU export quantities after listing, import data after listing, India and US prices	
Alachlor		b		b, a	b, a	b, a		b	No EU export quantities, import data before and after listing	Several EU countries usage (b)
Aldicarb		b	b	b		b, a		b	EU export quantities and import data before and after listing	
Azinphos Methyl		b		b	b, a	b, a		b	EU export quantities before and the year of listing, import data before and after listing	
Methamidophos		b		b		b		b	EU export quantities before listing, import data before listing and the year of listing	
Tributylin compounds		b				a			EU export quantities, Trade, India prices	
Endosulfan	b (India)	b	b, a	b, a			b, a	b	EU export quantities and import data before and after listing	China usage (b)
Trichlorfon		x	x			x		x	EU export quantities, import data), India and US prices	
Fenthion	x (India)	x				x	x	x	No EU export quantities, import data,	

Substance	Production	Manufacturers	UK usage (FERA)	US usage (USDA)	US Price (USDA)	FAO trade	India trade	EU Export	Alternatives	other
									India and US prices	
Paraquat	x (India)	x	x	x	x	x		x	No EU export quantities, US prices	
Chrysotile asbestos	x (1999)									Usage by world region (2003)
Carbofuran									No EU export quantities Import data, , India prices	
Carbosulfan									No EU export quantities, import data. India and US prices	

Legend:

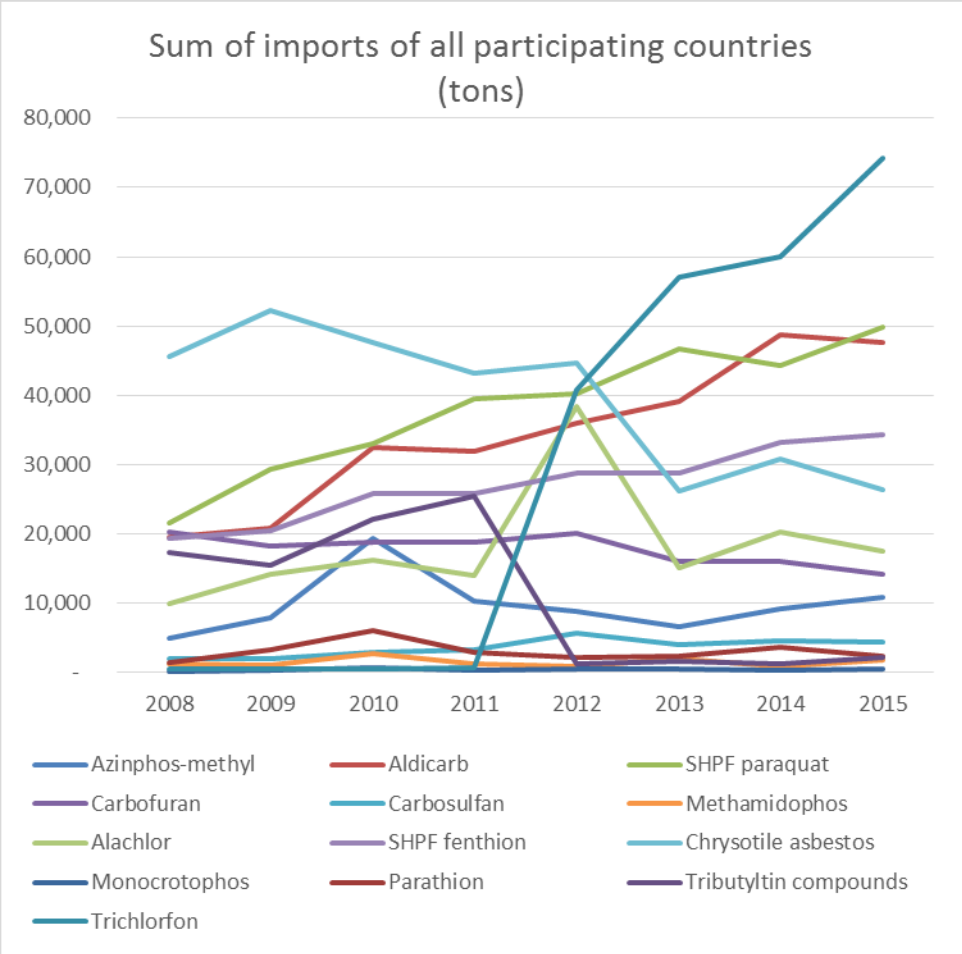
a – data available after listing
b – data available before listing
x – data generally available (substance not listed)
Data available for multiple years and countries, if not stated otherwise

Overview of evidence for all substances based on FAO data

The following provides brief overview analysis of the FAO trade data as the most comprehensive dataset available focusing on the evidence it may provide regarding the listing of substances in Annex III to the Rotterdam Convention.

The figure below shows the sum of imports of all countries providing data in the FAO survey, for all 12 substances for which data was provided. It reveals that imports of most substances increase from 2008 to 2015. The sharpest increase is that of Trichlorfon imports from very small amounts until 2011 to the most imported of the analysed substances from 2013 on. Only three substances were imported in lower quantities in 2015 than in 2008 in sum for all countries providing data: Carbofuran imports decreased 30%, Chrysotile Asbestos 42% and TBT compounds 88%.

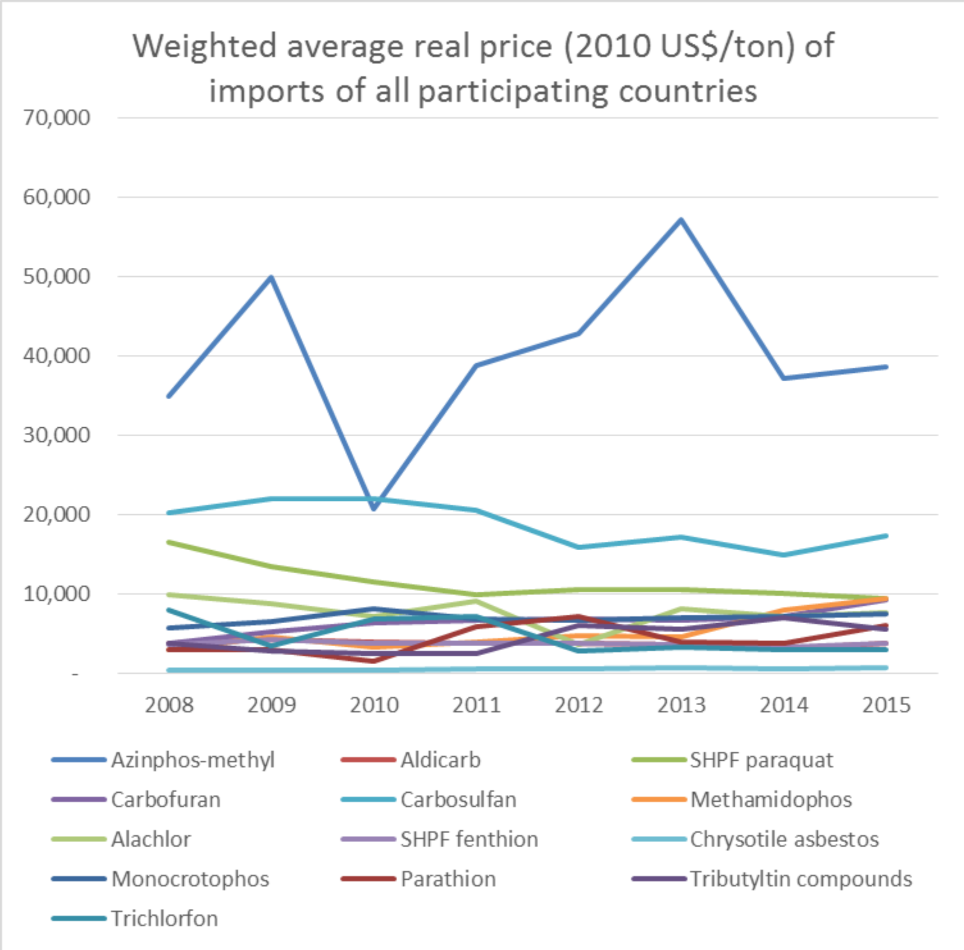
Figure 3-1 Sum of imports of substances on draft list for analysis, of all participating countries (tons), 2008-2015



Source: Amec Foster Wheeler 2016 based on data from FAO 2016

The average real price (in 2010 prices) of the sum of imports of all countries providing data in the FAO survey is shown in the figure below for all 12 substances for which data was provided. Notably, Azinphos-methyl exhibits much higher prices than all other substances, except for a drop in 2010, when the price falls below that of Carbosulfan, the second most expensive substance in all other years. For all substances except Azinphos-methyl, Carbosulfan and SHPF of Paraquat, average real prices are below 10,000 US$ per ton throughout the whole period. Average real prices increase overall for most substances from 2008 to 2015. The increases range between +95 US$/t or +3% (Aldicarb) and +6,361 US$/t or +210% (Methamidophos). Average real prices decrease for SHPF of Paraquat (-7,224 US$/t, -57%), Carbosulfan (-2,865 US$/t, -86%), Alachlor (-2,251 US$/t, -77%) and Trichlorfon (-4,892 US$/t, -38%).

Figure 3-2 Weighted average real price (2010 US$/ton) of imports of substances on draft list for analysis, of all participating countries, 2008-2015

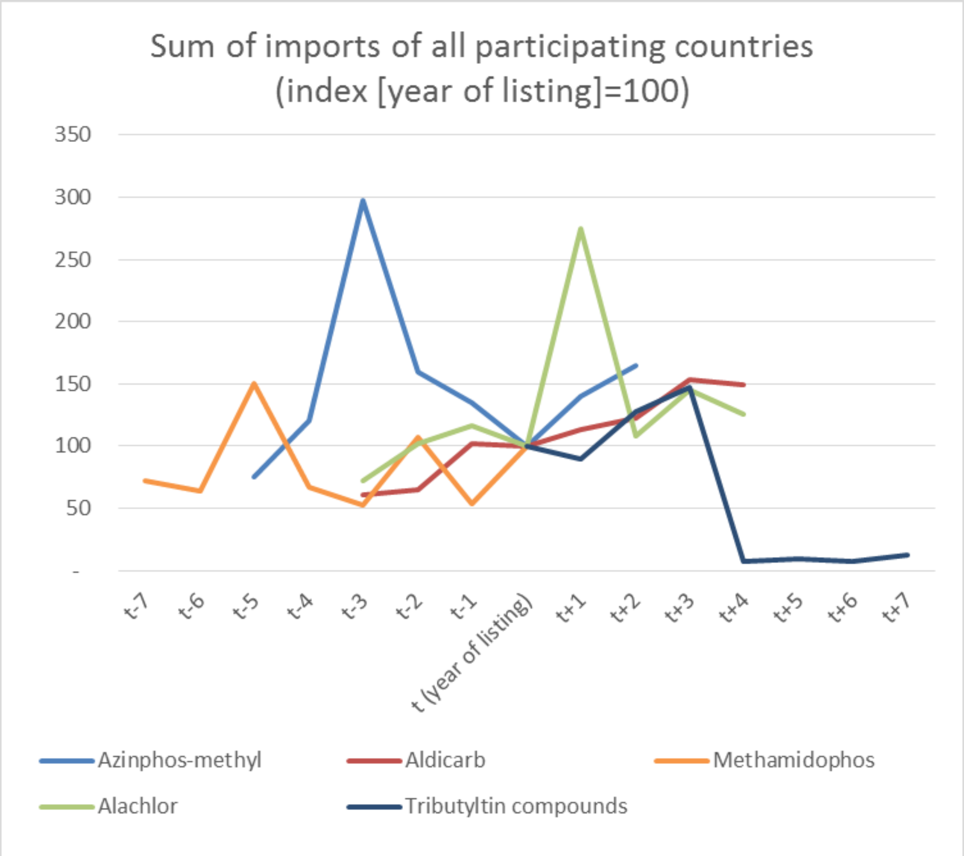


Source: Amec Foster Wheeler 2016 based on data from FAO 2016

The figures below present data on both the quantity (in terms of the weight) and average real price of the substances listed in Annex III to the Rotterdam Convention during the years for which FAO trade data is available (2008-2015).[11] Numbers for each substance reflect the sum of all countries providing data for the respective substance, and are indexed with the value for the year of listing being set to 100. As substances have been listed in different years, the year of listing is labelled as year "t" in the horizontal axis. The years before and after are labelled as the difference from the year t, i.e. "t-7" stands for 7 years before listing.

[11] The two substances from the draft list of substances for analysis that were listed on Annex III before 2008 (Monocrotophos and Parathion) are not included here as the following approach using an index adjusted to the value of the year of listing is not suitable if no value for the year of listing is available. Furthermore these substances will be analysed in more detail in case studies below.

Figure 3-3 Sum of imports of substances listed in Annex III to the Rotterdam Convention between 2008 and 2015, of all participating countries, indexed (year of listing [t] = 100)



Source: Amec Foster Wheeler 2016 based on data from FAO 2016

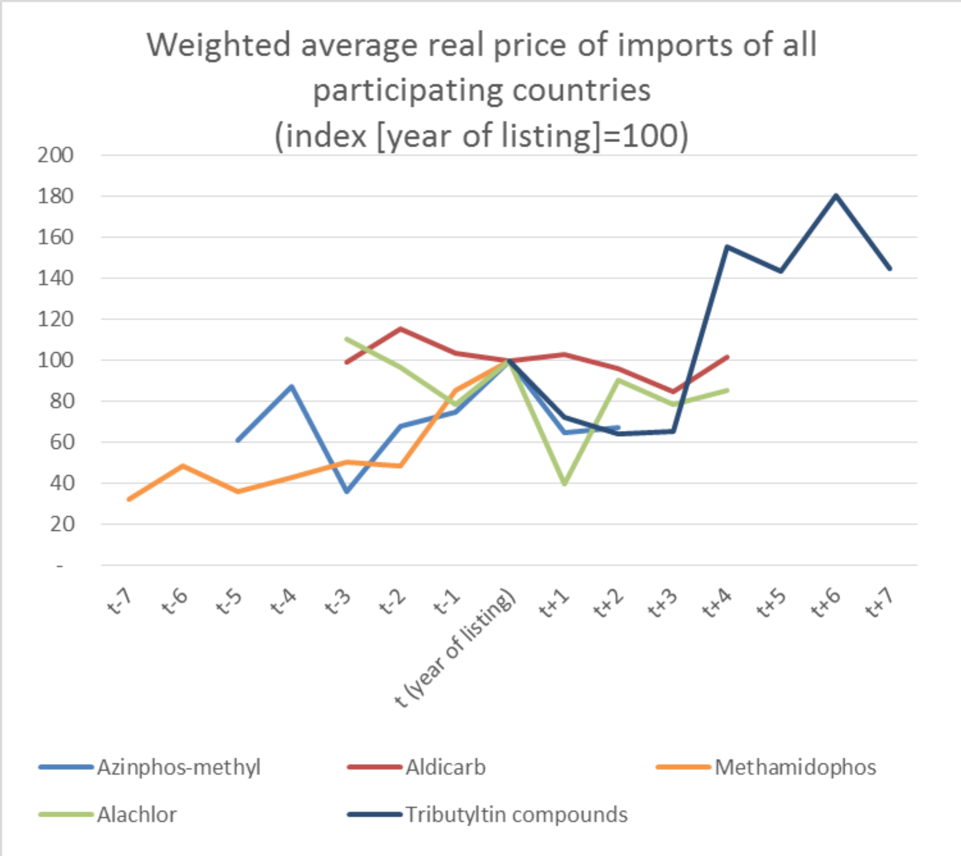
The available information will be analysed regarding whether it provides any evidence supporting or contradicting the following hypothesis:

- Listing reduces traded volume.
- Listing inflates prices.

Regarding quantities, the figure below reveals that imports of all substances listed between 2008 and 2015 have increased between the year of listing and 2015, with the exception of Methamidophos. This does not seem to provide any evidence supporting the hypothesis that listing on Annex III reduces traded volume for these substances. As for Methamidophos, the increasing imports in the two years after listing before a sharp drop suggest that either there is no short-term influence on traded volume but a strong long-term impact, or that other factors than the Rotterdam Convention are the main reason for the evolution of imports of Methamidophos.

Figure 3.4 shows that prices for all substances fell in the short term (2-3 years) after listing, which does not seem to support the hypothesis that listing increases prices. For Aldicarb and TBT compounds, prices start to increase after 3 years after listing. This suggests similarly to the analysis of quantities traded above that either there is no short-term impact of listing but a long-term impact, or that other factors than the Rotterdam Convention are the main reason for the evolution of prices of the substances at hand.

Figure 3-4 Weighted average real price of imports of substances listed in Annex III to the Rotterdam Convention between 2008 and 2015, of all participating countries, indexed (year of listing [t] = 100)



Source: Amec Foster Wheeler 2016 based on data from FAO 2016

Selection of substances taken forward for case study analysis

The ideal data requirements as set out previously in the data templates have not been met for any substance or country, so data availability is generally poor. However, a range of substances appear to demonstrate relatively better data availability in terms of production, use, prices and other data covering relevant years and geographical coverage. As FAO trade data is by far the most comprehensive dataset available, the extent of analysis of the impacts of the listing of a substance depends largely on the time of listing and whether FAO data cover sufficient time both before and after the listing to carry out the analysis. In particular, Alachlor and Aldicarb have been listed in 2011 and thus well within the range of FAO trade data. Furthermore there is US price dataset and some usage data available for these substances. For Parathion and Monocrotophos, FAO trade data is available only after listing, but for these substances more useful additional information has been found (e.g. US price data, some usage data) than for other substances for which data after listing is available.

The following substances are taken forward for further analysis in case studies:

- Alachlor
- Aldicarb
- Monocrotophos
- Parathion

3.3 Structure of the case studies

The case studies have been structured in a fashion to assess the available data gathered against the five hypothesis set out in the methodology section (see section 2.1). This approach is intended to test whether the objections raised by Parties at successive COPs can be validated. Namely that the addition of a chemical to Annex III of the Convention causes impacts on the farming community through increases in price of the named goods, decreases in availability of the named goods due to delays in gaining access, which can be evidenced by a decline in trade and move to using alternatives.

Each case study is therefore structured as shown in Table 3.2 with a thorough review and analysis of the data. Each sub-section concludes with a comment regarding whether the hypothesis has been proved (a positive result) suggesting that the objections raised by Parties at the COP have been upheld, i.e. that significant impacts have been witnessed. As the data analysed is on a regional and national basis, a complex set of factors can be expected at local level that may influence the data. Therefore expert judgement has been used to assess on a nation by nation basis whether the hypothesis has been met or otherwise.

Table 3.2 Structure of case studies

Section title	Information contained	Hypothesis	Hypothesis evidenced by
Overview	Background information on each chemical	-	-
Production	Number of producers, production rates, trends	Listing leads to a decrease in production and/or the number of manufacturers of the substance.	Decrease in the number of producers after listing. Total production rates decrease after listing.
Trade	Data on import of named chemical	Listing reduces traded volume.	Import rates on a national/regional basis decrease after listing
Prices	Data on prices of named chemical	Listing inflates prices	Increase in price on a regional/national basis after listing
Uses	Data on usage volumes	Listing leads to a reduction in use volumes of the substance	Usage rates decrease on a regional/national basis after listing
Alternatives	Data on the alternative chemicals, their application and details on price and efficacy	Listing leads to substitution of the substance with alternatives.	Increases in the use of alternatives – particularly where price is greater/efficacy is lower
Conclusion	Summary of conclusion against hypothesis	-	-

3.4 Case study 1: Alachlor (CAS No. 15972-60-8)

Overview

Alachlor is an herbicide for the selective control of broadleaf weeds and grasses, which affect a number of crops.

The Rotterdam Convention DGD document (2009) suggests that for European nation's usage of Alachlor has been to protect maize, sweetcorn, soybean, sunflowers, and cotton. Canada identified uses with soybean and corn, while the USDA (2016) identified key uses for corn, with other uses including soybean, and sorghum. No information on application uses of Alachlor outside of Europe and North America has been identified.

Alachlor is produced, traded and used in various countries globally. Countries for which evidence of production or use of Alachlor has been found are listed in the table below. Note that this list is likely not to be exhaustive.

Table 3.3 Indicative list of countries producing and using Alachlor currently or in the past

Production [a]	Use		
Brazil	Belarus [b]	Myanmar [b]	Malaysia [b]
Israel	Ecuador [b]	Russian Fed. [b]	Benin [b]
France	Georgia [b]	Serbia [b]	USA [c]
China	Macedonia [b]	Thailand [b]	European Community [d]
Greece	Malawi [b]	Turkey [b]	Canada [d]
India	Mexico [b]	Ukraine [b]	India [e]
	Mozambique [b]	Philippines [b]	

Sources:
[a)] Based on the list of basic manufacturers form the Decision Guidance Document for Alachlor. Only countries where the main manufacturing locations of the respective manufacturer can be clearly attributed to a specific country have been included.
[b)] Based on countries reporting imports of Alachlor to FAO and the assumption that at least part of the imports are used domestically and not re-exported.
[c)] Based on the US Department of Agriculture National Agricultural Statistics Service (https://www.nass.usda.gov/Quick_Stats/).
[d)] Based on the Decision Guidance Document for Alachlor.
[e)] Based on the Pesticides Manufacturers & Formulators Association of India (http://www.pmfai.org/images/183/Pesticides%20registered%20for%20use.pdf).

Trade names and mixtures: Alanex, Bronco, Cannon, Crop Star, Lasso, Lariat, Partner, Reneur, Traton, CP-51144, Alanex, Anachlor, Alanox, Chimichlor, Lasagrin, Lasso, Lazo, metachlor, Pilarzo, Pillarzo, Microtech

Main purpose and functionality: It is absorbed from the soil primarily by the shoots of emerging seedlings. Following absorption it is translocated throughout the plant. The mode of action appears to be inhibition of protein synthesis in susceptible plants. Working concentrations are quoted as 1.7 – 2.4 kg/hectare of active (Rotterdam Convention, 2009a)

Listing in the Rotterdam Convention: Listed in 2011 after all uses of Alachlor have been completely banned in Canada and the European Community.

Production

According to the Decision Guidance Document citing a source from 2006 there were at least nine manufacturers at that time (Monsanto, Makhteshim-Agan, Phytorus, Shinung Corporation, RPG, Efthymiadis, EMV, Rallis, Cequisa). A more recent publically available source listing manufacturers of Alachlor has not been identified. Production quantities are not available.

Hypothesis: Listing leads to a decrease in production and/or the number of manufacturers of the substance:

- Lack of data post listing means it has not been possible to comment on the outcome of this hypothesis.

Trade

Quantity and value of imports of Alachlor for the years 2008-2015 have been submitted to the FAO by 16 countries from various regions of the world. These are listed in the table below.

Table 3.4 List of countries that reported imports of Alachlor in response to the FAO survey, by region

Africa	Americas	Europe/Western Asia	South-East Asia
Benin	Ecuador	Belarus	Malaysia
Malawi	Mexico	Georgia	Myanmar
Mozambique		Macedonia	Thailand
		Russian Fed.	Philippines
		Serbia	
		Turkey	
		Ukraine	

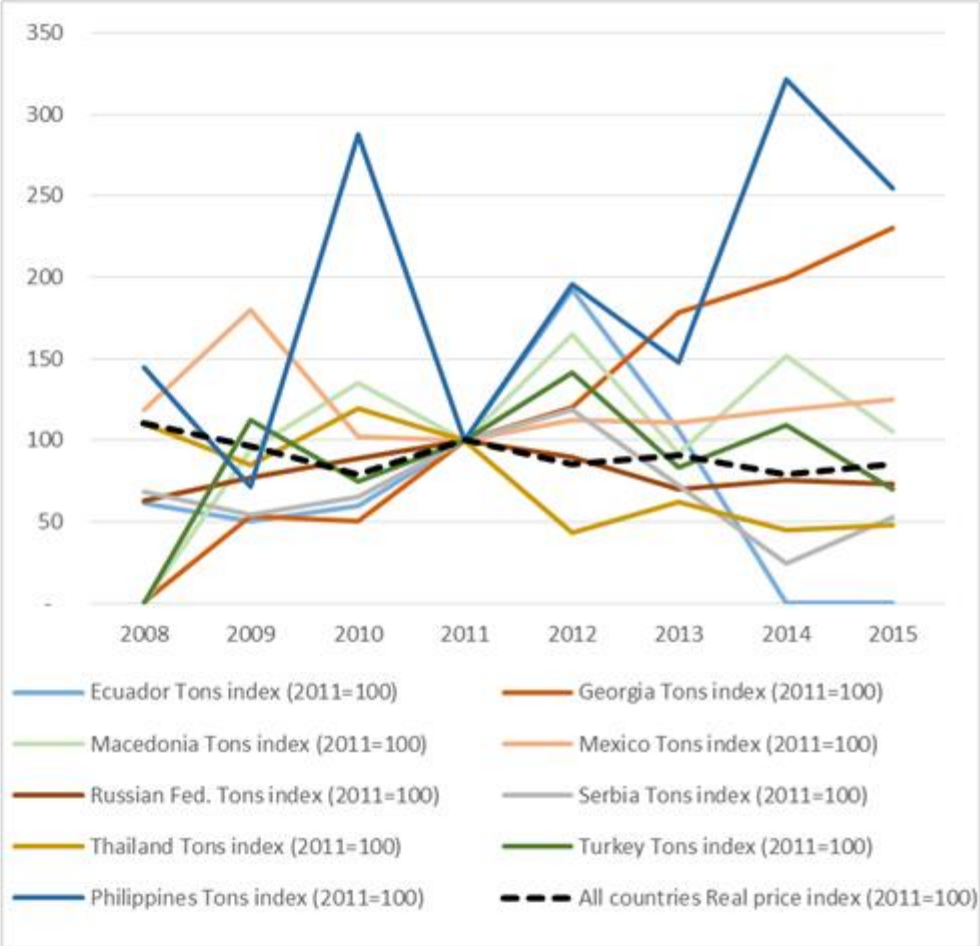
Source: Amec Foster Wheeler 2016 based on data from FAO 2016.

From the countries identified, five countries did not report any imports of Alachlor before its listing, but report imports from 2011 on or later (Benin, Malaysia, Ukraine, Malawi, Belarus). Another country, Mozambique, had only small quantities of imports (<20kg) prior to 2011, before increasing the levels of import after this date. These countries have started importing Alachlor in significant amounts only after listing of the substance on the Rotterdam Convention and being subject to the PIC procedure, thereby suggesting no impact of the listing on the traded volume of the substance.

Myanmar reported imports only in 2011.

The remaining nine countries reported imports both before and after listing of Alachlor. Figure 3.5 shows an index of reported quantities of trade of those countries. The index is adjusted to 100 in 2011 to reveal trends before and after listing. The wide spread of the graphs indicates that the evidence is mixed, with some countries each exhibiting increasing and decreasing imports of Alachlor both before and after listing.

Figure 3-5 Alachlor import quanity by country, indexed (year of listing 2011 = 100)



Source: Amec Foster Wheeler 2016 based on data from FAO 2016.

Alachlor was added to Annex III of the Rotterdam Convention in 2011, with four countries (Russia, Serbia, Thailand, Turkey) displaying decreased imports in the period between 2011 and 2015. For all four countries the compound annual growth rate (CAGR, listed in the table below) was lower from 2011 to 2015 than it was from 2008 to 2011. Hence, in these countries positive growth turned negative or negative growth became more rapid after the date of listing in these countries, which could indicate that listing had a hampering effect on trade. In Serbia and Turkey however, imports have temporarily risen first (in 2012) before falling below 2011 levels in the following years, calling into question whether listing in the Rotterdam Convention is the main influencing factor in the evolution of import quantities. The most pronounced decline is seen in Thailand, where import rates had started to decline shortly prior to listing but fall noticeably after this period, with the 2011 – 2015 annual import rates lower than 2008 – 2011.

Philippines, Macedonia and Mexico exhibit an overall rise in imports between 2011 and 2015 and a higher CAGR during that period compared to 2008 to 2011, which could contradict the hypothesis of listing reducing trade. However, there is a high fluctuation of imports in these countries throughout the years with the peak import quantity before listing in the cases of the Philippines. Georgia exhibits an increase in imports in almost all years, but the CAGR is lower after listing than before, suggesting listing could have had a hampering effect on the growth of imports here. However, the use and thus indirectly imports of pesticides depend on the need to use them (i.e. the risk of infestation with pests) which is subject to high variability amongst years, especially locally. Therefore, conclusions based on only one country have to be interpreted with particular caution. Ecuador exhibits only small imports (9-36 tons) increasing until 2012 and ending in 2014.

Overall, the quantity of imports of all countries that had provided data has increased both before and after listing. The CAGR in the years leading up to the listing (2008-2011) was 11.7% and then declined to 5.9% for the years 2011 to 2015, indicating that overall, the growth rate of Alachlor import in all countries providing data was lower after the listing than before. However, as trade is still increasing this does not significantly support the hypothesis that listing reduces traded volumes of the substances. As shown above, evidence from different countries is mixed, which suggests that either the trends in imports of Alachlor are determined mostly by other factors than the Rotterdam Convention, or local conditions determine whether listing has a significant impact on imports.

Table 3.5 Compound annual growth rate (CAGR) of Alachlor import quantity before and after listing, by country

Country	CAGR 2008-2011	CAGR 2011-2015
Belarus	Imports only after 2011	
Ecuador	17.8%	-100.0% (Imports only until 2013)
Georgia	343.0%	23.2%
Macedonia	Imports only after 2008	1.3%
Malawi	Imports only in 2013	
Mexico	-5.6%	5.8%
Mozambique	No imports in 2011	
Myanmar	Imports only in 2011	
Russian Fed.	16.6%	-7.5%
Serbia	13.6%	-14.9%
Thailand	-3.2%	-16.7%
Turkey	Imports only after 2008	-8.6%
Ukraine	Imports only after 2013	
Philippines	-11.6%	26.3%
Malaysia	Imports only 2011-2013	-100.0% (Imports only until 2013)
Benin	Imports only in 2015	
Sum of all countries	11.7%	5.9%

Source: Amec Foster Wheeler 2016 based on data from FAO 2016.

Hypothesis: Listing reduces traded volume.

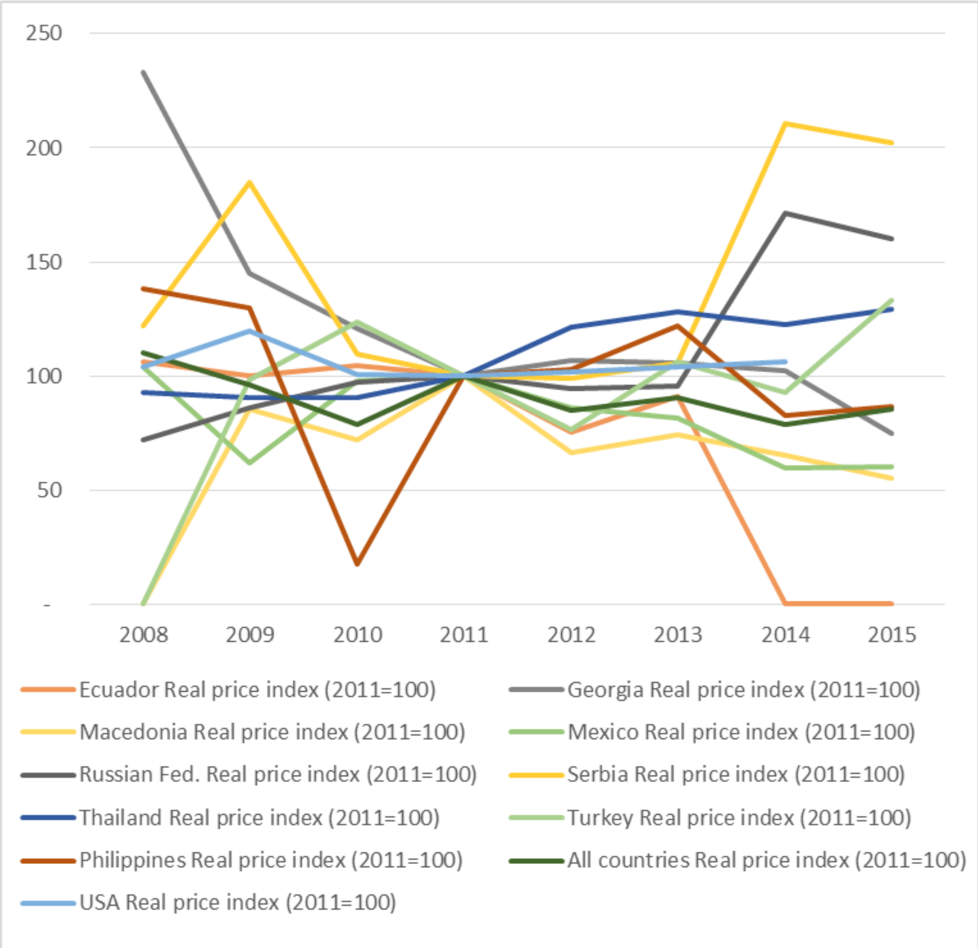
- Some evidence does exist to suggest a decrease in trade after listing of the chemical in Annex III, particularly for Thailand. However, evidence from other countries is mixed and overall there is no significant reduction in trade, but only a reduction in the growth rate of traded volumes.

Prices[12]

Average prices of imports of Alachlor for the years 2008-2015 have been calculated from import quantity and value data submitted to the FAO by 16 countries from various regions of the world. As discussed in the previous section, seven countries (Benin, Malaysia, Ukraine, Malawi, Belarus, Mozambique, Myanmar) reported no or only marginal trade of Alachlor before listing. Price data from these countries is therefore not suitable for analysis of the impact of listing of Alachlor.

The remaining nine countries reported imports both before and after listing of Alachlor. In addition, the United States Department of Agriculture National Agricultural Statistics Service (USDA, 2016) provides yearly data on prices paid for Alachlor[13] in US Dollar per gallon from 2001 to 2014. The figure below shows an index of the calculated average real price of Alachlor imports of those countries from 2008 to 2015. The index is adjusted to 100 in 2011 to reveal trends before and after listing. As for quantities traded, the wide spread of the graphs indicates that the evidence is mixed.

Figure 3-6 Alachlor average real import price by country, indexed (year of listing 2011 = 100)[14]



Source: Amec Foster Wheeler 2016 based on data from FAO 2016 for all countries except USA, which is based on data from USDA, 2016.

In the four countries in which import quantities have fallen between 2011 and 2015 (Russia, Serbia, Thailand, Turkey), real average prices of Alachlor imports increased during the same period. It should be noted that in Thailand and Russia Alachlor real prices have already inflated before the listing , but in both countries the CAGR (listed in table below) was higher from 2011 to 2015 than from 2008 to 2011, hence prices have

[12] All prices have been converted to real prices (2010 USD) using the US Wholesale price index from the World Bank (http://databank.worldbank.org/data/reports.aspx?source=2&series=FP.WPI.TOTL&country=).
[13] Specified as ALACHLOR (LASSO) 4#/GAL EC.
[14] Further information on calculation of pricing is given in the methodology under section 2.2

increased more rapidly after the date of listing. Hence, the data could indicate listing had an inflating effect on Alachlor prices in Russia, Serbia, Thailand and Turkey. In Serbia however, prices have fluctuated strongly both before and after the listing, with peaks in 2009 and 2014, calling into question whether listing in the Rotterdam Convention is the main influencing factor in the evolution of Alachlor real import prices.

In the USA, real prices have fallen slowly before listing, more rapidly from 2001-2011 (CAGR -2.9%) than 2008-2011 (CAGR -1.2%), whereas they have increased after listing (CAGR 2.1% in 2011-2014). Note that the USA is not a Party to the Rotterdam Convention. However, if listing reduced production of Alachlor, this could increase prices on the global market. Hence, the real price increase in the USA could support the hypothesis of increasing prices due to listing, but it is worth noting that the diminishing of the decrease in prices before listing may indicate some larger underlying trend irrespective of the Rotterdam Convention. It is also worth noting that contrary to the data for all other countries, US data reflects prices paid by farmers in the country rather than the value of imports.

Table 3.6 Compound annual growth rate (CAGR) of Alachlor average real import prices before and after listing, by country

Country	CAGR 2008-2011	CAGR 2011-2015
Ecuador	-2.0%	Imports only until 2013
Georgia	-24.6%	-7.0%
Macedonia	Imports only after 2008	-13.8%
Mexico	-1.2%	-11.8%
Russian Fed.	11.6%	12.5%
Serbia	-6.5%	19.3%
Thailand	2.6%	6.6%
Turkey	Imports only after 2008	7.4%
Philippines	-10.2%	-3.6%
Sum of all countries with FAO data	-3.3%	-3.8%
USA	-2.9% (2001-2011); -1.2% (2008-2011); 2.1% (2011-2014)	

Source: Amec Foster Wheeler 2016 based on data from FAO 2016 for all countries except USA, which is based on data from USDA (2016).

For the sum of imports of all countries that had provided data (excluding the USA, which is not a Party to the Convention), the real price has fallen both before and after listing. The CAGR was -3.3% in the years with data available up to listing (2008-2011) and -3.8% for the years 2011 to 2015, indicating that the decline in real prices of Alachlor imports over all countries providing data was slightly stronger after listing than before. This could contradict the hypothesis that listing of the substance leads to an increase in its price, but as for quantities traded, evidence from countries is mixed, once again suggesting that other factors play an important role.

Hypothesis: Listing inflates prices

- Evidence of price increases for those four nations where trade decreased suggests that this hypothesis may have been fulfilled. Overall price index for Alachlor however fell, suggesting that there may be specific issues possibly unrelated to the Rotterdam Convention for the four countries identified which warrant closer examination.

Application/Use

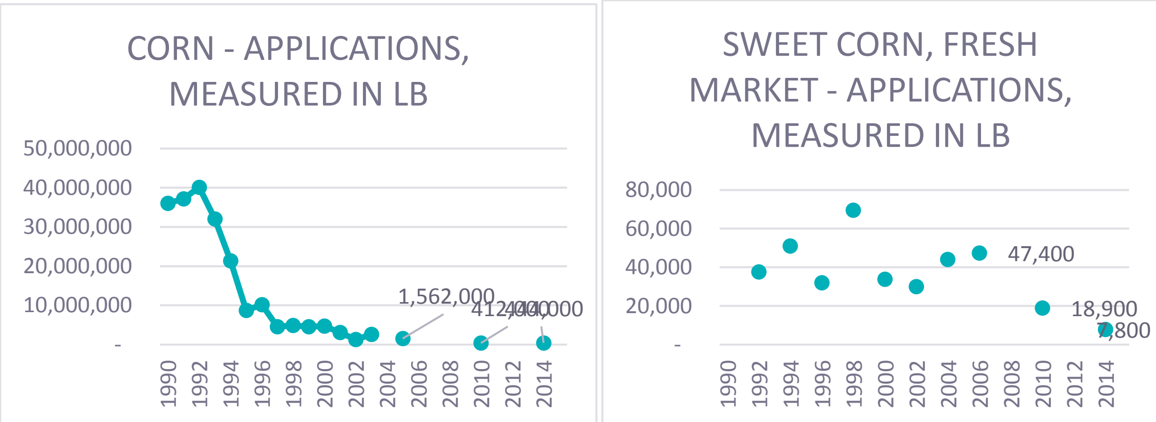
Alachlor has been used in a wide range of countries, as indicated in the Draft Decision Guidance Document for Alachlor (European Community, Canada) and the FAO import data analysed above (e.g. countries in Eastern Europe, Latin America, Sub-Sahara Africa and South-East Asia)[15]. However, no evidence supporting or contradicting cessation of use of Alachlor by countries since its listing in Annex III of the Rotterdam Convention in 2011 has been found.

Data on the quantities of Alachlor applied before and after the year of listing has only been identified for the US. This data from the United States Department of Agriculture National Agricultural Statistics Service (USDA, 2016) includes application of Alachlor to corn and sweet corn until 2014.

The figures below show that application of Alachlor to corn, which accounts for much larger amounts of Alachlor used than sweet corn, has not decreased 2010 to 2014 (CAGR: 1.9%). On the other hand, data for earlier years shows that the amounts of Alachlor applied to corn in the USA has decreased dramatically during the 1990s and further during the 2000s (CAGR 1990-2010: -20.0%). This suggests that the use of Alachlor has been strongly affected by other factors than the Rotterdam Convention in the US.

The application of Alachlor on sweet corn has decreased around the time of listing from 2010 to 2014 (CAGR: -19.8%). However, this is slightly slower decrease than in the years before listing (CAGR 2006-2010: -20.5%), suggesting once again that there may be a larger trend of reducing the use of Alachlor, independent from the Rotterdam Convention. Older data (1990-2006) show a lot of fluctuation and an overall slight increase (CAGR: 1.7%). Hence, there is no evidence supporting the hypothesis that listing leads to a reduction in use volumes of the substance.

Figure 3-7 Alachlor application in surveyed US states for corn and sweet corn 1990-2014



Source: Amec Foster Wheeler 2016 based on data from USDA (2016).

Hypothesis: Listing leads to a reduction in use volumes of the substance.

- Very limited data exists to confirm or deny this hypothesis. An examination of data from the USA suggests that there has been a long-term trend of reducing the use of Alachlor that is independent from the Rotterdam Convention.

[15] Import itself does not guarantee the substance is used in the importing country as it could be fully re-exported. However it seems reasonable to assume that the majority of countries reporting imports to the FAO also use at least parts of their imports.

Analysis of alternatives to Alachlor

Overview of alternatives

The main alternative identified to Alachlor, is **Metolachlor**. Metolachlor is an herbicide applied to soil in a similar way to Alachlor to inhibit the growth of weeds and grasses before plants emerge from soil.

Metolachlor is applied in Canada and USA[16]. It is also registered in India and commercialised by Novertis Crop Protection, AG (India, 1968).

In the USA, Metolachlor has been commercialised by Ciba-Geigy Corporation (nowadays Syngenta) under the trade names and mixtures Bicep, CGA-24705, Dual, Pennant, and Pimagram. More recent information on trade names was not identified.

In addition to this identified chemical alternative, an herbicide containing **Isoxaflutole** as active substance is commercialised by Bayer CropScience and it is available in African countries for corn crops as an alternative for Alachlor.

Table 3.7 provides a comparison of Alachlor to Metolachlor indicating that the application covers many of the same crop types, while efficacy in Metolachlor is slightly weaker than Alachlor, although the dosage ranges do overlap.

Table 3.7 Comparison of Alachlor to Metolachlor

Herbicide	Dosage rates	Target crops	Pests
Alachlor	1.7 – 2.4 kg/hectare active ingredient	Corn, cotton, maize, sweetcorn, soybean, sunflowers, and sorghum.	weeds
Metolachlor	2.2 – 4.5 kg/hectare active ingredient 1.35 – 5.45 as emulsifiable concentrate kg/hectare active ingredient (India, 1968), (FAO, 2016a).	Corn[17], cotton, peanuts, pod crops, turf, potatoes, safflowers, sorghum, soybeans, stone fruits, tree nuts, non-bearing citrus, non-bearing grapes, cabbage, peppers, buffalo grass, and Guymon Bermuda grass.	grasslike weeds (barnyard grass, browntop panicum, crabgrass, crowfoot grass, fall panicum, giant foxtail, goose grass, green foxtail, red rice, signal grass, southwestern cup grass, witch grass, yellow foxtail, foxtail millet, praiglrie cup grass, yellow nutsedge) and broad leaf weeds (Eastern black nightshade, carpetweed, Florida pusley, galinsoga, pigweed) (India, 1968), (European Commission, 2016), (USDA, 2016).

Non-chemical alternatives have not been identified for Alachlor.

Analysis of short- and long-term impacts on Metolachlor market

As the Conference of the Parties agreed to list Alachlor in Annex III at its fifth meeting on 20th to 24th of June 2011, short- and long- term impacts on markets are assessed for the time periods 2008-2011 and 2011-2015.

Availability of Metolachlor

According to information from the Food and Agriculture Organisation of the United Nations (FAO, 2016b) Metolachlor has been imported from 2008 to 2015 by 6 developing countries and economies in transition from

[16] http://extoxnet.orst.edu/ghindex.html
[17] As a band, broadcast, soil incorporated, or no-till or minimum-till soil treatment. Apply with either a granule or pneumatic compressed air applicator post emergence, post transplant, layby, postplant, preemergence, preplant, ground crack, pre transplant, or when needed.

Europe (Serbia and Turkey), Africa (Malawi), Latin America and the Caribbean (Ecuador) and Asia (Myanmar and Malaysia).

However, Malawi, Ecuador and Myanmar reported marginal imports (imported less than 1 ton) or sporadic imports (e.g. imported not all the years). Thus, these countries were not considered in the market trends analysed.

Table 3.8 shows the annual growth rates (%) of import quantities of Metolachlor for the period 2008-2015 as well as the growth average rates for periods 2008-2011 and 2011-2015. These import quantities are based on the total imports of all countries reporting imports in the FAO survey (with the exception of Malawi, Ecuador and Myanmar).

Table 3.8 Annual growth rates of import quantities of Metolachlor and geometric average of growth rates between 2008-2011 and 2011-2015[18]

Years	2008-09-	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Annual growth rate* $_{(t-t+1)}$	706% (increase was from 481 tons to 3,887 tons)	-28 %	37%	37 %	-39%	13%	-26%
Geometric average of growth rate* $_{(2008-2011)}$=100%**				**Geometric average of growth rate ****$_{(2011-2015)}$=-1%**			

In the period before listing (2008-2011) import quantities of Metolachlor strongly increased (100%), however in the period after listing (2011-2015) import quantities of Metolachlor decreased (-1%). Thus it appears that listing of Alachlor in 2011 did not increase import quantities of Metolachlor.

In order to better analyse this, Figure 3.8 shows the development of imports by country for the period 2008-2015 (FAO, 2016b) for Serbia, Turkey and Malaysia. As illustrated in the table, there is a strong increase in imports of Metolachlor after 2012 for Malaysia, whilst there is no change for Turkey and Serbia. Malaysia reported only imports of Alachlor after listing from 2011-2013, however Metolachlor was reported from 2009-2015. Thus, the available data does not allow affirming that in the case of Malaysia the listing has led to a substitution of Alachlor by Metolachlor.

[18] The annual growth rate is calculated by the formula (Q_t - Q_{t-1}/Q_{t-1}) x 100. ** The geometric average growth rate for 2008-2015 is calculated by the formula $(\prod_{t=1}^{n} annual\ growth\ rate\ t)^{1/n}$= (annual growth rate$_{2008}$ x annual growth rate$_{2009}$ x ….x annual growth rate$_{2015}$)$^{1/8}$. *** The geometric average of growth rate for the period 2008-2011 is calculated by the formula $(\prod_{t=1}^{n} \mathrm{annual\ growth\ rate}\ t)^{1/n}$= (annual growth rate $_{2009}$ x….x annual growth rate $_{2011}$)$^{1/3}$. **** The geometric average of growth rate for the period 2011-2015 is calculated by the formula $(\prod_{t=1}^{n} annual\ growth\ rate\ t)^{1/n}$= (annual growth rate$_{2011}$ x ….x annual growth rate%$_{2015}$)$^{1/5}$

Figure 3-8 Metolachlor import quantity by country, indexed (year of listing 2011 = 100)

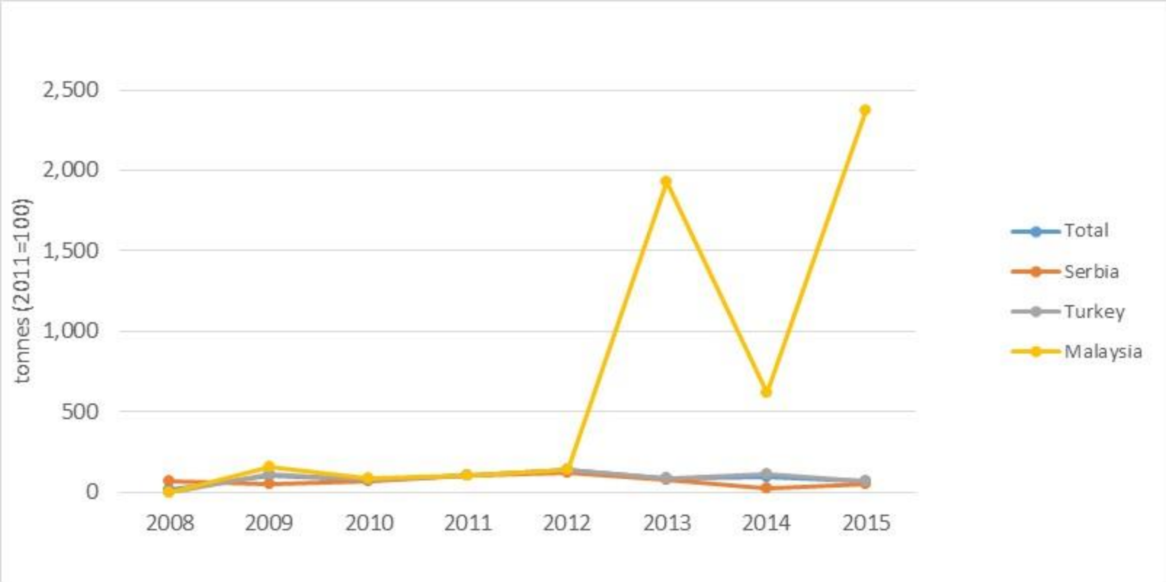
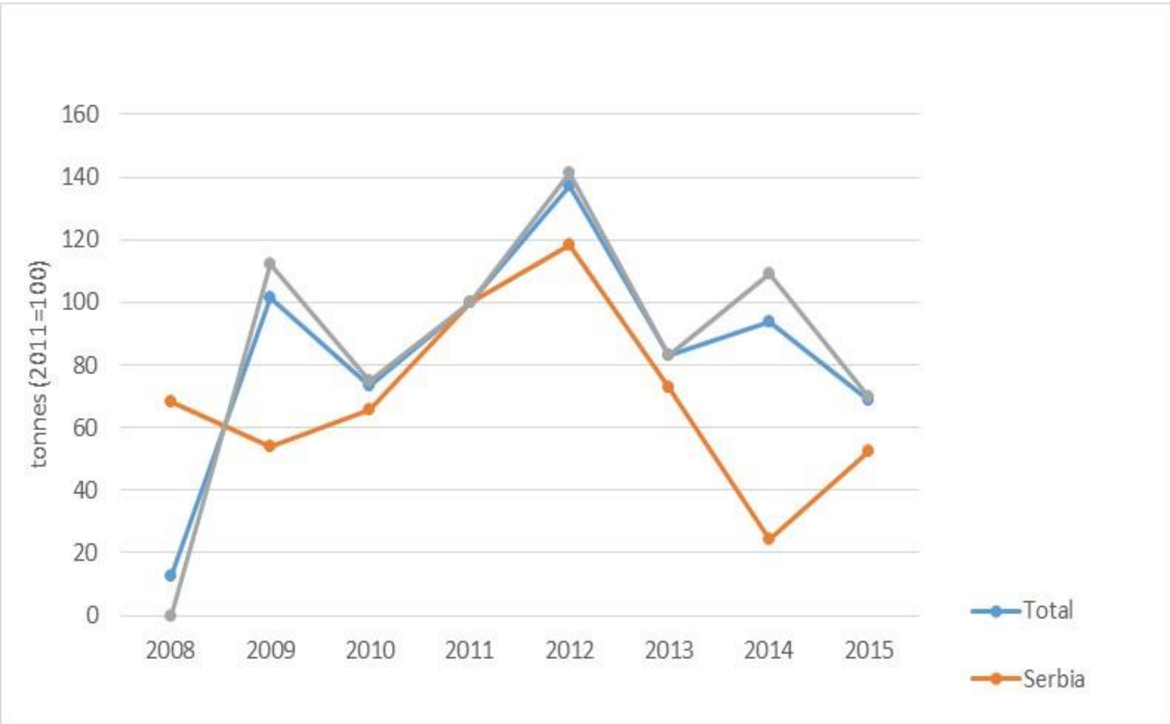


Figure 3.9 provides a more detailed picture for Serbia and Turkey. The Figure shows a considerable reduction in imports for Serbia, which however may not be related to the ban itself but could be due to economic conditions. As illustrated, available import data are dominated by Turkish imports which hence also determine the overall import trend. Comparing this data with the overall import quantities of Alachlor, import quantities of Alachlor slightly increased after listing but decreased for Serbia and Turkey. Thus, for both countries import quantities of both substances decreased after listing. However, the overall import quantities after listing show that Metolachlor quantities decreased and Alachlor quantities slightly increased.

Figure 3-9 Metolachlor import quantity by country (except Malaysia), indexed (year of listing 2011 = 100)



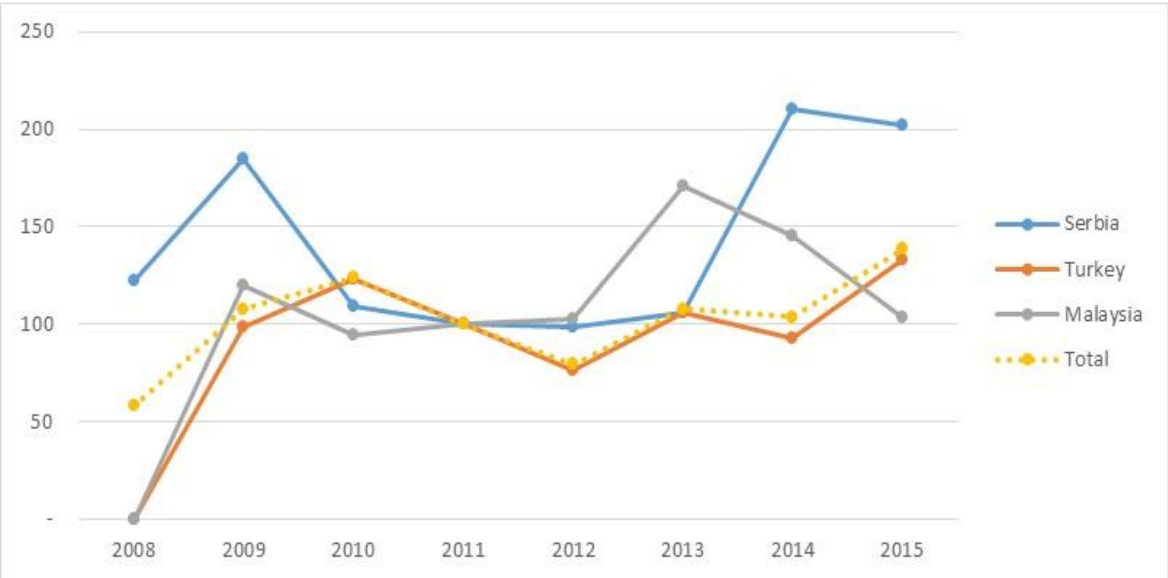
Source. BiPRO 2016, from data from FAO

For the countries not included in the evaluation due to their marginal or sporadic imports the available data does not provide any additional information that is relevant for evaluation (Ecuador <1 ton in 2014 and 2015, Myanmar 5 tons each in 2011 and 2012). It however shows imports after the listing of Alachlor. Furthermore, import quantities of Alachlor for Ecuador decreased after listing, whereas Myanmar reported imports only for 2011. In the case of Malawi import quantities of Alachlor were reported only after listing and for the period 2011-2013.

Pricing of Metolachlor shows a differentiated time trend as illustrated in Figure 3-10.. According to available data, the strongest increase in market price could be observed for the year 2008-2009, which is prior to the listing of Alachlor. There is not much change in market prices one year after the listing (2011-2012), but an increase for Turkey and Malaysia for the years 2012-2013. Whereas prices in these two countries fell between 2013 and 2014, there was a strong increase in the market price for Serbia. Overall it seems that prices of Metolachlor tended to increase after the listing, but they did not follow a common pattern of increase. The only cases that follow the same pattern are overall total import quantities and Turkish import quantities[19]. However, it is difficult to say whether this increase in prices is related to the listing of Alachlor or rather to other market reasons. For example, compared with prices of Alachlor, import prices of both substances increased after listing for Turkey and Serbia. Ecuador only imported Alachlor until 2013. Malaysia only imported Alachlor from 2011-2013, whereas prices of Metolachlor slightly increased after listing.

For Myanmar import prices remained stable for 2011 and 2012. Import average prices indexed (year of listing 2011 = 100) for Ecuador and Malawi could not be calculated due to the fact that Ecuador did not reported imports in 2011 and Malawi did not provide the amount of imported tons in 2011. However, from the data available Malawi import prices increased when comparing prices from 2008 and 2015 (8,379 and 12,528 US$ (2010)/ton). In the case of Ecuador, import prices decreased from 2014 to 2015 (752,745,745 to 114,411,413 US$ (2010)/ton).

Figure 3-10 *Metolachlor average real import price by country, indexed (year of listing 2011 = 100[20])*



Source. BiPRO 2016, from data from FAO

Conclusion

The decision for addition of Alachlor to Annex III of the Rotterdam Convention has been based on the available data gathered. This indicates a mixed picture for regional and national effects reflecting the complexity of global markets. However, following the details set out in the methodology (see section 2), it is apparent that for at least one nation there has been a decline in imports of Alachlor together with market price increases and a

[19] Total import prices might be dominated by import prices from Turkey.
[20] Further information on calculation of pricing is given in the methodology under section 2.2

seemingly increase in the use of alternative chemicals. However, evidence from other countries is mixed and conclusions based on only one country have to be interpreted with particular caution as specific regional factors may be in play. Two chemical alternatives were identified and no non-chemical alternative was identified. Metolachlor seems to be a good alternative as it can be applied to a broad number of crops against weeds. On the other hand, Isoxaflutole is more selective, as it is used only in corn crops in African countries. Producers identified were Novertis Crop Protection, Syngenta and Bayer Crop Science. User countries identified for Metolachlor were Canada and the USA, as well as developing countries and economies in transition like India. Furthermore, based on the available information from FAO Metolachlor has been available in 6 developing countries[21] and economies in transition (Serbia, Turkey, Malawi, Ecuador, Myanmar and Malaysia), which also have imported Alachlor during the same period (2008-2015). Overall, import quantities of Metolachlor tend to decrease[22] after listing of Alachlor, except for one nation (Malaysia) with an increase and there seems to be an increase in the use of alternative chemicals. On the other hand, overall Alachlor import quantities seem to slightly increase after listing, whereas it decreased for Turkey and Serbia.

Overall import prices[23] of Metolachlor tend to increase as well as do the import prices in all countries. On the other hand, overall import prices of Alachlor after listing remained quite stable and increased for Turkey and Serbia. Thus, it seems that for Serbia and Turkey no significant impact is caused by the listing as for both substances prices increased and it seems that the increase is caused by other reasons. Since overall import prices of Metolachlor are determined by Turkey, it might also be the case that the increase is caused by other reasons rather than the Convention.

There were no data on exports from the EU of alternatives to Alachlor.

Furthermore, the efficacy of Metolachlor is slightly weaker than Alachlor meaning that more product is required to achieve the same effects. Market prices of Alachlor in 2015 were 8,000 US$/ton and for Metolachlor 11,200 US$/ton (real price 2010) for all 6 countries. Therefore, based on the available information, it seems that as the use of Metolachlor is more costly than Alachlor. Thus, Metolachlor seems not to be feasible as an alternative to Alachlor in developing countries and economies in transition. Furthermore, considering available information, the number of producers seems to be reduced. However, as no data was available for the other alternative Isoxaflutole, it would be highly recommended to consider further research on this alternative.

3.5 Case study 2: Aldicarb (CAS No. 116-06-3)

Overview

Aldicarb is an insecticide, nematicide and acaricide. It is produced, traded and used in various countries globally. The Rotterdam Convention DGD document (2008) highlighted that Aldicarb had a broad range of applications spanning from citrus fruits and ornamental plants up to a range of vegetables including carrots, potatoes, parsnips, and uses for protection of cereals and cotton. Countries for which evidence of production or use of Aldicarb has been found are listed in the table below. Note that this list is likely to be not exhaustive.

Table 3.9 Indicative list of countries producing and using Aldicarb currently or in the past

Production	Use		
USA [a]	Argentina [b]	Macedonia [b]	Benin [b]
	Belarus [b]	Mexico [b]	USA [c]
	Burundi [b]	Mozambique [b]	European Community [d]
	Ecuador [b]	Serbia [b]	Jamaica [d]
	Georgia [b]	Turkey [b]	India [e]

Sources:
[a)] Based on http://www.scientificamerican.com/article/toxic-pesticide-banned-after-decades-of-use/ and the list of basic manufacturers

[21] Assuming that these imports are not re-exported.
[22] However, overall import quantities are leaded by imports of Turkey.
[23] Overall import prices seem to be determined by import prices of Turkey

form the Decision Guidance Document for Aldicarb. Only countries where the main manufacturing locations of the respective manufacturer can be clearly attributed to a specific country have been included.
[b)] Based on countries reporting imports of Aldicarb to FAO and the assumption that at least part of the imports are used domestically and not re-exported.
[c)] Based on the US Department of Agriculture National Agricultural Statistics Service (https://www.nass.usda.gov/Quick_Stats/).
[d)] Based on the Rotterdam Convention: 2007-CRC.4-10. Aldicarb.
[e)] Based on the Pesticides Manufacturers & Formulators Association of India (http://www.pmfai.org/images/183/Pesticides%20registered%20for%20use.pdf).

Trade names and mixtures: Temik; Sanacarb, Sentry; Tranid; Cardinal (+ Fipronil); Regent Plus (+ Fipronil); Trident (+ Fipronil)

Main purpose and functionality: Aldicarb is based on oxime Carbamate and works as a systemic pesticide, meaning it is absorbed by the plants itself, killing the insects or worms feeding on it (Rotterdam Convention, 2009b)

Listing in the Rotterdam Convention: Listed in 2011 after all uses of Aldicarb have been completely banned in Jamaica and the European Community.

Production

According to the Decision Guidance Document citing a source from 2006 there were at least three manufacturers (Bayer CropSciences, Agrochem, Dow AgriSciences). A more recent publically available source listing manufacturers of Aldicarb has not been identified. Production quantities are not available. Hence, there is no sufficient evidence available to assess the relevant hypotheses.

Hypothesis: Listing leads to a decrease in production and/or the number of manufacturers of the substance.

- Lack of data post listing means it has not been possible to comment on the outcome of this hypothesis.

Trade

Quantity and value of imports of Aldicarb for the years 2008-2015 have been submitted to the FAO by 12 countries from various regions of the world. These are listed in the table below.

Table 3.10 List of countries that reported imports of Aldicarb in response to the FAO survey, by region

Africa	Americas	Europe	Western Asia
Benin	Argentina	Belarus	Georgia
Burundi	Ecuador	Macedonia	Turkey
Malawi	Mexico	Serbia	
Mozambique			

Source: Amec Foster Wheeler 2016 based on data from FAO 2016.

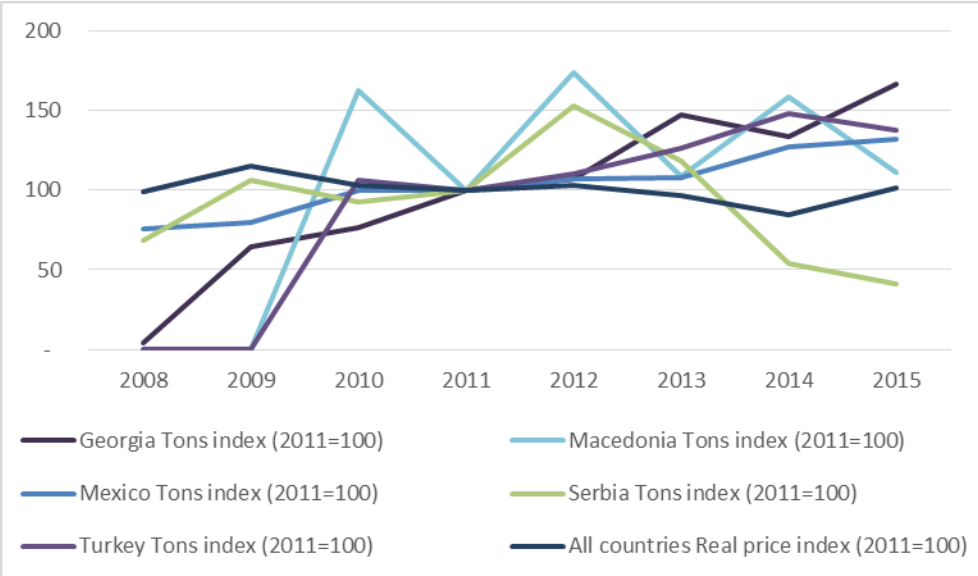
Burundi and Ecuador only report marginal amounts of imports (<= 1 ton) and only in some years. Malawi only reports imports in 2008, but in none of the years after. The evidence for these countries is therefore not sufficient to allow any conclusions regarding the hypothesis.

Belarus did not report any imports of Aldicarb before its listing, but report imports from 2012 on. Two countries, Mozambique and Benin, had only small quantities of imports (up to about 1.3 tons) prior to 2011, before increasing the levels of import after this date. These countries have started importing Aldicarb in significant amounts only after the listing of the substance on the Rotterdam Convention and it being subject to the PIC procedure, thereby suggesting no significant impact of the listing on the traded volume of the substance.

Argentina imported significant amounts of Aldicarb until 2010 and ceased importing thereafter. This might suggest that in Argentina the PIC procedure had a profound effect on imports of Aldicarb.

The remaining five countries reported imports both before and after listing of Aldicarb. The figure below shows an index (adjusted to 100 in 2011) of reported quantities of trade of those countries. It indicates that most countries exhibit an overall increase of imports from 2008 to 2015, also after listing. This will be analysed in more detail below.

Figure 3-11 Aldicarb import quantity by country, indexed (year of listing 2011 = 100)



Source: Amec Foster Wheeler 2016 based on data from FAO 2016.

Only in Serbia, imports have fallen between 2011 and 2015. Imports increased in Serbia before 2011, but this increase continued until the peak amount of imports was reached in 2012, after listing. This calls into question whether listing in the Rotterdam Convention is the main influencing factor in the recent decrease of import quantities of Aldicarb in Serbia.

The remaining four countries have reported growing imports of Aldicarb both before and after listing. Turkey and Macedonia only reported imports from 2010 on. In both imports fell from 2010 to 2011 but showed an overall increase after that until 2015. Hence, the evidence suggests that in these countries listing may have hampered imports in the short term, but no apparent effect can be observed in the longer term.

Georgia and Mexico exhibit an overall rise in imports throughout the whole period. Between 2011 and 2015 imports in both countries grew more slowly with a lower Compound annual growth rate (CAGR, listed in the table below) during that period than compared to 2008 to 2011, which could suggest that the trade of Aldicarb was affected in these countries by the listing. However, it should be noted that in Georgia, growth started from a very small amount as starting point in 2008 (15 tons) and a decreasing growth of imports may be expected when a certain level of market saturation is reached, regardless of the regulatory circumstances.

Overall, the quantity of imports of all countries that had provided data has increased both before and after listing. The CAGR in the years with data available up to listing (2008-2011) was 17.7% and declined to 9.0% for the years 2011 to 2015, indicating that overall, the growth trend of quantities of Aldicarb import in all countries providing data was lower after listing than before. This allows for a similar conclusion as in the case of Alachlor imports. The evidence from the sum of imports can be interpreted as supporting the hypothesis that listing reduces traded volumes of the substances. However, as shown above the evidence available on different countries is mixed, which suggests that either the trends in imports of Aldicarb are determined mostly by other factors than the Rotterdam Convention, or local conditions determine whether listing has a significant impact on imports.

Table 3.11 Compound annual growth rate (CAGR) of Aldicarb import quantity before and after listing, by country

Country	CAGR 2008-2011	CAGR 2011-2015
Georgia	194.6%	13.7%
Macedonia	Imports only from 2010	2.8%
Mexico	9.6%	7.3%
Serbia	13.4%	-19.9%
Turkey	Imports only from 2010	8.2%
Benin	26.5%	56.3%

Source: Amec Foster Wheeler 2016 based on data from FAO 2016.

Hypothesis: Listing reduces traded volume.

- Aside from Serbia where the decreasing trend in imports looks difficult to explain, in all other cases the trade in Aldicarb has either maintained at a constant rate or increased. This does not support the hypothesis that listing of Aldicarb has affected trading of goods.

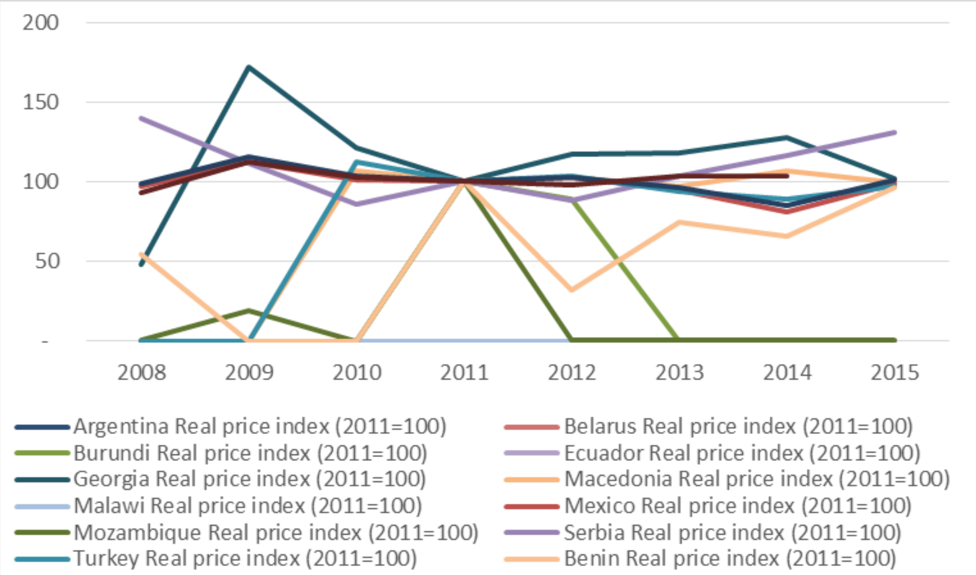
Prices[24]

Average prices of imports of Aldicarb for the years 2008-2015 have been calculated from import quantity and value data submitted to the FAO by 12 countries from various regions of the world. As discussed in the previous section, six countries (Benin, Burundi, Ecuador, Malawi, Belarus, Mozambique) reported no or only marginal trade of Aldicarb before listing, whereas Argentina reported no imports since 2011. Price data from these countries are, therefore, not suitable for the analysis of the impact of listing of Aldicarb.

The remaining five countries reported imports both before and after the listing of Aldicarb. In addition, the United States Department of Agriculture National Agricultural Statistics Service (USDA, 2016) provides yearly data on prices paid for Aldicarb[25] in US Dollar per gallon from 2001 to 2014. The figure below shows an index of the calculated average real price of Aldicarb imports of those countries from 2008 to 2015 adjusted to 100 in 2011, as previously.

[24] All prices have been converted to real prices (2010 USD) using the US Wholesale price index from the World Bank (http://databank.worldbank.org/data/reports.aspx?source=2&series=FP.WPI.TOTL&country=).
[25] Specified as ALDICARB (TEMIK) 15% G.

Figure 3-12 Aldicarb average real import price by country, indexed (year of listing 2011 = 100)[26]



Source: Amec Foster Wheeler 2016 based on data from FAO 2016 for all countries except USA, which is based on data from USDA, 2016.

The graphs show that in most countries (all except Serbia), real prices of Aldicarb imports in 2015 are nearly the same as at the time of listing in 2011. More specifically, in five countries (Benin, Georgia, Macedonia, Mexico, Turkey) the absolute value of the CAGR (listed in table below) was smaller than 1%, meaning that real average import prices of Aldicarb have not changed more than 1% per year on average since listing. In Turkey and Macedonia, imports were reported only since 2010, so no comparison to the long term trend before listing can be made. In Mexico, real prices have increased with a CAGR of 1% before listing, indicating no strong change, but in Benin and Georgia real prices were rapidly increasing in the period 2008-2011, an inflation of Aldicarb import prices that has halted after listing. Hence, for the five countries discussed, especially Benin and Georgia, the evidence does not indicate listing had an inflating effect on Aldicarb prices in these countries.

Serbia is the only country that seems to support the hypothesis regarding listing inflating prices, as real average import prices have increased significantly from 2011 to 2015, but were falling in the previous years. It should be noted however, that prices were still falling from 2011 to 2012, after listing. As for import quantities, this calls into question whether listing in the Rotterdam Convention is the main influencing factor or this development in Serbia.

For the sum of imports of all countries that had provided data to the FAO, the real price has increased at the same low CAGR of 0.3% both before and after listing. This could contradict the hypothesis that listing of the substance leads to an increase in its price.

In the USA, real prices have fallen in the long term before listing (CAGR -2.9% in 2001-2011), but increased since 2008 until 2011 (CAGR 2.4%). This inflation of Aldicarb real prices continued after listing, but at a lower rate (CAGR 1.1% in 2011-2014). Note that the USA is not a Party to the Rotterdam Convention. However, if listing reduced production of Alachlor, this could increase prices on the global market. Hence, the slowing of price increases if real prices in the US could contradict the hypothesis of increasing prices due to listing. Note that contrary to the data for all other countries, US data reflects prices paid by farmers in the country rather than the value of imports.

[26] Further information on calculation of pricing is given in the methodology under section 2.2

Table 3.12 Compound annual growth rate (CAGR) of Aldicarb average real import prices before and after listing, by country

Country	CAGR 2008-2011	CAGR 2011-2015
Georgia	28.1%	0.5%
Macedonia	Imports only from 2010	-0.2%
Mexico	1.0%	-0.3%
Serbia	-10.6%	7.0%
Turkey	Imports only from 2010	-0.8%
Benin	22.4%	-0.9%
USA	-3.6% (2001-2011); 2.4% (2008-2011); 1.1% (2011-2014)	

Source: Amec Foster Wheeler 2016 based on data from FAO 2016 for all countries except USA, which is based on data from USDA (2016).

Hypothesis: Listing inflates prices

- Based on the available evidence reviewed, the price index for Aldicarb shows a broadly level picture, with no significant increases in price after the listing in Annex III. This does not support the hypothesis.

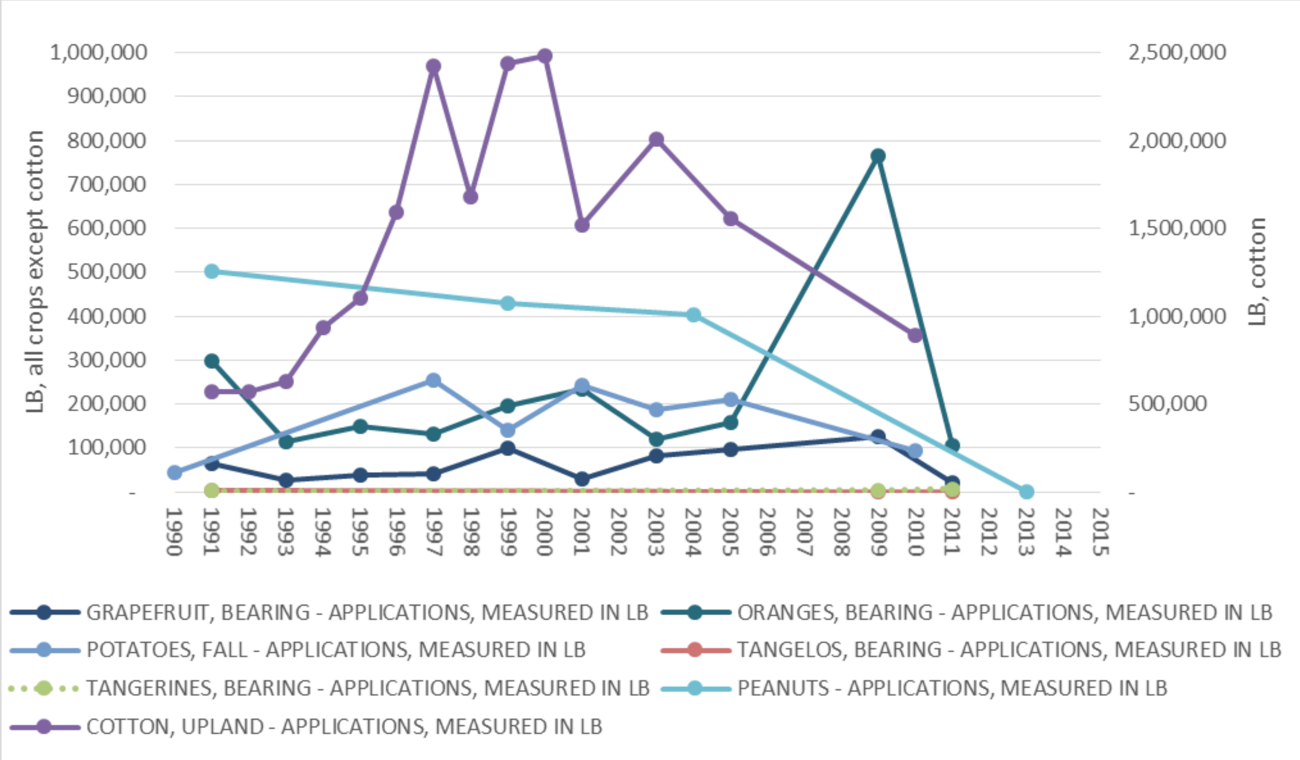
Application/Use

Aldicarb has been used in a wide range of countries, as indicated in the Draft Decision Guidance Document for Aldicarb (European Community, Jamaica) and the FAO import data analysed above (e.g. countries in the Americas, Eastern Europe, Sub-Sahara Africa and Eurasia)[27]. However, no evidence supporting or contradicting cessation of use of Aldicarb by different countries since its listing in Annex III of the Rotterdam Convention in 2011 has been found. As stated above, Argentina ceased to import Aldicarb after 2010, but no information is available if Aldicarb is produced domestically.

Data on the quantities of Aldicarb applied has been identified for the US and the UK. Data from the United States Department of Agriculture National Agricultural Statistics Service (USDA, 2016) includes application of Aldicarb to a range of crops, but the data only ranges until 2011 or earlier, except for peanuts where it is stated that no Aldicarb was applied in 2013. In 2004 and before, significant but decreasing amounts of Aldicarb had been applied to peanuts in the USA. Note that the USA is not a Party to the Rotterdam Convention, so this could suggest that there may be other factors than the Rotterdam Convention that led to the Aldicarb use being ceased for peanuts in the USA. For all other crops in the US, no clear conclusion can be drawn with regard to the hypothesis, but it is worth noting that the application of Aldicarb on all crops has fallen since 2009 or earlier, as can be seen in the figure below. This may suggest as well that other factors than the Rotterdam Convention leading to a decrease in use of Aldicarb in the USA.

[27] Import itself does not guarantee the substance is used in the importing country as it could be fully re-exported. However it seems reasonable to assume that the majority of countries reporting imports to the FAO also use at least parts of their imports.

Figure 3-13 Aldicarb application in surveyed US states for various crops 1990-2015



Source: Amec Foster Wheeler 2016 based on data from USDA (2016).

Data on the application of Aldicarb by crop was also available for Great Britain from FERA (formerly the Food and Environment Research Agency of the UK Department for Environment, Food and Rural Affairs). However, use of Aldicarb in Great Britain phased out prior to listing on Annex III to the Rotterdam Convention due to EC regulatory action[28], so that listing couldn't have had any impact on use in Great Britain. The data is therefore not suitable for analysis with respect to the hypothesis.

Hypothesis: Listing leads to a reduction in use volumes of the substance.

- Very limited data exists to confirm or deny this hypothesis. An examination of data from the USA suggests that there has been a decline up to 2011, but not related to the listing in the Rotterdam Convention. Given that there is a lack of data it has not been possible to comment on this hypothesis.

Analysis of alternatives to Aldicarb

As Aldicarb has a potential application for a wide range of crops spanning fruits, vegetables and cereals, there is an equally large number of viable alternative chemicals used on a broad range of crops. Based on the literature and data reviewed, 9 alternatives have been identified for Aldicarb. Out of these alternatives 7 are chemical alternatives and 2 are non-chemical alternatives.

The chemical alternatives include Abamectin, Bromopropylate, Dimethoate, Imidacloprid, Fenbutine Oxide, DiazinonShell White Oil with Diazinon, and Fluopyram. Producers of these alternatives are provided in Table C.3 in Appendix C, which shows a wide number of producers of alternatives, some of them being companies with global presence.

Not all of them, however, can be used for all crops, and information on user countries is limited to Jamaica and India. Abamectin, Imidacloprid and Dimethoate are used for many crops. Further details on their application and target crops are provided within Table C.1 in Appendix C. According to information provided by a

[28] "*The authorisations for plant protection products containing Aldicarb had to be withdrawn by 18 September 2003. Certain essential uses listed in the Annex to Council Decision 2003/199/EC remained authorised until 30 June 2007 under specific conditions.*" Rotterdam Convention: Decision Guidance Document Aldicarb. http://www.pic.int/Portals/5/DGDs/DGD_Aldicarb_EN.pdf

producer company, Fluopyram is used and as chemical alternative for Aldicarb for nematode control in African countries (FAO, 2016a).

Non-chemical alternatives identified for Aldicarb have been integrated pest management programmes and predatory species such as purpureocillium lilacinum (a type of fungus). Integrated pest management programmes are known to be used in Jamaica (FAO, 2016a) and purpureocillium lilacinum is available as an alternative for Aldicarb in African countries[29].

Analysis of short- and long-term impacts on alternative substances markets

As the Conference of the Parties agreed to list Aldicarb in Annex III at its fifth meeting on 20-24 June 2011, short- and long-term impacts on markets are assessed for the time periods 2008-2011 and 2011-2015.

- Availability of alternative substances

For Bromopropylate, Fluopyram and purpureocillium lilacinum it was not possible to identify data about imports, exports or prices. For Imidacloprid there was no data on export or import, thus analysis on availability, prices and short- and long-term impacts was not possible. However, a pesticide producer provided information stating that Imidacloprid is used in African countries as an alternative to Aldicarb for aphid control. Data on demand and prices for India from 2005-2010 are provided in Table C.3 in Appendix C. For Fenbutine Oxide, only export quantities were available.

Based on the available data an analysis is provided here for three of the main chemical alternatives to Aldicarb, namely Abamectin, Dimethoate and DiazinonShell White Oil with Diazinon. This analysis covers the time period 2008-2015 for imports and the time period 2006-2013 for exports. It will identify developing countries and economies in transition, where alternatives have been exported / imported, in order to assess their availability[30]. The analysis will also consider export / import quantities and import prices of these alternatives, in order to determine if they have been affected by listing of Aldicarb in 2011. Table 3.13 provides an overview of the analysis as well as which variables are consider.

Table 3.13 Analysis overview

Scope	Variables	Reason of analysis
Import export/ quantities	▶ Annual growth rates, geometric average growth rates 2008-2011 and 2011-2015 of import quantities ▶ Annual growth rates, geometric average growth rates 2008-2011 and 2011-2013 of export quantities ▶ Import quantities (indexed to year 2011) in total and by country ▶ Export quantities before and after listing (indexed to year 2011) in total	In order to know if there is a change on trend of export/ import quantities after listing of Aldicarb. Especially if import quantities after listing (2011-2015) tended to increase or export quantities after listing tended to rise (2011-2013).
Import prices	Real import price (2010 US$/ton) (indexed to year 2011) in total and by country	In order to show if there is a change on import prices trend after listing of Aldicarb. Especially if import prices after listing (2011-2015) tended to rise.

Furthermore a summary is provided at the end of this analysis in table 3.17. This table summarises trends on export / import quantities and prices of alternatives and compares them with the trends on Aldicarb. This will sum up if there is any effect on import quantities and prices (i.e. increase) after listing of Aldicarb.

[29] http://extoxnet.orst.edu/ghindex.html
[30] Assuming that imports are not re-exported

Analysis

Abamectin

According to data from FAO, Abamectin has been imported from 2008 to 2015 by 13 developing countries and economies in transition from Europe (Serbia and Turkey), Near East (Lebanon), Africa (Malawi, Madagascar, Senegal), Latin America and the Caribbean (Ecuador and Dominican Republic) and Asia (Thailand, Bangladesh, Philippines, Myanmar and Malaysia) (India, 1968). Lebanon, Senegal, the Dominican Republic, Malawi and Ecuador reported marginal imports (e.g. imported quantities less than one ton) or sporadic imports (e.g. imported not all years), so that they were not considered in the current analysis. Table 3.14 shows annual growth rates (%) for import quantities of Abamectin for the period 2008-2015 as well as the geometric average growth rates for the periods 2008-2011 and 2011-2015. Figure 3-15 and Figure 3-16 shows annual growth rates (%) for import quantities of Abamectin for the period 2008-2015 as well as the geometric average growth rates for periods 2008-2011 and 2011-2015.

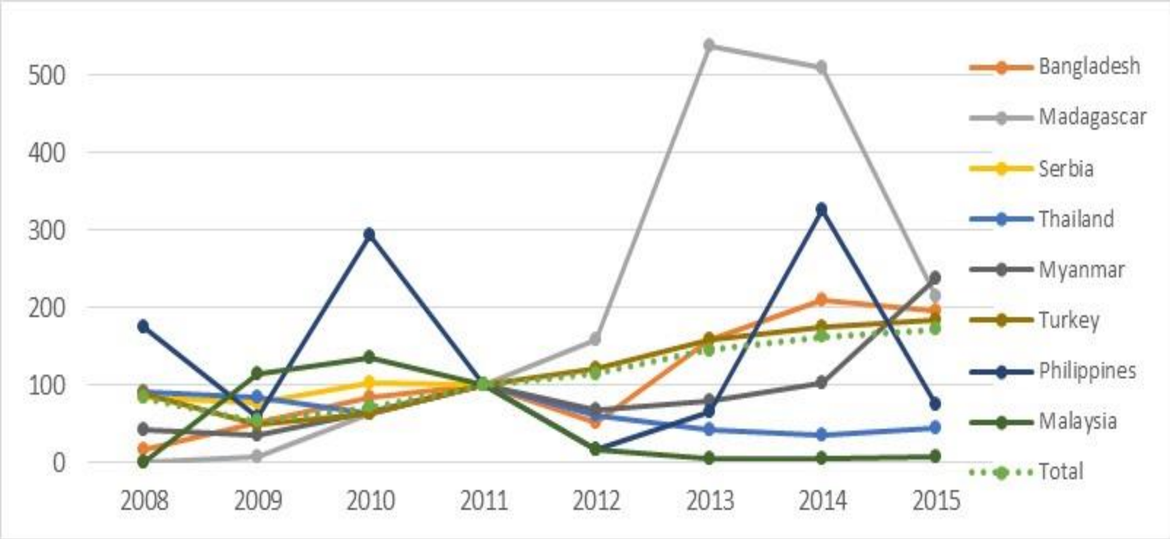
Table 3.14 Annual growth rates and geometric average of growth rates of Abamectin import quantities between 2008-2011 and 2011-2015[31]

Years	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Annual growth rate* $_{(t\text{-}t+1)}$	-36%	35 %	39%	15 %	27%	12%	5%
Geometric average of growth rate* $_{(2008\text{-}2011)}$= 6%**				**Geometric average of growth rate **** $_{(2011\text{-}2015)}$ = 19%**			

Considering the geometric average growth rates before and after listing, the imports increased in both periods: 6% (2008-2011) and 19% (2011-2015). In order to better analyse this, Figure 3-14 and Figure 3-15 show import quantities in tons (indexed, year of listing 2011 = 100) and average real import prices of 8 countries for the period 2008-2015 (India, 1968).

[31] * The annual growth rate is calculated by the formula (Q_t - Q_{t-1}/Q_{t-1}) x 100. ** The geometric average growth rate for 2008-2015 is calculated by the formula ($\prod_{t=1}^{n} annual\ growth\ rate\ t$) $^{1/n}$= (annual growth rate$_{2008}$ x annual growth rate$_{2009}$ x ….x annual growth rate$_{2015}$)$^{1/8}$. *** The geometric average of growth rate for the period 2008-2011 is calculated by the formula ($\prod_{t=1}^{n} \text{annual growth rate } t$) $^{1/n}$= (annual growth rate $_{2011}$ x annual growth rate $_{2012}$)$^{1/3}$. **** The geometric average of growth rate for the period 2011-2015 is calculated by the formula ($\prod_{t=1}^{n} annual\ growth\ rate\ t$) $^{1/n}$= (annual growth rate$_{2011}$ x annual growth rate$_{2013}$ x ….x annual growth rate%$_{2015}$)$^{1/5}$

Figure 3-14 Abamectin import quantity by country, indexed (year of listing 2011 = 100)



Source. BiPRO 2016, from data from FAO

As illustrated in Figure 3.16 the overall import quantities increased after the listing of Aldicarb. However, overall import quantities seem to be determined by import quantities of Turkey.

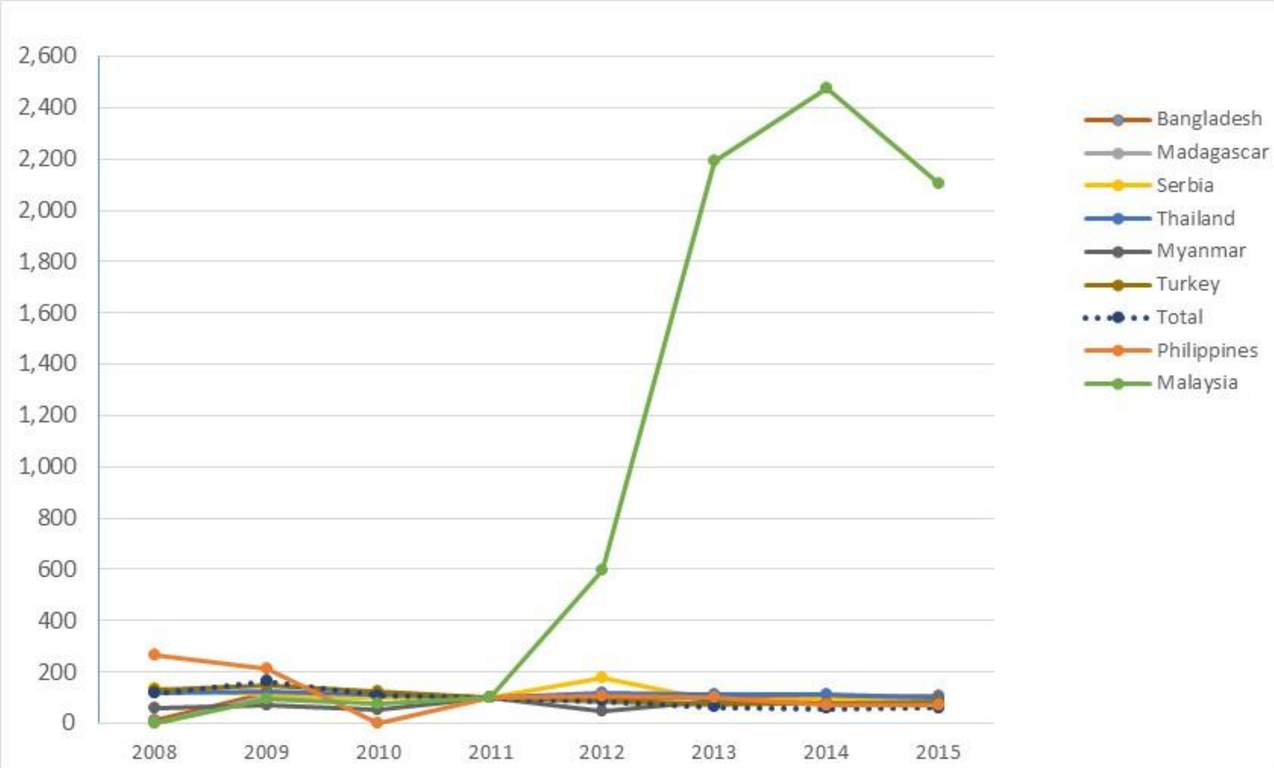
However, there is no uniform trend. For Thailand and Malaysia, for example, imports declined after the listing, whereas Madagascar shows a high increase of imports after the listing of Aldicarb. In the Philippines, import quantities tend to decrease one year after listing and highly increase from 2012-2014, to finally return to a quantity similar to 2013 in 2015.

For countries that reported marginal or sporadic imports (Lebanon, Senegal, the Dominican Republic, Malawi and Ecuador) individual differences are observed. In the Lebanon import quantities decreased after listing (imports have been reported only after listing). However for Senegal import quantities increased before and decreased after listing (no imports in 2013). In the case of Malawi imports increased from 0.30 (2014) to 5.50 (2015) tons (only years reported). Ecuador import quantities increased before and after listing. In the Dominican Republic import quantities decreased before and decreased after listing.

Figure 3-15 shows that market prices for Abamectin tend to decrease in general. For most of the countries, prices decreased after listing, except for Bangladesh and Thailand. Furthermore, prices in Serbia and the Philippines seem to be more fluctuant. Prices for Malaysia are represented separately in Figure 3-16 because these prices have higher levels. In the case of Malaysia prices increased sharply (by factor 20) in particular from 2012-2013.

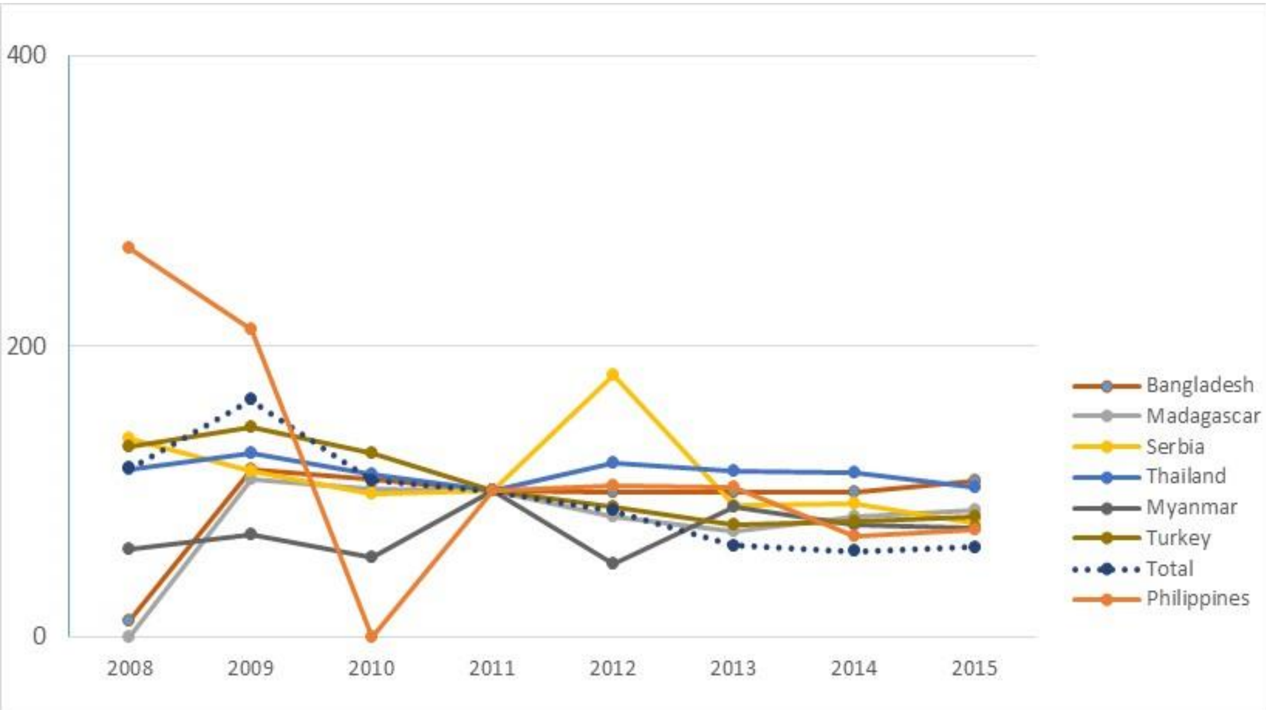
In the countries that reported marginal or sporadic imports (Lebanon, Dominican Republic and Ecuador) import prices increased. However, for Malawi and Senegal, imports prices could not be calculated because Malawi did not report imports in 2011 and Senegal did not provide import values in US$.

Figure 3-15 *Abamectin average real import price (2010 US$/ton) by country, indexed (year of listing 2011 = 100)*[32]



Source. BiPRO 2016, from data from FAO

Figure 3-16 *Abamectin average real import price (2010 US$/ton) by country (excluding Malaysia), indexed (year of listing 2011 = 100)*



[32] Further information on calculation of pricing is given in the methodology under section 2.2

Dimethoate

According to data from FAO, Dimethoate has been imported from 2008 to 2015 by 10 developing countries and economies in transition from Europe (Serbia), Near East (Lebanon), Africa (Burundi, Malawi, Madagascar and Senegal), Latin America and the Caribbean (Ecuador) and Asia (Thailand, Myanmar and Malaysia)[33].

Lebanon, Senegal and Ecuador presented marginal imports (i.e. imported less than one ton) or sporadic imports (imported not all years). Thus, they were not considered in considered in Thus, they were not considered in considered in the current analysis. Table 3.15 shows annual growth rates (%) of imported quantities for the period 2008-2015 as well as the geometric average growth rates for the periods 2008-2011 and 2011-2015.

Figure 3.17 and Figure 3.18 shows annual growth rates (%) of imported quantities for the period 2008-2015 as well as the geometric average growth rates for the periods 2008-2011 and 2011-2015.

Table 3.15: Annual growth rates and geometric average of growth rates for 2008-2011 and 2011-2015 of Dimethoate import quantities[34]

Years	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Annual growth rate* $_{(t-t+1)}$	-1%	39 %	-6%	-14 %	-18%	-37%	-4%
Geometric average of growth rate* $_{(2008-2011)}$** = 9%				**Geometric average of growth rate ****** $_{(2011-2015)}$ **=** -17%			

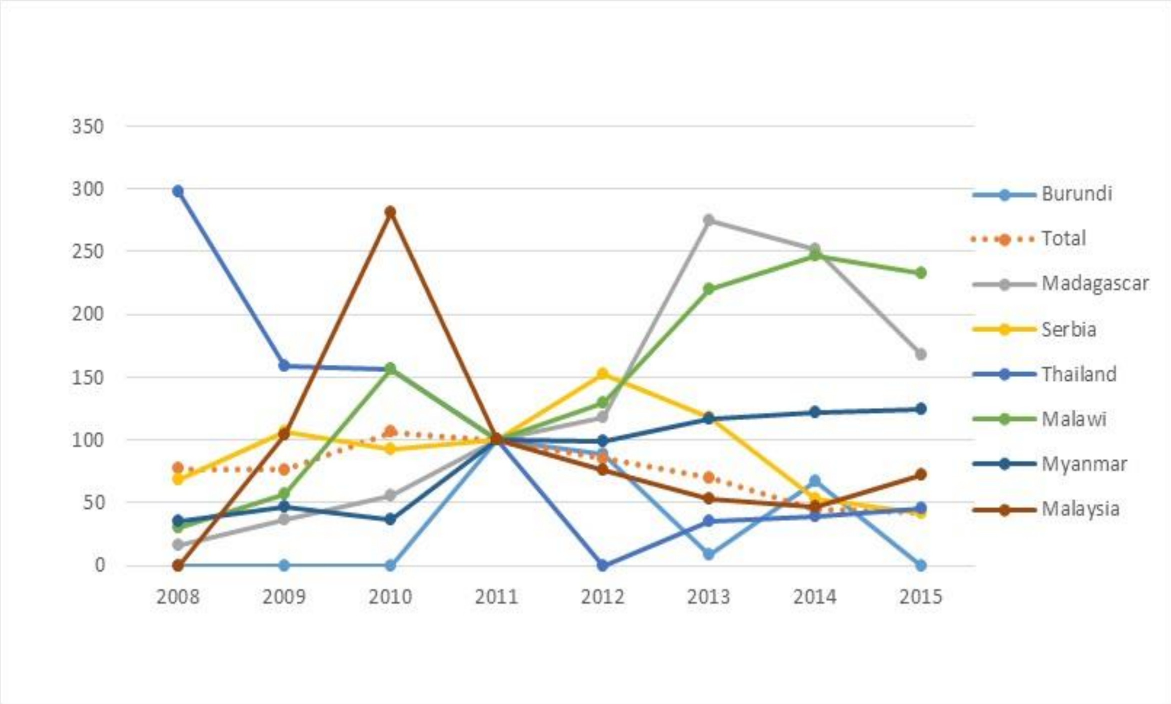
An evaluation of the geometric average growth rates for the time periods before and after listing shows an increase of 9% before listing (2008-2011) compared to a 17% decrease for the time period after listing (2011-2015). Thus, listing of Aldicarb does not seem to have positively affected the Dimethoate trade globally; however, there is no uniform trend.

In order to better analyse this observation, Figure 3.17 and Figure 3.18 show imports in tons (indexed 2011=100) and average real import prices of those countries for the period 2008-2015 (India, 1968).

[33] http://www.pic.int/

[34] * The annual growth rate is calculated by the formula (Q_t - Q_{t-1}/Q_{t-1}) x 100. ** The geometric average growth rate for 2008-2015 is calculated by the formula ($\prod_{t=1}^{n} annual\ growth\ rate\ t$) $^{1/n}$= (annual growth rate$_{2008}$ x annual growth rate$_{2009}$ x ….x annual growth rate$_{2015}$)$^{1/8}$. *** The geometric average of growth rate for the period 2011-2012 is calculated by the formula ($\prod_{t=1}^{n} \text{annual growth rate } t$) $^{1/n}$= (annual growth rate $_{2011}$ x annual growth rate $_{2012}$)$^{1/2}$. **** The geometric average of growth rate for the period 2013-2015 is calculated by the formula ($\prod_{t=1}^{n} annual\ growth\ rate\ t$) $^{1/n}$= (annual growth rate$_{2013}$ x ….x annual growth rate%$_{2015}$)$^{1/3}$

Figure 3-17 Dimethoate import quantity by country, indexed (year of listing 2011 = 100)



Source. BiPRO 2016, from data from FAO

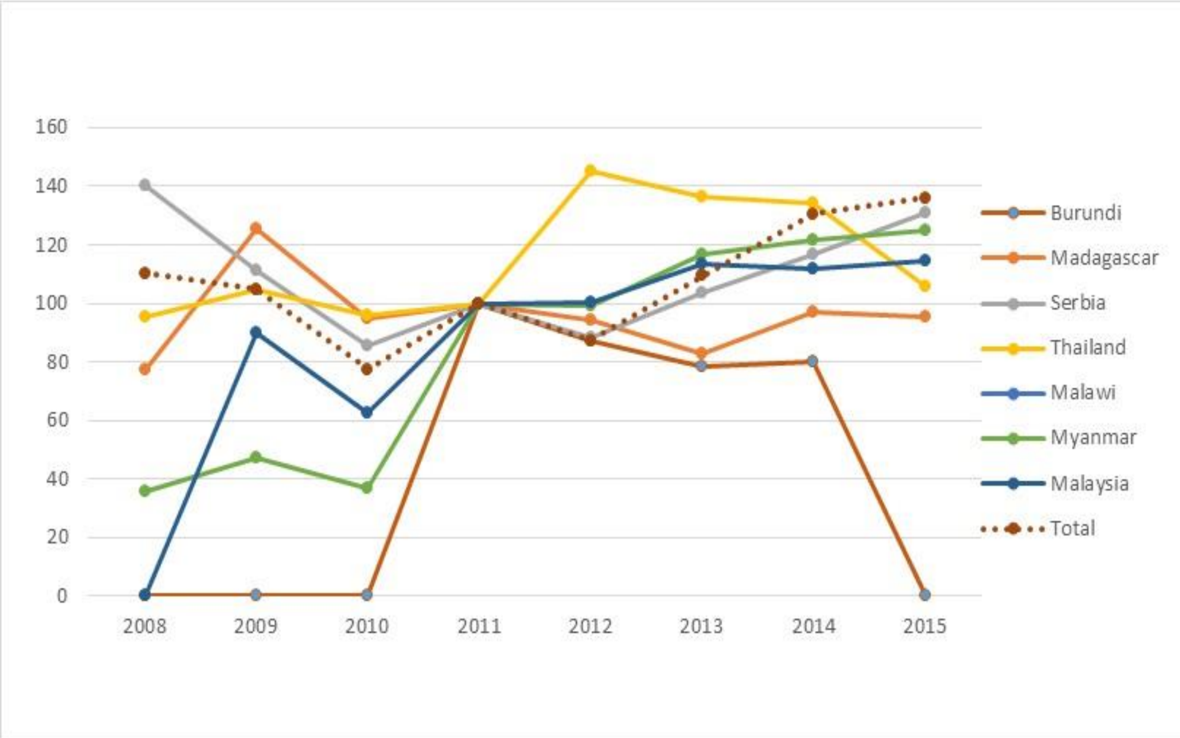
Figure 3.17 clearly shows that the time trends in import are country specific and range from strong decrease to considerable increase.

Overall imports tend to slightly increase before and slightly decrease after listing. In the cases of Serbia, Burundi, Thailand and Malaysia import quantities tend to decrease. However, in the cases of Madagascar, Malawi and Thailand there is a trend to increase. For the countries that reported marginal or sporadic imports, such as Lebanon, Senegal and Ecuador, there are differences in the trends. For Lebanon import quantities slightly increase after listing, with the exception of 2013. For Senegal import quantities increase after listing, except for the years 2014 and 2015. In the case of Ecuador import quantities slightly increase after listing. Figure 3.18 shows the time trend for market prices for Dimethoate.

As indicated, overall import prices are relatively stable after listing. Individually, for most countries prices increased after listing of Aldicarb. In the case of Madagascar the price increases, but returns to a level below the one of 2011 in 2015. For Serbia, Malaysia and Myanmar there is a clear trend of import prices to increase after listing. In the case of Thailand there is a trend of prices to increase after listing, except for the year 2015. For Madagascar import prices decrease after listing until 2013 to increase again in 2014 and 2015. However, for Burundi there is a clear trend of import prices to decrease, especially in 2015. However, it is difficult to say whether this increase in prices is related to the listing of Aldicarb or rather to other market reasons. For example, as there are more chemical alternatives identified for Aldicarb, it might be that the price of Dimethoate is not strongly influenced by the listing of Aldicarb. Thus, overall, there does not seem to be a strong impact of the listing on the prices. In the case of Malawi prices could not be calculated because it did not provide the imported US$ value for 2011.

For countries that reported marginal or sporadic imports such Lebanon, Senegal, and Ecuador there are differences. For Senegal prices could not be calculated because it did not report import values (US$). In the case of Ecuador and Lebanon, import prices tend to increase.

Figure 3-18 Dimethoate average real import price (2010 US$/ton) by country, indexed (year of listing 2011 = 100)[35]



Source. BiPRO 2016, from data from FAO

Furthermore, data on demand, imports and prices were available for India for the period 2005-2010. This is provided in Table 63 in Appendix E.

Additionally, prices of Dimethoate, which was commercialised under the trade name Cygon were available in US$ for the period 2002-2008. These prices are provided (expressed in US$/gallon) in the in Table 64 in Appendix E.

Fenbutine Oxide

According to data from European Commission, Fenbutine Oxide has been exported to African, Middle East, Asian and South Asian countries and Oceania in 2009, 2010 and 2013 (European Commission, 2016). Importing partner's countries were Turkey, Taiwan, South Africa, Ethiopia, Arab Emirates, Kenya, Morocco, Israel, Thailand, Japan, Australia, Jordan, Oman, Palestine and Saudi Arabia.

Imidacloprid

For Imidacloprid there was no data on export or import, thus analysis on availability, prices and short- and long-term impacts could not be done. Furthermore, for Imidacloprid data on demand and prices for India from 2005-2010 was available. This is provided in Appendix E Table 65.

Additionally, prices of Imidacloprid, which is commercialised as Kelthane, were available in US$ for the period 2002-2006. This period is not relevant for the analysis, thus, these prices have not been considered but are included in Appendix E in

Table 66.

DiazinonShell White Oil with Diazinon

This alternative was mentioned in one of the Convention documents but no further information has been found. However, Diazinon data on exports are analysed below. According to European Commission, Diazinon was

[35] Further information on calculation of pricing is given in the methodology under section 2.2

exported to Europe, Africa, Near East, and Latin America and the Caribbean from 2007 to 2013 with an average of 38.45 tons (ranging between min 4.30 and max. 64.88 tons) (European Commission, 2016). EU exporter countries were France, Italy, Slovenia, Germany, Spain, Latvia and the United Kingdom. Those countries exported to Ivory Coast, Ghana, Ukraine, Switzerland, Bahrain, Bosnia and Herzegovina, Saudi Arabia, Lebanon, Kosovo, Hong Kong, Uruguay, Morocco, Croatia, Serbia, Chile, Venezuela, Libya, Qatar, Russia, Congo, Dominican Republic, United Arab Emirates, South Africa, Iran, Brazil, Costa Rica and Australia.

Annual growth rates and geometric average of growth rates of export quantities of Diazinon, 2008-2011 and 2011-2013 shows export quantities (2006-2013) and annual growth rates. In addition, it contains geometric averages of growth rates for the periods 2008-2011 and 2011-2013. There were no exports in 2006.

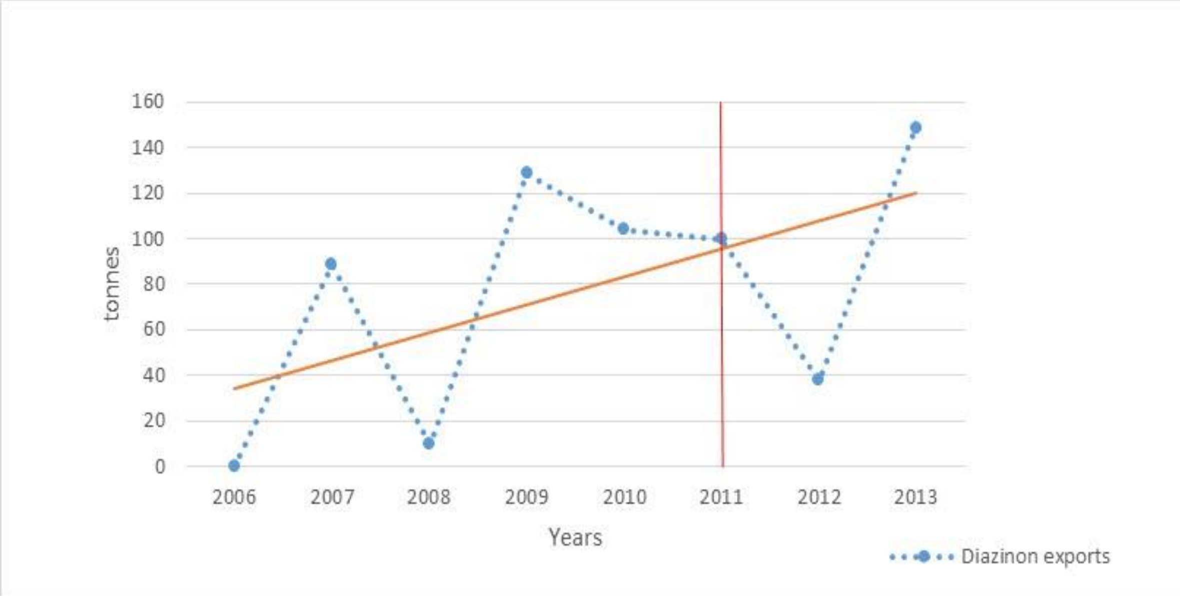
Table 3.16 Annual growth rates and geometric average of growth rates of export quantities of Diazinon, 2008-2011 and 2011-2013[36]

Years	2006	2007	2008	2009	2010	2011	2012	2013
Annual growth rate* $_{(t-t+1)}$	n/a	n/a	-89 % (2007-2008)	1,203% (2008-2009)	-19 % (2009-2010)	-4% (2010-2011)	-62% (2011-2012)	293% (2012-2013)
Geometric average of growth rate*** $_{(2008-2011)}$= 3%							Geometric average of growth rate*** $_{(2011-2013)}$= 13%	

Before 2008-2011 and after 2011-2013 export quantities of Diazinon increased by 3% and 13%, respectively. Thus, no increase in export quantities of Diazinon seems to be reflected in the data after the listing of Aldicarb.

[36] * The annual growth rate is calculated by the formula (Q_t - Q_{t-1}/Q_{t-1}) x 100. ** The geometric average growth rate for 2008-2013 is calculated by the formula ($\prod_{t=1}^{n} annual\ growth\ rate\ t)^{1/n}$= (annual growth rate$_{2008}$ x annual growth rate$_{2009}$ x ….x annual growth rate$_{2013}$)$^{1/6}$. *** The geometric average of growth rate for the period 2008-2011 is calculated by the formula ($\prod_{t=1}^{n} \text{annual growth rate } t)^{1/n}$= (annual growth rate $_{2011}$ x annual growth rate $_{2012}$)$^{1/4}$. **** The geometric average of growth rate for the period 2011-2013 is calculated by the formula ($\prod_{t=1}^{n} annual\ growth\ rate\ t)^{1/n}$= (annual growth rate$_{2013}$ x ….x annual growth rate%$_{2015}$)$^{1/3}$

Figure 3-19 Diazinon export quantity indexed (year of listing 2011 = 100)



Source. BiPRO 2016, from data from European Commission about export quantities in tons

As shown in Figure 3-19 export quantities are quite dispersing in comparison with the trend line. However, this data shows that Diazinon export quantities in European countries in general tend to increase. On the other hand, just after a year of listing export quantities of Diazinon sharply decreased and increased again in 2013. Thus, it cannot be stated that the listing of Aldicarb affects Diazinon trade. Additionally, prices of Diazinon, which was commercialised under the trade name of Gallec, were available in US$ for the period 2002-2008. This period is not relevant for the analysis, thus, this US prices have not been considered in this analysis.

Summary

Table 3.17 summarises the trends for all alternatives assessed and compares this trends with the trends of Aldicarb.

Overall import quantities of Abamectin increased after listing, which also occurred with overall import quantities of Aldicarb. Serbia and Turkey were the only countries from the information analysed in which both substances were available. In the case of Turkey import quantities of Abamectin increased and import quantities of Aldicarb increased, whereas for Serbia import quantities of Abamectin decreased and increased for Abamectin. Thus, substitution of Aldicarb by Abamectin seems to occur only in the case of Serbia. Overall prices of Abamectin tend to decrease after listing, thus it seems that listing did not affected prices of Abamectin. Furthermore, prices of Aldicarb slightly increased after listing. Individual countries as Serbia and Turkey, in which both substances were available, present differences in their trends. In Serbia prices of Abamectin tend to decrease, and prices of Aldicarb to increase. However, in Turkey, prices of both substances decreased. Thus, it seems that prices of Abamectin are not influenced by the listing of Aldicarb.

In the case of Dimethoate, overall import quantities decreased, whereas Aldicarb quantities increased. For Serbia, where both substances were available, it seems no effect is caused by listing as import quantities of both substances decreased. Overall prices of Dimethoate increased, however, Aldicarb prices did too. For Serbia, where both substances were available, prices of both substances increased. Thus it seems that this increase in prices might be caused by other conditions rather than the listing of Aldicarb.

For Diazinon export quantities seem not to be influenced by the listing of Aldicarb as the trend before and after the listing is the same, i.e. it increases

.

Table 3.17 Summary of effects for all alternatives, which data were available, in general (total of all countries)

Alternative	Trend after listing	
	Import quantities	**Import prices**
Abamectin	**Overall import quantities increased** Countries increased: Bangladesh, Madagascar, Serbia, Turkey, Myanmar and Thailand. Countries decreased: Thailand, Malaysia, Lebanon, Philippines and Senegal	**Overall prices tended to decrease** Countries increased: Malaysia, Thailand and Bangladesh Countries decreased: Madagascar, Serbia, Thailand, Myanmar, Turkey and Philippines
Dimethoate	**Import quantities decreased** Countries increased: Malawi, Madagascar and Myanmar Countries decreased: Burundi, Serbia, Thailand and Malaysia	**Prices increased** Countries increased: Serbia, Thailand, Malawi, Myanmar and Malaysia Countries decreased: Burundi and Madagascar
Diazinon	**Export quantities of Diazinon sharply decreased (after year of listing) and increased again in 2013**	**No data on prices**
Aldicarb	**Import quantities increased** For Serbia import quantities decreased For Turkey import quantities increased Burundi and Ecuador only report marginal amounts of imports (<= 1 ton) and only in some years. Malawi only reports imports in 2008, but in none of the years after	**Import prices slightly increased** Import prices for Serbia increased Import prices for Turkey decreased

Conclusions

Nine alternatives for Aldicarb were identified (7 chemical alternatives and 2 non-chemical alternatives). Abamectin, Dimethoate and Imidacloprid can be applied to a broad number of crops and pests. Fenbutine Oxide, Bromopropylate, Fluopyram and Shell white oil along with Diazinon seem to be more selective. Alternatives are used in Jamaica, India and African countries. Furthermore, non-chemical alternatives like integrated pest management programmes and predatory species such as purpureocillium lilacinum are known as being used in some developing countries and economies in transition.

Comparing the alternatives with the use of Aldicarb, Abamectin and Dimethoate can be used as insecticide and acaricide in numerous crops and pests like Aldicarb. However, Fenbutine Oxide and Bromopropylate can be used only as acaricide for red spider mites. On the other hand Imidacloprid and Shell white oil along with Diazinon can be used only as insecticides.

There is a wide number of producers of alternatives, some of them being global companies. Based on the information available, Abamectin and Dimethoate were available[37] in 14 developing countries and economies in transition. Furthermore, Diazinon (Shell white oil along with Diazinon) was available[38] in numerous developing countries and economies in transition.

For these three alternatives no relation between increase on quantities and listing of Aldicarb was observed.

In spite of the overall increase in import quantities of Abamectin after listing of Aldicarb, this trend is obviously not related to the Convention because it tended to increase already before listing. Furthermore, Aldicarb import quantities also increased after listing. The only country for which it seems that the listing leads to the substitution of Aldicarb by Abamectin is Serbia, where import quantities increased for Abamectin and decreased for Aldicarb. Since Serbia is an accession country to the EU and is already in the process of adopting EU legislation, the cause of this increase for Abamectin and decrease for Aldicarb might be that Aldicarb was phased-out in order to comply with EU pesticides legislation. Regarding the prices the listing did

[37] Assuming that there is no post-exporting of the imported quantities
[38] Assuming that there is no post-exporting of the imported quantities

not lead to an inflation of the prices of Abamectin. Overall import prices of Abamectin decreased, whereas import prices of Aldicarb increased after listing.

On the other hand Dimethoate import quantities decreased and Aldicarb quantities increased after listing. Thus, listing of Aldicarb did not lead to a substitution of Aldicarb by Dimethoate. In general, prices of Abamectin tend to decrease after listing, whereas prices of Dimethoate tend to increase, except for Burundi and Madagascar. However, for Aldicarb overall prices slightly increase. Considering these increases in prices of both substances, it could be caused by market reasons rather than the Convention.

In the case of Diazinon, export quantities tend to increase before and after listing. Thus, the increase of export quantities could not be related to the listing of Aldicarb. Diazinon prices were not available.

To sum up, the hypothesis that the listing of Aldicarb leads to a substitution of the substance with alternatives is not certain. However, it might be possible that in the case of Serbia listing leads to the substitution of Aldicarb by Abamectin as import quantities increased for Abamectin and decreased for Aldicarb. Nonetheless, it might be possible that export/import quantities and prices of alternatives are not highly influenced by the listing of Aldicarb as there are 9 alternatives in total and they may compete between them.

3.6 Case study 3: Monocrotophos (CAS No 6923-22-4)

Overview

Monocrotophos is a fast-acting insecticide and acaricide for a broad spectrum of pests and crops. The Rotterdam Convention DGD document (2005) suggests that Monocrotophos has been used to protect cotton, citrus, olives, rice, maize, sorghum, soybeans and tobacco, without naming a specific country or region where these uses have been observed. The WHO (2009) lists cotton, rice, wheat, various types of pulses, ground nut, soyabean, tea, chillies and mango as main crops treated with Monocrotophos is India. Monocrotophos is produced, traded and used in various countries globally. Countries for which evidence of production or use of Monocrotophos has been found are listed in the table below. Note that this list is likely to be not exhaustive.

Table 3.18 Indicative list of countries producing and using Monocrotophos currently or in the past

Production [a]		Use	
Switzerland	Brazil	Belarus [b]	Malaysia [b]
India	Argentina	Ecuador [b]	Serbia [b]
China	Singapore	Macedonia [b]	Turkey [b]
Taiwan		Malawi [b]	India [c]

Sources:
[a)] Based on PAN UK (http://www.pan-uk.org/pestnews/Actives/monocrot.htm) and the list of basic manufacturers form the Decision Guidance Document for Monocrotophos. Only countries where the main manufacturing locations of the respective manufacturer can be clearly attributed to a specific country have been included.
[b)] Based on countries reporting imports of Monocrotophos to FAO and the assumption that at least part of the imports are used domestically and not re-exported.
[c)] Based on the Pesticides Manufacturers & Formulators Association of India (http://www.pmfai.org/images/183/Pesticides%20registered%20for%20use.pdf) and WHO (http://www.searo.who.int/entity/occupational_health/health_implications_from_Monocrotophos.pdf).

Trade names and mixtures: Azodrin, Bilobrin, Crisodrin, Crotos, Glore Phos36, Harcros Nuvacron, MorePhos, Monocil, Monocron, Monocrotophos 60 WSC, Nuvacron 600 SCW, Plantdrin, Red Star Monocrotophos, Susvin, Phoskil 400 (PANAP, 2016)

Main purpose and functionality: Monocrotophos is a contact and systemic organophosphate. Used to control a wide range of pests on a wide range of crops (Rotterdam Convention, 2005).

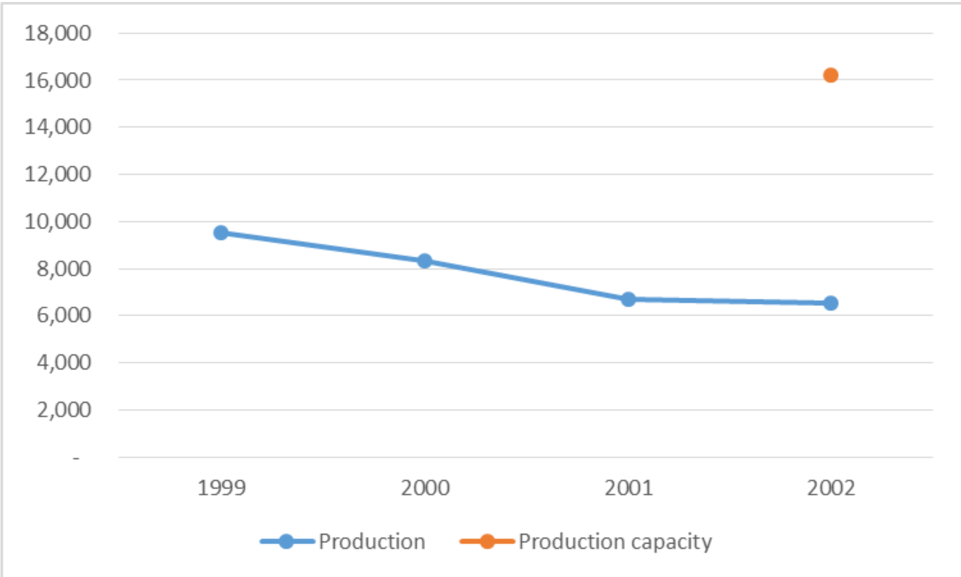
Listing in the Rotterdam Convention: Listed in 2004 after all uses of Monocrotophos have been completely banned in Australia and Hungary.

Production

According to the Decision Guidance Document (2005) there were at least 15 manufacturers from India, China, Taiwan, Singapore, Brazil and Argentina. The Pesticide Action Network Asia and the Pacific (PANAP, 2011) confirms that after the listing there were still active manufacturers of Monocrotophos at least in India and China, so listing has not led to abandoning of Monocrotophos production by all manufacturers in these countries.

According to data from the Pesticides Manufacturers & Formulators Association of India (PMFA, 2016), Monocrotophos production in India decreased from about 9,500 metric tons in 1999 to 6,000 metric tons in 2002[39] which is still before listing, as shown in the figure below. According to the same source, India had a capacity of 16,200 metric tons in 2002.[40]

Figure 3-20 Monocrotophos production quantity and production capacity in India in metric tons[41], 1999-2002.



Source: Amec Foster Wheeler 2016 based on PMFAI (http://www.pmfai.org/images/183/%20Production%20of%20pesticides.pdf)

Production quantities or the number of manufacturers more recently are not available.

Hypothesis: Listing leads to a decrease in production and/or the number of manufacturers of the substance.

- Lack of data post listing means it has not been possible to comment on the outcome of this hypothesis.

Trade

Quantity and value of imports of Monocrotophos for the years 2008-2015 have been submitted to the FAO by 7 countries from various regions of the world. These are listed in the table below. Note that a much larger number of countries has provided data for imports of Monocrotophos aggregated with other pesticides, in most cases with fluoroacetamide and phosphamidon (according to HS code 2924.12). However, this data cannot be used to assess the relevant hypotheses as it is not clear what share of the aggregated imports reported refers to Monocrotophos only, so the impacts of listing on the Monocrotophos market are likely to be masked

[39] Note that the source failed to state a unit for the figures, so metric tons is assumed as the most reasonable estimate based on consumption figures in India of the same magnitude.
[40] Source failed to state a unit, so metric tons is assumed as explained above.
[41] Source failed to state a unit, so metric tons is assumed as explained above.

by developments in the markets of other substances present in the aggregation (i.e. if imports after the listing are reported, it is not clear what share of these import quantities refer to Monocrotophos).

Table 3.19 List of countries that reported imports of Monocrotophos in response to the FAO survey, by region

Africa	Americas	Europe	Western Asia	South-East Asia
Malawi	Ecuador	Belarus	Turkey	Malaysia
		Macedonia		
		Serbia		

Source: Amec Foster Wheeler 2016 based on data from FAO 2016.

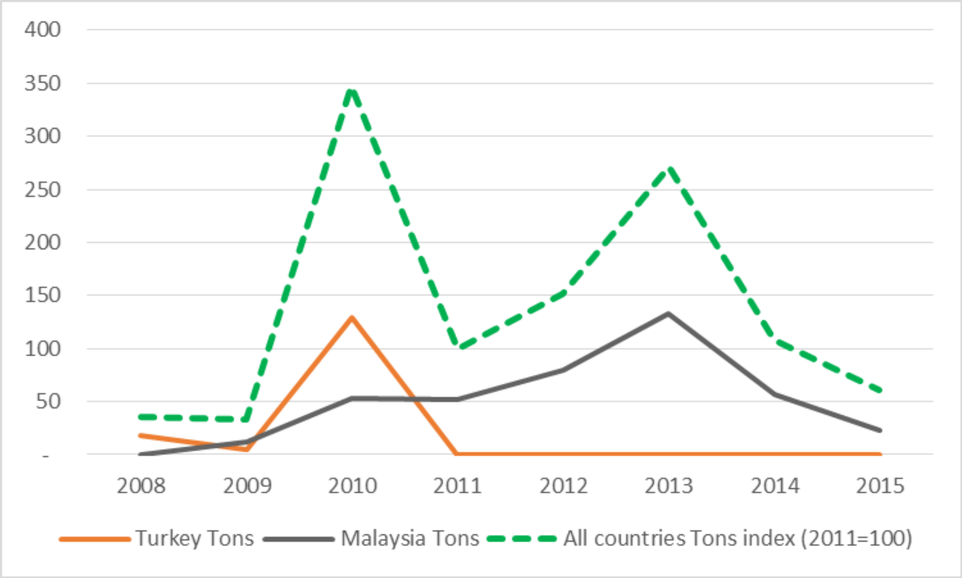
As data has been reported only from 4 years after listing, it cannot be used to assess the short term impact of listing of Monocrotophos in Annex III to the Rotterdam Convention. Furthermore, it is not known if up to the listing in 2004 there were larger imports of Monocrotophos then reported from 2008, so the exact impact of listing cannot be assessed based on this data. However, the data can indicate if Monocrotophos is still traded in the long term and thus if listing has led to the cessation of trade in the long term.

Four countries (Belarus, Ecuador, Macedonia and Serbia) report only marginal imports (<1 ton) and only in some years.

The remaining two countries report significant quantities of Monocrotophos imports after listing, as illustrated in the figure below. Turkey reports small amounts of Monocrotophos imports in 2008 and 2009 (18 and 5 tons respectively). Then, in 2012 it reports a peak import of 129 tons before imports drop to marginal amounts of less than one ton per year from 2011 on. Malaysia first reports imports of Monocrotophos in 2009 (12 tons) which increase until 2013 (133 tons). Afterwards, imports fall back to 23 tons in 2015. These trends do not seem to support the hypothesis that listing has decreased imports of Monocrotophos in the long term in Turkey and Malaysia, as both countries reported increasing imports years after listing, which then dropped again at much later points in time.

The sum of imports of all countries reporting on imports of Monocrotophos in the FAO survey is clearly dominated by the imports of Turkey and Malaysia as can be seen in the peaks in 2010 (Turkey) and 2013 (Malaysia). This provides no additional insight with regard to assessing the hypothesis other than already stated for the Turkey and Malaysia.

Figure 3-21 Monocrotophos import quantity (tons) of Turkey, Malaysia and sum of all countries reporting imports, 2008-2015



Source: Amec Foster Wheeler 2016 based on data from FAO 2016.

Hypothesis: Listing reduces traded volume.

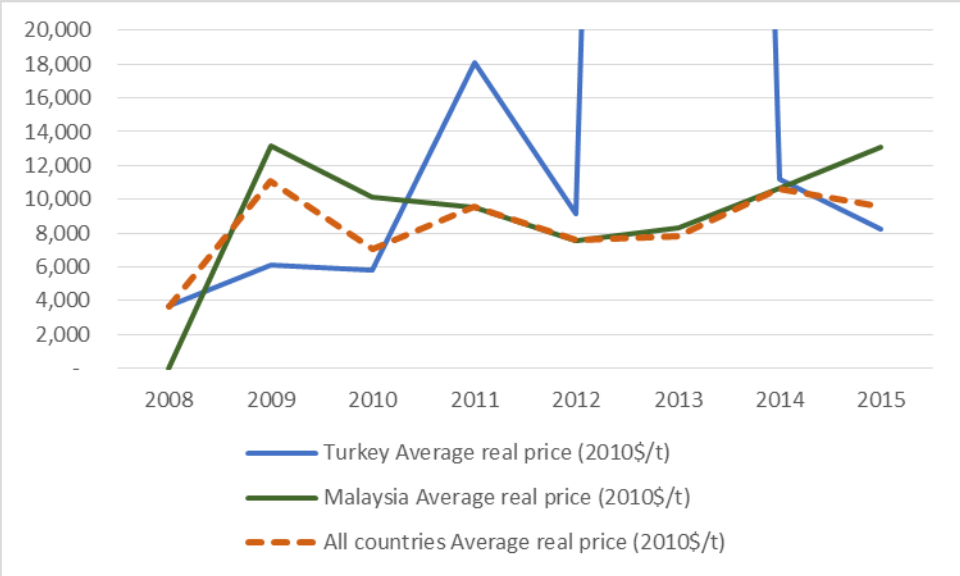
- Turkey and Malaysia reported significant imports years after listing, which would reject the extreme case of the hypothesis that listing of Monocrotophos has led to a (near) cessation of trading of goods. Lack of data pre listing means it has not been possible to comment on the outcome of this hypothesis more generally.

Prices[42]

Average prices of imports of Monocrotophos for the years 2008-2015 have been calculated from import quantity and value data submitted to the FAO. As discussed in the previous section, only Turkey and Malaysia have reported significant imports, so the figure below shows the real average import prices for these two countries, as well as for the sum of imports of all countries reporting imports of Monocrotophos to the FAO.

[42] All prices have been converted to real prices (2010 USD) using the US Wholesale price index from the World Bank (http://databank.worldbank.org/data/reports.aspx?source=2&series=FP.WPI.TOTL&country=).

Figure 3-22 Monocrotophos average real import price (2010 US$/ton) for Turkey, Malaysia and sum of all countries reporting imports, 2008-2015 (USDA, 2016)



Source: Amec Foster Wheeler 2016 based on data from FAO 2016 for all countries except USA, which is based on data from USDA, 2016.

Overall, an increasing trend in prices can be observed for both countries analysed as well as the sum of all countries reporting imports of Monocrotophos.[43] However, as the price level of Monocrotophos for these countries before listing of Monocrotophos in Annex III to the Rotterdam Convention is not available, no meaningful conclusions can be drawn from this data with regards to the hypothesis that listing inflates prices. Given the time between listing and the data at hand, it is not clear if the observed inflation of Monocrotophos could be caused by listing.

Hypothesis: Listing inflates prices

- Lack of data pre listing means it has not been possible to comment on the outcome of this hypothesis.

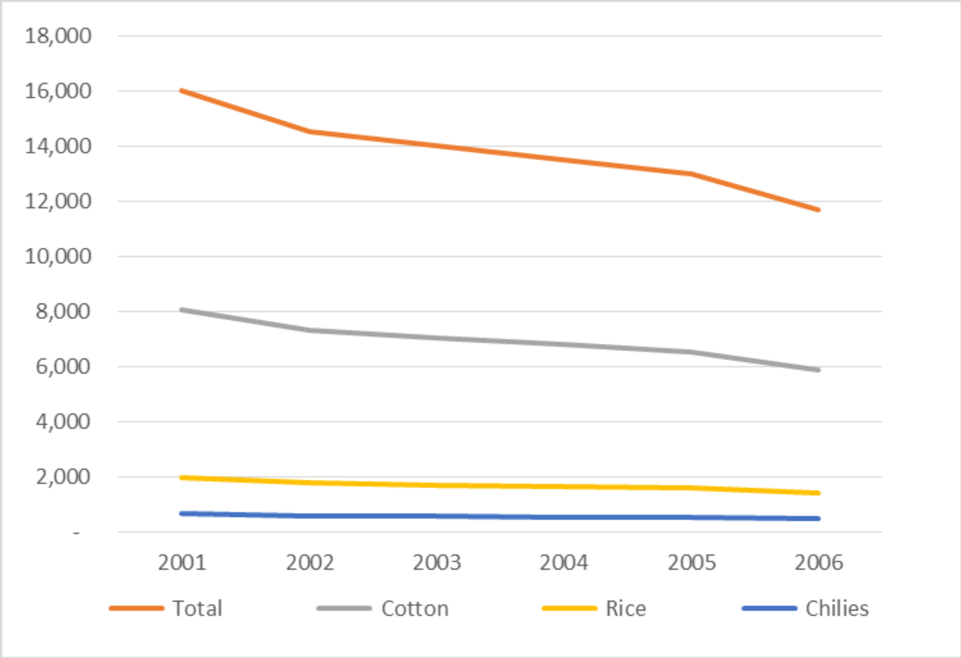
Application/Use

Monocrotophos has been used in a wide range of countries. An article from 1997 indicates that at the time Monocrotophos was registered in approximately 60 countries and the total sales of Monocrotophos accounted for about 3% of all insecticide products. Data on the current number of countries using Monocrotophos, or on the numbers more shortly before and after listing is not available, so no conclusion can be drawn with regards to whether or not listing of Monocrotophos in Annex III to the Rotterdam Convention has led to countries ceasing to use Monocrotophos.

Data on the quantities of Monocrotophos used is available for India in the years around listing (2001-2006) from a WHO report (WHO, 2009). The figure below shows the amount of Monocrotophos applied to the three crops with the highest amount of Monocrotophos application and the total amount of Monocrotophos applied to all crops.

[43] Note that the strong fluctuation of prices for Turkey after 2010 may mostly be caused by the small sample they are based on, i.e. very small amounts of imports, as discussed in the previous section.

Figure 3-23 Monocrotophos application (metric tons per year) in India for selected crops and the total of all crops 2001-2006



Source: Amec Foster Wheeler 2016 based on data from WHO (2009).

Cotton is clearly the crop accounting for the majority of Monocrotophos usage in India. For all crops, a constant reduction in the application of Monocrotophos can be observed throughout the whole period (2001-2006). Hence, already before listing, use of Monocrotophos was decreasing in India. However, the absolute value of the compound annual growth rate (CAGR) of Monocrotophos use was higher in the years after listing (-6.9% in 2004-2006) than before (-5.5% in 2001-2002). This means that on average the reduction in use volumes seems to have been more rapid in the years after listing of Monocrotophos in Annex III to the Rotterdam Convention than before, which is consistent with the hypothesis that listing led to a reduction of use of Monocrotophos in India, but the general decreasing trend suggests a wider phasing-out of Monocrotophos use unrelated to the Rotterdam Convention. Note that no statistical significance testing was undertaken.

The CAGR for all crops was identical[44], suggestion that the breakdown by crops was based on simplifying assumptions rather than reported data. An analysis by crops therefore provides no additional evidential value regarding the hypothesis.

Hypothesis: Listing leads to a reduction in use volumes of the substance.

Very limited data exists to confirm or refute this hypothesis. An examination of data from India shows trends consistent with the hypothesis, but these are also potentially explained by a wider phasing-out of Monocrotophos use unrelated to the Rotterdam Convention.

Analysis of alternatives to Monocrotophos

A total number of 18 alternatives have been identified. From these alternatives 16 are chemical alternatives and 2 are non-chemical alternatives.

Chemical alternatives: Acetamiprid, Alpha-Fenvalerate, Alphamethrin, Carbamate, Chlorpyrifos, Cypermethrin, Dimethoate, Dicofol, Fenitrothion, Indoxacarb, Malathion, Profenofos and Pyrethroids. Not all of them however, can be used for all crops, and information on user countries is limited to Sahel and India. Acetamiprid, Chlorpyrifos, Cypermethrin, Dimethoate, Dicofol, Indoxacarb, Malathion and Profenofos are used in a broad number of crops. However, Pyrethroids, Fenitrothion and Alpha-Fenvalerate are only used in one

[44] With the exception of a few crops with relatively small quantities of Monocrotophos use.

crop. On the other hand, for Alphamethrin and Carbamate crops could not be identified (for further details about uses, producers and user countries please see Table C.5 in Appendix C).

Furthermore a pesticide manufacturer provided information stating that Spirotetramat, Thiacloprid and Imidacloprid are chemical alternatives to Monocrotophos available in African countries (FAO, 2016a).

Non-chemical alternatives: azadirachtine and bacillus thuringiensis and its varieties. They can be used in a wide number of crops. However, information on user countries is limited to India and Sahel (for further details about uses, producers and user countries please see Table C.7 in Appendix C).

Producers of alternatives to Monocrotophos are listed in Table C.8 in Appendix C. Numerous producers were identified. Some of them are global producers of pesticides. Furthermore, there are also Indian and African companies.

A pesticide manufacturer provided information stating that bacillus thrungiensis is used as a non-chemical alternative in African countries (FAO, 2016a). Furthermore one Indian producer of neem products (insecticides, fungicides and fertilizers) gave information on azadirachtin. The producer indicated that its products are manufactured in India and 50% of them are exported to mainly African, Middle East, South East Asian countries, the USA and some EU countries. Its main competitors are in India (FAO, 2016a). Information on trade names, crops, pests and annual production of those products is provided Appendix C in Table C.7. Prices differ depending on the different products.

Analysis of short- and long-term impacts on alternative substances markets

- Availability of alternative substances

As the Conference of the Parties agreed to list Monocrotophos in Annex III at its first meeting between 20-24 September 2004, short- and long-term impacts on markets are assessed for the time periods 2002-2004 and 2004-2008 for prices in US$ for alternatives for which data are available. Furthermore, since FAO data was available for 2008-2015 and data on quantities exported from the EU was available for 2006-2013, import/export quantities as well as prices before and short-term after listing could not be assessed. Only long-term impacts after listing were assessed.

Based on the available data an analysis is provided here for seven of the main chemical alternatives to Monocrotophos, namely Chlorpyrifos, Cypermethrin, Dicofol, Dimethoate, Fenitrothion, Indoxacarb and Malathion. In the case of Fenitrothion only availability in developing countries and economies in transition could be assessed. This analysis covers time period 2008-2015 for imports and the time period 2006-2013 for exports. It will identify developing countries and economies in transition, where alternatives have been exported / imported, in order to assess their availability[45]. The analysis will also consider export / import quantities and import prices of these alternatives, in order to determine if they have been affected by listing of Monocrotophos (in 2004) in long-term. Table 3.20 provides an overview of the analysis as well as which variables are consider.

Table 3.20 Analysis overview

Scope	Variables	Reason of analysis
Import export/ quantities	▶ Annual growth rates, geometric average growth rates 2008-2015 of import quantities ▶ Annual growth rates, geometric average growth rates 2006-2013 of export quantities (after listing) ▶ Import quantities in tons in total and by country	In order to know if there is a change on trend of export/ import quantities after listing of Monocrotophos in long-term. Especially if import quantities after listing (2011-2015) tended to increase or export quantities after listing tended to rise (2011-2013).

[45] Assuming that imports are not re-exported

	▶ Export quantities after listing in tons in total	
Import prices	Real import price (2010 US$/ton) in total and by country	In order to show if there is a change on import prices trend after listing of Monocrotophos in long-term. Especially if import prices after listing (2008-2015) tended to rise.

Additionally, prices in US are also considered in the analysis for the period 2002-2008 in order to assess short-term impact in prices of alternatives. Prices for this period were not available for developing countries and economies in transition, with the exception of India. Indian prices were available for some substances from 2005-2010.

Furthermore a summary is provided at the end of this analysis in Table 3.25, which summarises trends on export / import quantities and prices of alternatives and compares them with the trends on Monocrotophos. This will sum up if there is any effect on import quantities and prices (i.e. increase) after listing of Monocrotophos.

Analysis

Chlorpyrifos

According to FAO, Chlorpyrifos has been imported from 2008 to 2015 by 12 developing countries and economies in transition from Europe (Serbia and Turkey), Near East (Lebanon), Africa (Burundi, Malawi, Madagascar and Senegal), Latin America and the Caribbean (Ecuador) and Asia (Thailand, Bangladesh, Myanmar and Malaysia) (India, 1968).

Lebanon, Senegal and Ecuador reported marginal imports (e.g. imported less or close than 1 tone) or sporadic imports (e.g. imported not all years). Thus these imports were not considered in the current analysis.

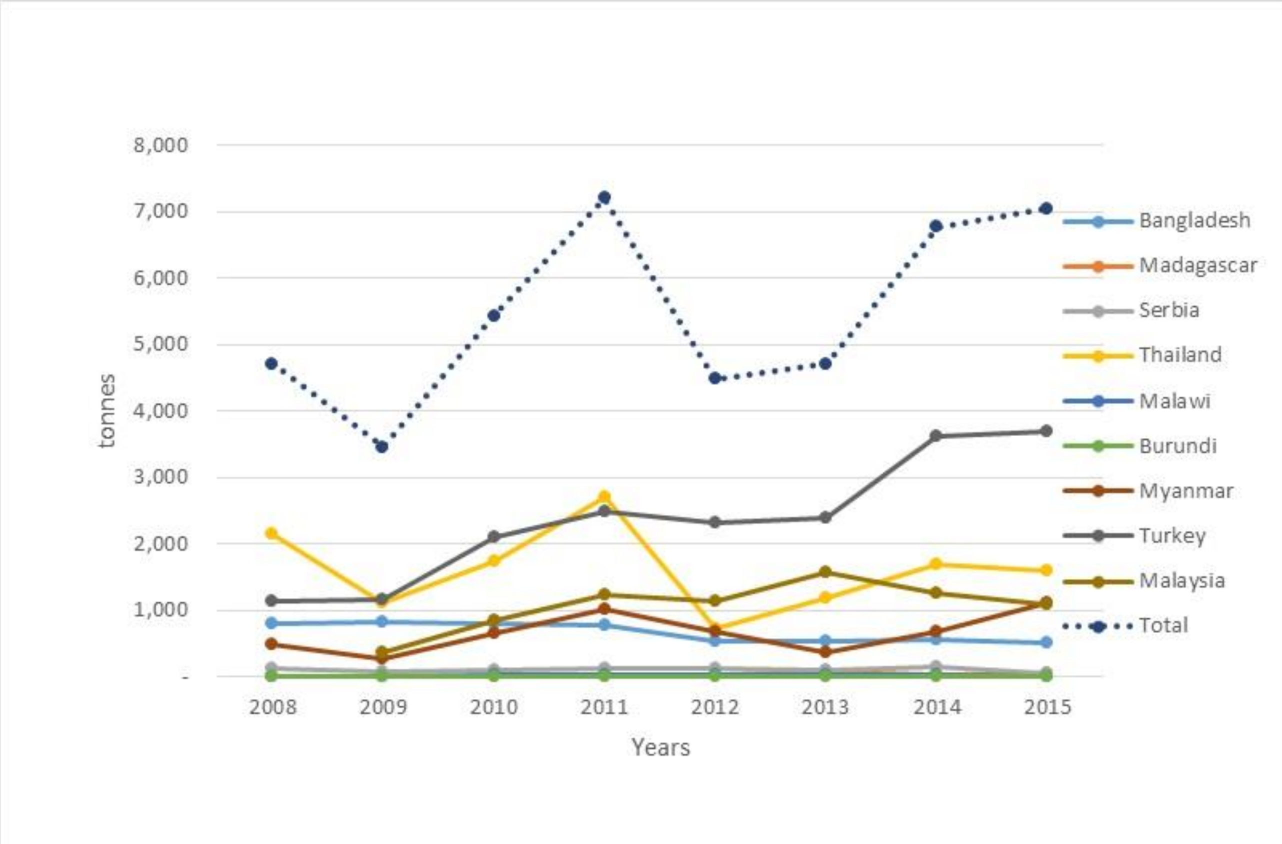
Figure 3.24 and Figure 3.25 shows the annual growth rates (%) of import quantities of Chlorpyrifos in tons for the period 2008-2015 as well as the growth average rate for period 2008-2015.

Table 3.21 Annual growth rates and geometric average of growth rate 2008-2015[46] of import quantities of Chlorpyrifos

Years	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**
Annual growth rate* $_{(t\text{-}t+1)}$	-27%	57 %	33%	-38%	5%	43%	4%
Geometric average of growth rate** $_{(2008\text{-}2015)}$ = 6%							

[46] * The annual growth rate is calculated by the formula (Q_t - Q_{t-1}/Q_{t-1}) x 100. ** The geometric average growth rate for 2008-2015 is calculated by the formula $\left(\prod_{t=1}^{n} annual\ growth\ rate\ t\right)^{1/n}$ = (annual growth rate$_{2008}$ x annual growth rate$_{2009}$ x ….x annual growth rate$_{2015}$)$^{1/8}$.

Figure 3-24 Chlorpyrifos import amounts (tons)



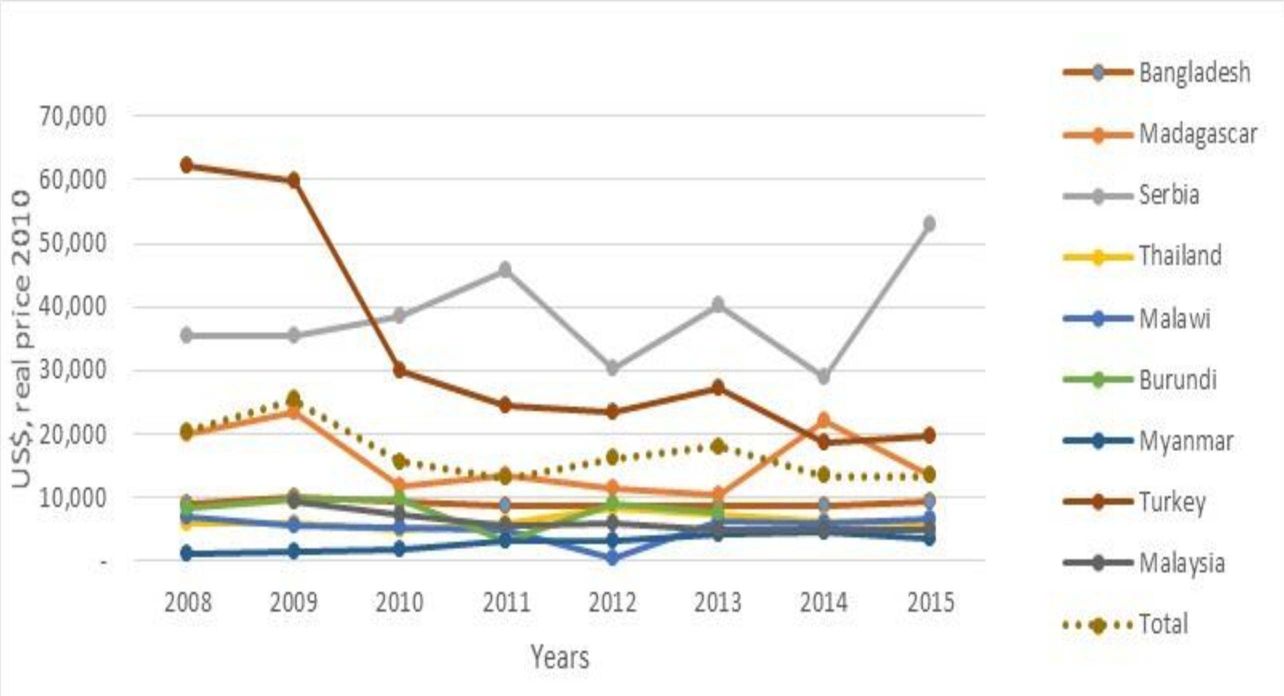
Source. BiPRO 2016, from data from FAO

Overall import quantities tend to increase except for the periods 2008-2009 and 2011-2012. If the hypothesis were that before listing quantities decreased, the general increase from 2008-2015 would have been caused by listing of Monocrotophos. As this hypothesis is uncertain, this could not be confirmed.

For Turkey import quantities followed a clear trend to increase. Malaysia and Myanmar import quantities tend to increase, despite some slightly decreases for some years. In the case of Burundi and Serbia import quantities remained rather stable. In the case of Thailand, quantities decreased from 2008-2009 and 2011-2012 and 2014-2015, and increased for the rest of the periods. Import quantities of Bangladesh and Thailand decreased for the period 2008-2015.

For countries that reported marginal imports such Lebanon, Senegal and Ecuador there are differences. In the case of Lebanon import quantities slightly increased for all periods, except for 2014-2015. In the case of Senegal import quantities decreased from 2008-2009 and 2011-2012 and increased again in 2014 (imports were reported only for those years). In the case of Ecuador import quantities slightly increased from 2008-2015, despite some decreases in 2008-2009 and 2010-2011.

Figure 3-25 Chlorpyrifos average real import price (2010 US$/ton)[47]



Source. BiPRO 2016, from data from FAO

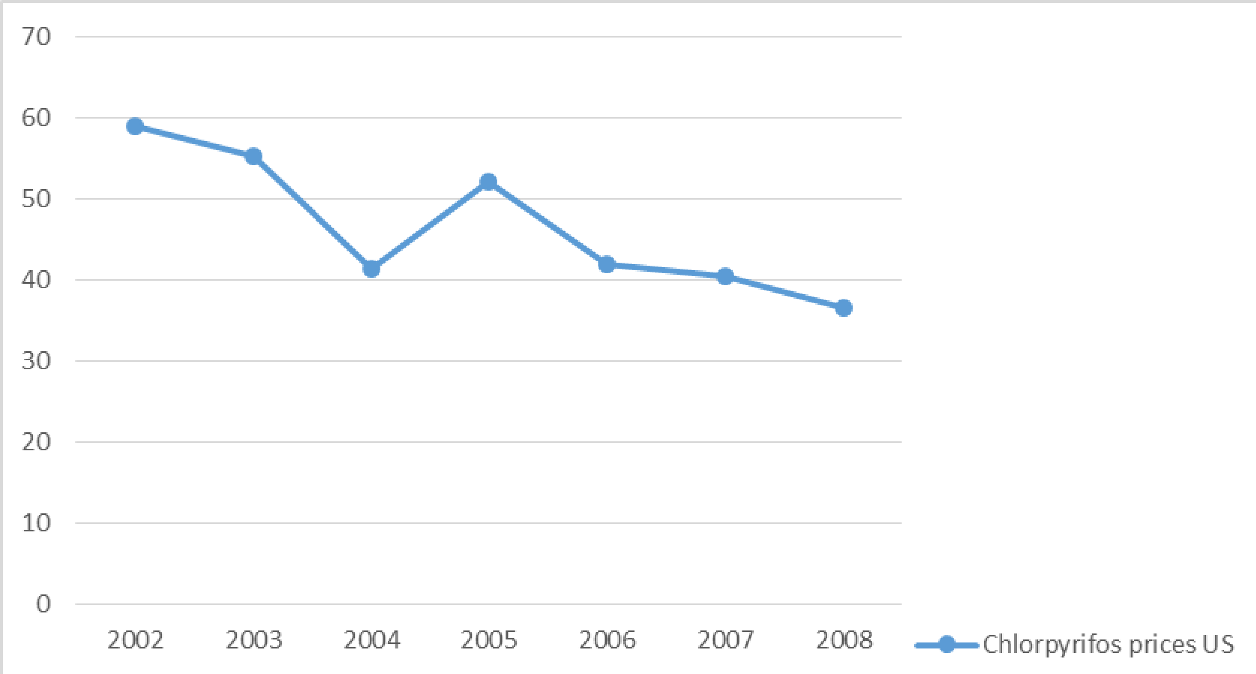
Overall import prices decreased. As they decrease, listing of Monocrotophos did not cause any long-term impact in prices. For short-term impact it is uncertain as prices are not available after 0-2 years after the listing. In the cases of Bangladesh, Thailand, Malawi, Burundi, Myanmar and Malaysia import prices remained rather stable. However, in the case of Serbia there is an increase in import prices from 2008 to 2011, 2012-2013 and 2014-2015. In the case of Turkey, there is a clear trend of prices to decrease. For Madagascar import prices decreased in general, except for the periods 2008-2009, 2010-2011 and 2013-2014.

For countries that reported marginal or sporadic imports such Lebanon, Senegal and Ecuador there are differences in the trends. For Senegal prices could not be calculated as US$ import values were not provided. Ecuador and Senegal prices increased.

Furthermore data on demand, production, imports and prices were available for the period 2005-2010 for India. This is provided in Table 70 Appendix E. Analysis of impacts on the prices from India could not be done as prices were not available before listing of Monocrotophos. However, Indian prices for Chlorpyrifos decreased from 2005-2010. Additionally, prices of Chlorpyrifos, which was commercialised under the trade name of Lorsban, were available in US$ (US$ real price/gallon) for the period 2002-2008. These prices are represented in Figure 3.26.

[47] Further information on calculation of pricing is given in the methodology under section 2.2

Figure 3-26 Chlorpyrifos average real price (2010 US$/gallon)[48]



Source. BiPRO 2016

The trend on US$ prices for Chlorpyrifos is to decrease for the period 2002 to 2008. Before and after listing of Monocrotophos prices of Chlorpyrifos decreased. The only year when prices increased was one year after the listing of Monocrotophos (2004-2005).

Cypermethrin

According to data from FAO, Cypermethrin has been imported by 10 developing countries and economies in transition from Asia (Bangladesh, Thailand, Malaysia and Myanmar), Near East (Lebanon), Africa (Madagascar, Senegal, Malawi), Europe (Serbia) and Latin America and Caribbean (Ecuador) from 2008 to 2015 (India, 1968).

Lebanon, Senegal and Ecuador reported marginal imports (e.g. imported less than one ton) or sporadic imports (e.g. imported not all years). Thus, these imports were not considered in the current analysis. Figure 3.27 and Figure 3-28 show imports in tons and average real import price (2010 US$/ton) of those countries for the period 2008-2015 (FAO, 2016b).

Table 3.22 shows the annual growth rates (%) of import quantities of Cypermethrin (in tons) for the period 2008-2015 as well as the growth average rate for period 2008-2015.

Table 3.22 Annual growth rates of Cypermethrin and geometric average of growth rate 2008-2015[49] of import quantities of Cypermethrin

Years	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Annual growth rate* $_{(t\text{-}t+1)}$	2%	-6 %	19%	-22%	13%	-15%	34%
Geometric average of growth rate** $_{(2008\text{-}2015)}$= 2%							

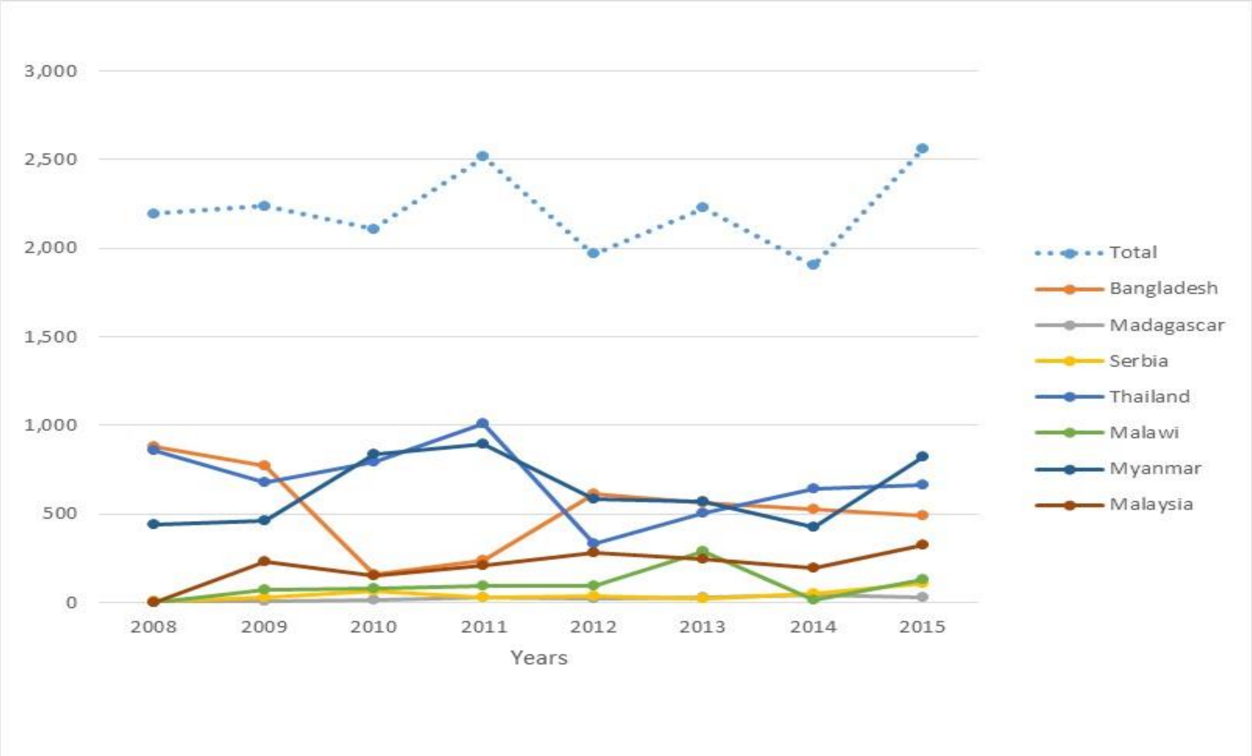
[48] Further information on calculation of pricing is given in the methodology under section 2.2

[49] * The annual growth rate is calculated by the formula (Q_t - Q_{t-1}/Q_{t-1}) x 100. ** The geometric average growth rate for 2008-2015 is calculated by the formula ($\prod_{t=1}^{n} annual\ growth\ rate\ t$) $^{1/n}$= (annual growth rate$_{2008}$ x annual growth rate$_{2009}$ x ….x annual growth rate$_{2015}$)$^{1/8}$.

Import quantities increase from 2008-2015. If the hypothesis were that before listing quantities decreased, the increase of 2% (2008-2015) would have been caused by listing of Monocrotophos. As this hypothesis is uncertain, this could not be confirmed.

Figure 3.27 and Figure 3-28 show imports in tons and average real import price (2010 US$/ton) of those countries for the period 2008-2015 (FAO, 2016b).

Figure 3-27 Cypermethrin import amounts (tons)



Source. BiPRO 2016, from data from FAO

Overall import quantities range between 1,903 and 2,557 tons. Import quantities increase for periods 2008-2009, 2010-2011, 2012-2013 and 2014-2015, however for the rest of the periods decreased. In general prices increased from 2008-2015. If the hypothesis were that before listing prices decreased, these increase from 2008-2015 would have been caused by the listing of Monocrotophos. As this hypothesis is uncertain, this could not be confirmed.

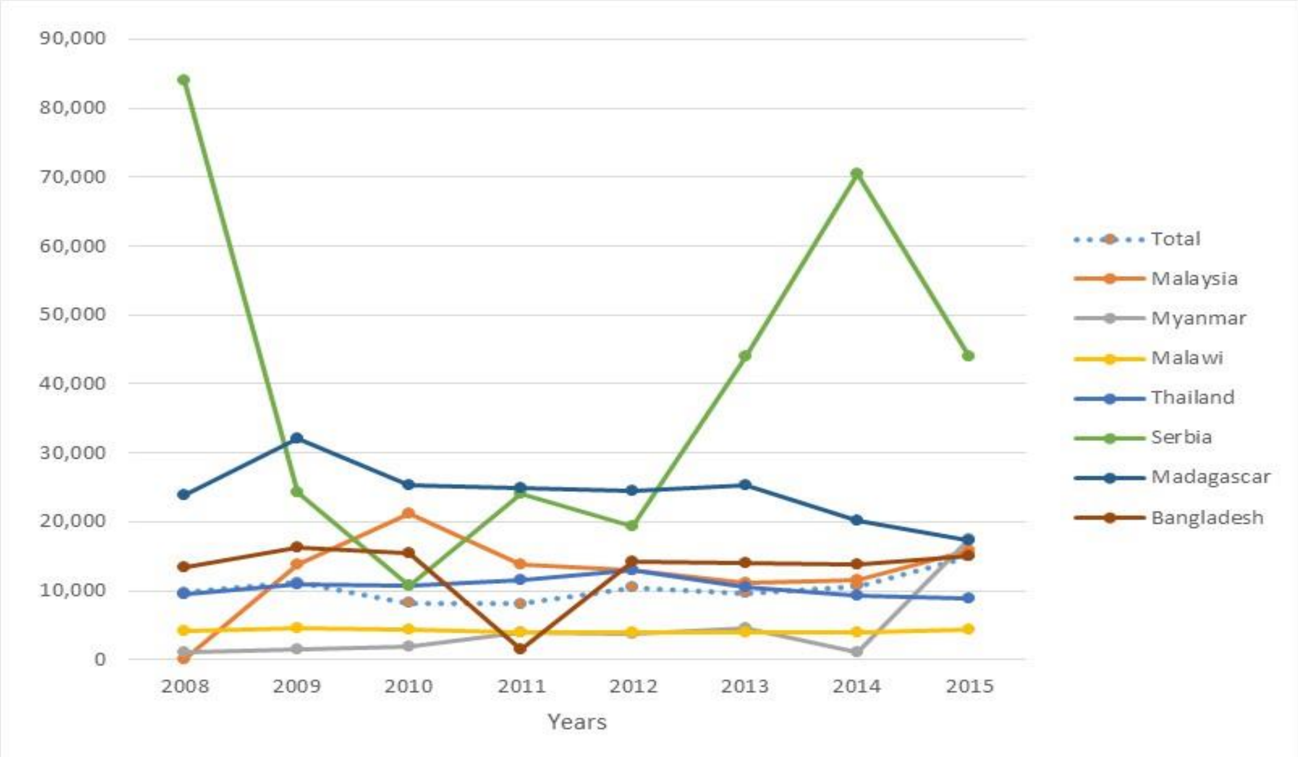
In the case of Serbia and Madagascar import quantities remained quite stable. However in the case of Malaysia there is a trend to increase import quantities from 2008-2015. In Malawi import quantities increased for all periods, except for 2013-2014. In the case of Myanmar import quantities tend to decrease until 2014 and reach a level similar to 2011 in 2015. In Thailand import quantities tend to decrease in general for the period 2008-2015.

For countries that reported marginal or sporadic imports such Lebanon, Senegal and Ecuador the import quantities remain stable below 1 ton.

Overall import prices seem to increase slightly. If the hypothesis were that before listing prices decreased, this slight increase from 2008-2015 would have been caused by listing of Monocrotophos. As this hypothesis is uncertain, this could not be confirmed.

In the case of Madagascar prices tended to decrease. For Malawi and Thailand prices remained rather stable. Bangladesh import prices remain stable too, except for the year 2011, for which it fell until 1,424.21US$/ton. In the case of Myanmar, import prices slightly increased until 2013, fell in 2014 and again increased in 2015. However import prices of Serbia are quite fluctuant, it sharply fell from 2008-2010 and 2014-2015, and sharply increased from 2010 to 2014. For countries that reported marginal or sporadic imports such Lebanon, Senegal and Ecuador there are differences in the trends. Import prices in Lebanon increased from 2011-2012 and decreased from 2012-2014 (only years with available data). Import prices in Ecuador increased from 2008-2009, 2010-2011 and 2013-2014, and decreased during the rest of the periods. In the case of Senegal import prices could not be calculated as imported values (US$) were not available.

Figure 3-28 Cypermethrin average real import price (2010 US$/ton)[50]



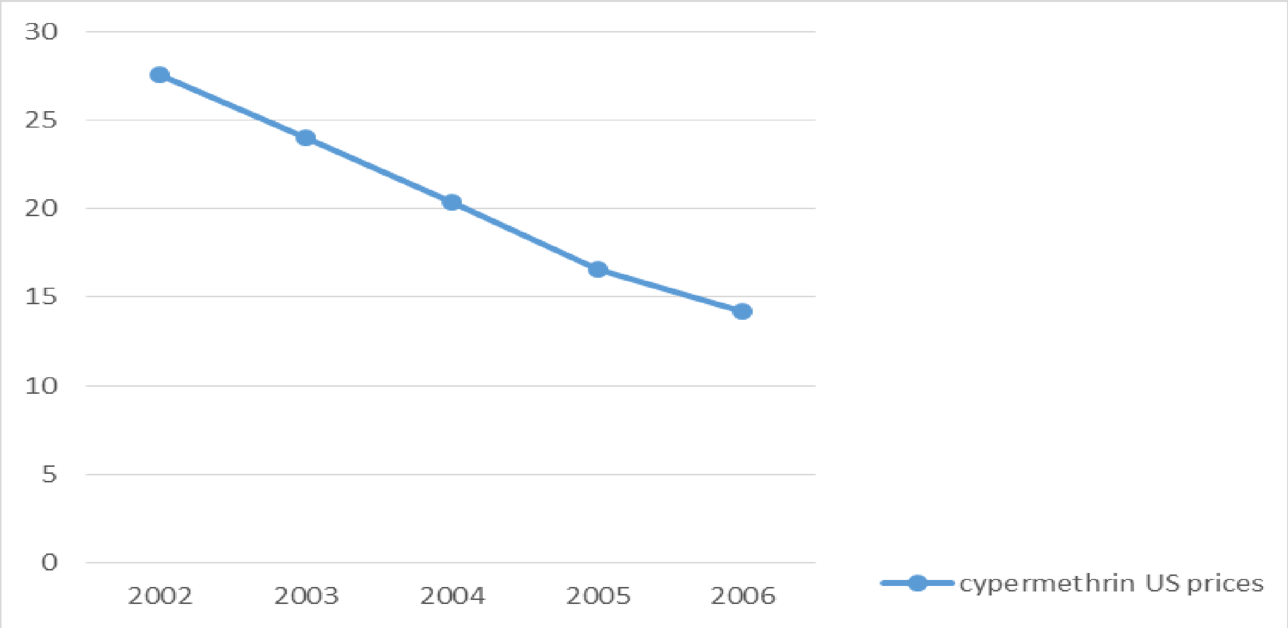
Source. BiPRO 2016, from data from FAO

Furthermore, data on demand, production, imports and prices were available for the period 2005-2010 for India. This is provided in Table 71 in Appendix E.

Analysis of the prices and imports from India could not be done as data was not available before listing of Monocrotophos. Figure 3-29 provides Cypermethrin average real price (2010 US$/gallon), there is a clear trend of US$ prices of Cypermethrin to decrease. Cypermethrin prices fell from 27.6 (2002) to 14.23 (2006) US$ real prices 2010/gallon.

[50] Further information on calculation of pricing is given in the methodology under section 2.2

Figure 3-29 Cypermethrin average real price (2010 US$/gallon)[51]

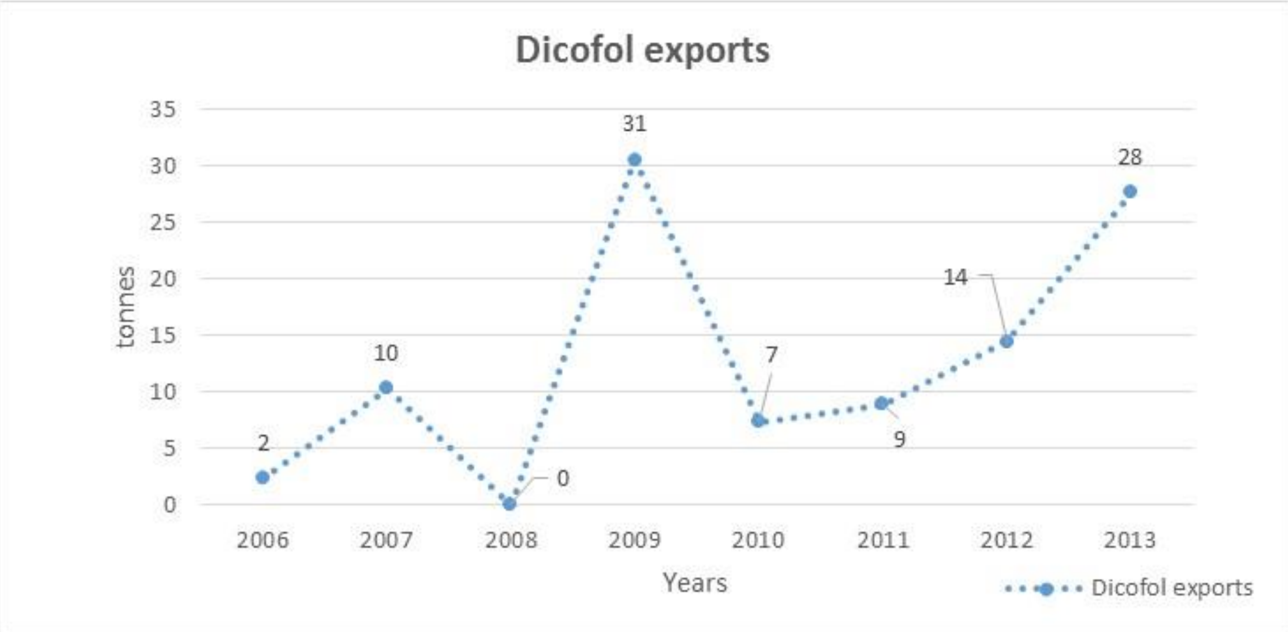


Source: BiPRO, 2016 from data from United States Department of Agriculture (USDA, 2016)

Dicofol

According to data from European Commission, Dicofol has been exported to African countries and Latin America and the Caribbean from 2006 to 2013 with an average of 14.52 tonnes (ranging between min. 2.34 and max. 30.53 tonnes) (European Commission, 2016). For the years 2004 and 2005 there was no reported exports of Dicofol, thus those years could not be evaluated. It was exported from 3 EU countries (Spain, United Kingdom and France). Importer partners were 5 countries (Morocco, Mauritania, Senegal, Niger and Dominican Republic). Figure 3.30 presents the total exports expressed in tonnes of these 3 European countries for the period 2006-2013.

Figure 3-30 Export amounts (tonnes)



[51] Further information on calculation of pricing is given in the methodology under section 2.2

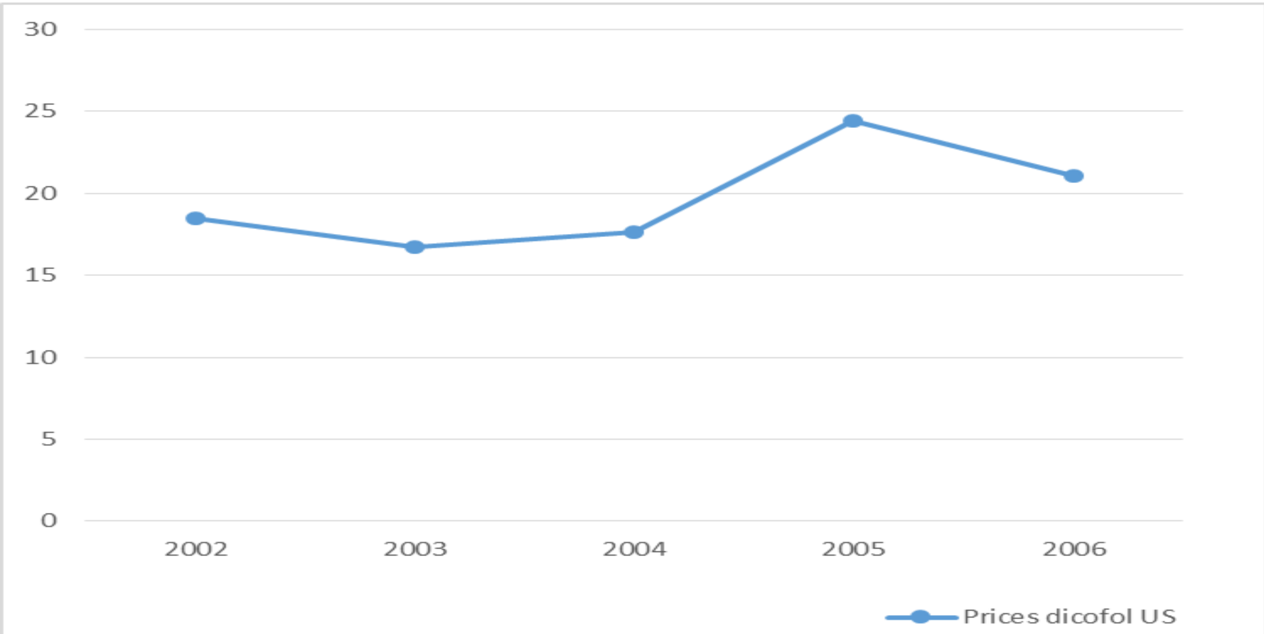
BiPRO 2016, from data from European Commission about export quantities in tonnes

Export quantities of Dicofol tended to increase from 2006 to 2013, except for the periods 2007-2008 and 2009-2010. If the hypothesis were that before listing quantities decreased, these increase from 2006-2013 would have been caused by the listing of Monocrotophos. As this hypothesis is uncertain, this could not be confirmed.

Furthermore, data on demand and production of Dicofol were available for the period 2005-2010 for India. This is provided in Table 72 in Appendix E

Additionally, prices of Dicofol, which is commercialised under Kelthane, were available in U$ for the period 2002-2006. These prices are provided in Figure 3-31 . For the period 2002- 2006 there is a trend of prices of Dicofol to increase from 18.45 (2002) to 21.07 (2006) US$ (real price 2010/gallon). Major increase occurred for the period 2004-2005 (one year after listing), followed by a decrease on the price in 2006. Since prices increased right after listing, it seems that the listing affected prices of Dicofol in US$. However, this hypothesis cannot be confirmed because between 2005 and 2006 prices sharply decreased. It might be possible that those changes in prices are caused by other market conditions rather than the Convention.

Figure 3-31 Dicofol average real price (2010 US$/gallon)[52]



Source: BiPRO, 2016 from data from United States Department of Agriculture (USDA, 2016)

Dimethoate

According to data from FAO, Dimethoate has been imported to 10 developing countries and economies in transition from 2008-2015 from Europe (Serbia), Africa (Burundi, Madagascar, Senegal and Malawi), Asia (Thailand, Myanmar and Malaysia), Near East (Lebanon) and Latin America and the Caribbean (Ecuador). Since the analysis in section 3.5 for Dimethoate in the case of Aldicarb was done considering 2011 as a base year and this is not applicable to the case of Monocrotophos, imported tons and import prices are represented below without being indexed to 2011.

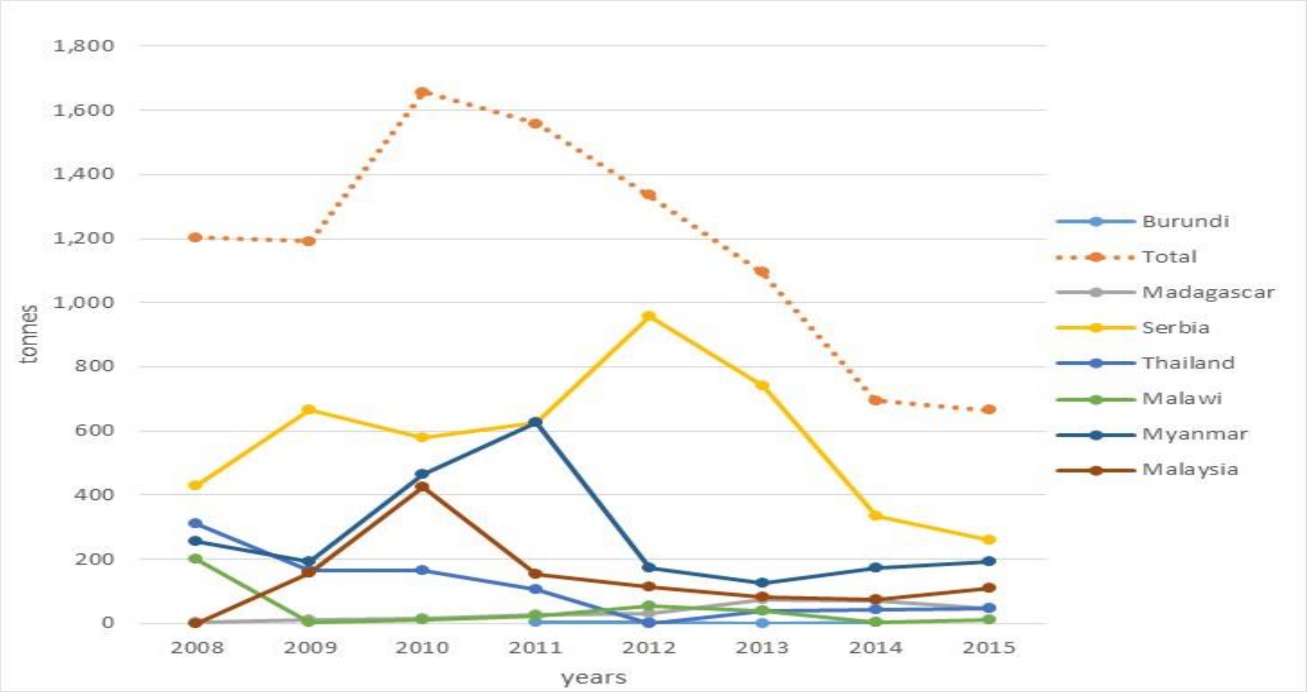
Lebanon, Senegal and Ecuador reported marginal imports (i.e. imported less than 1 ton) or sporadic imports (i.e. imported not all years). Thus, these imports were not considered in Figure 3.32, ,

Figure 3-33 and Figure 3.34 show imports in tons and import real prices of 7 countries for the period 2008-2015 (India, 1968).

[52] Further information on calculation of pricing is given in the methodology under section 2.2

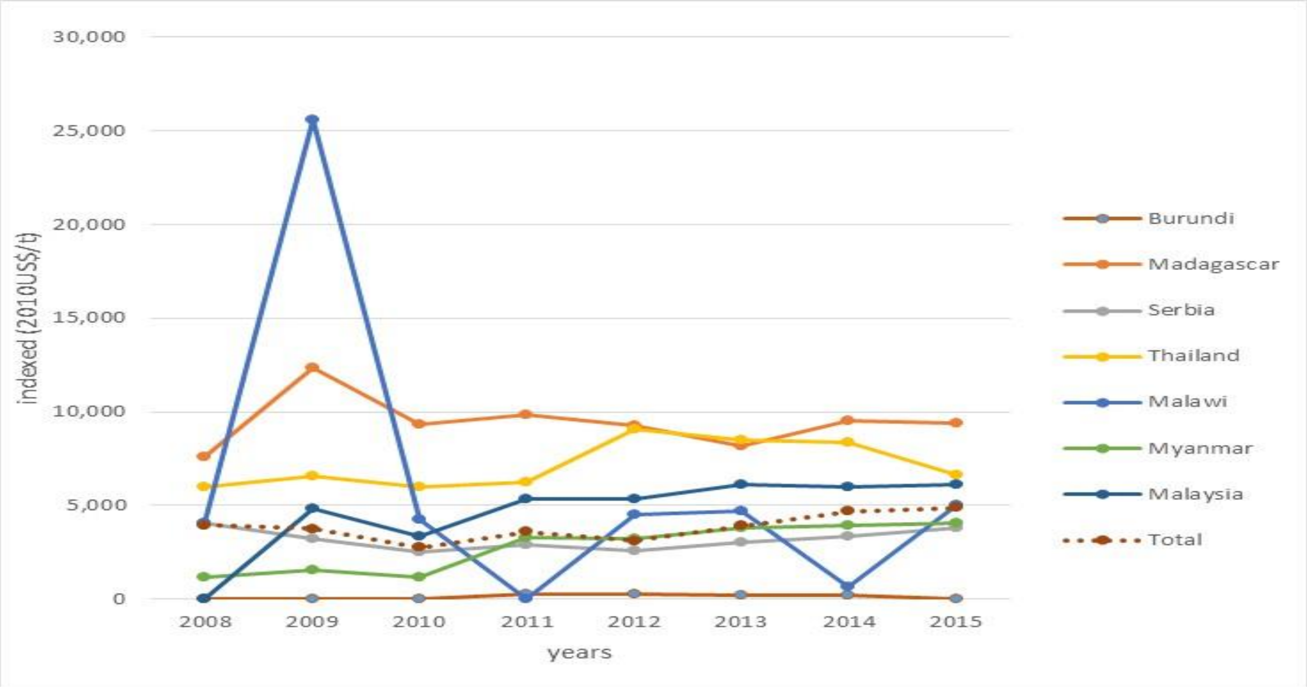
Figure 3-34 excludes Malawi import prices in order to show more clearly the effect in prices for other countries, as Malawi import prices fluctuate strongly. Figure 3.36 excludes Malawi import prices in order to show more clearly the effect in prices for other countries, as Malawi import prices fluctuate strongly.

Figure 3-32 Dimethoate import amounts (tons)



Source. BiPRO 2016, from data from FAO

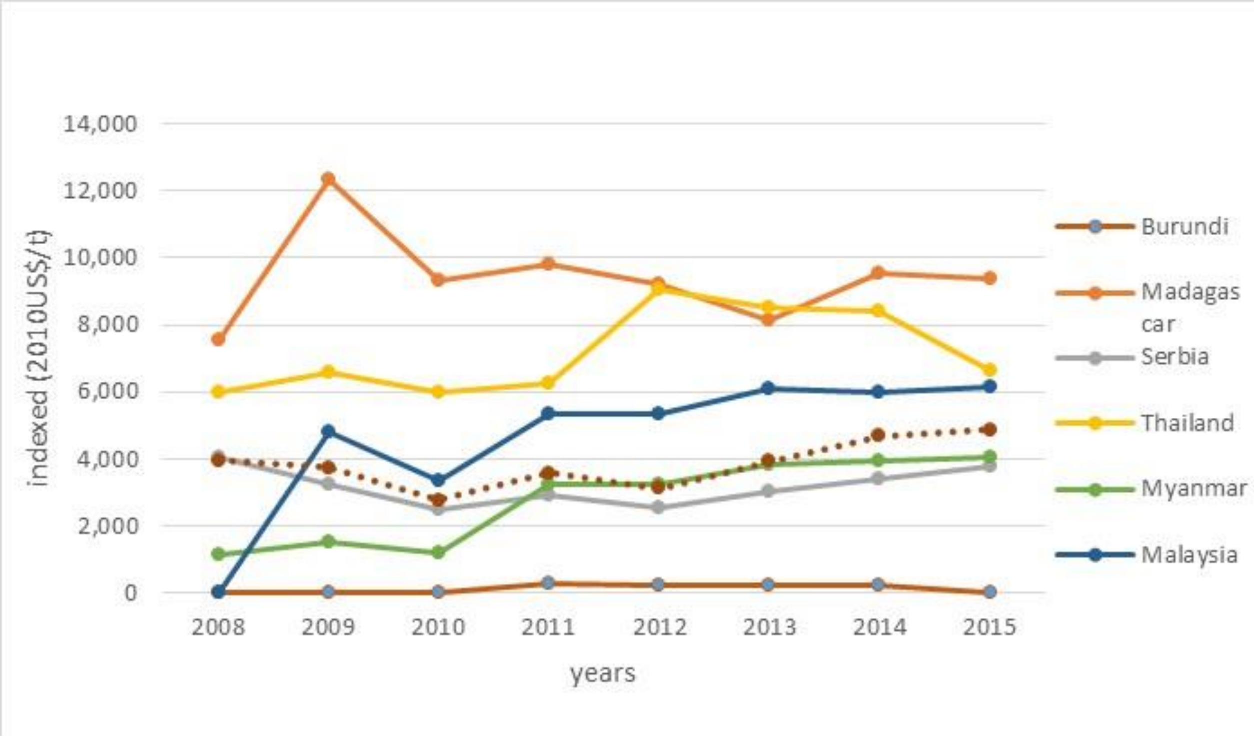
Figure 3-33 Dimethoate average real import price (2010 US$/ton)[53]



Source. BiPRO 2016, from data from FAO

[53] Further information on calculation of pricing is given in the methodology under section 2.2

Figure 3-34 Dimethoate average real import price by country, excluding Malawi (2010 US$/ton)



Source. BiPRO 2016, from data from FAO, 2016b

Overall import quantities decreased from 2008-2015. Countries like Serbia, Myanmar and Malaysia followed the trend to decrease import quantities. In Malawi, Thailand and Madagascar import quantities tended to decrease too, however this decrease is not as sharp as in the rest of the countries.

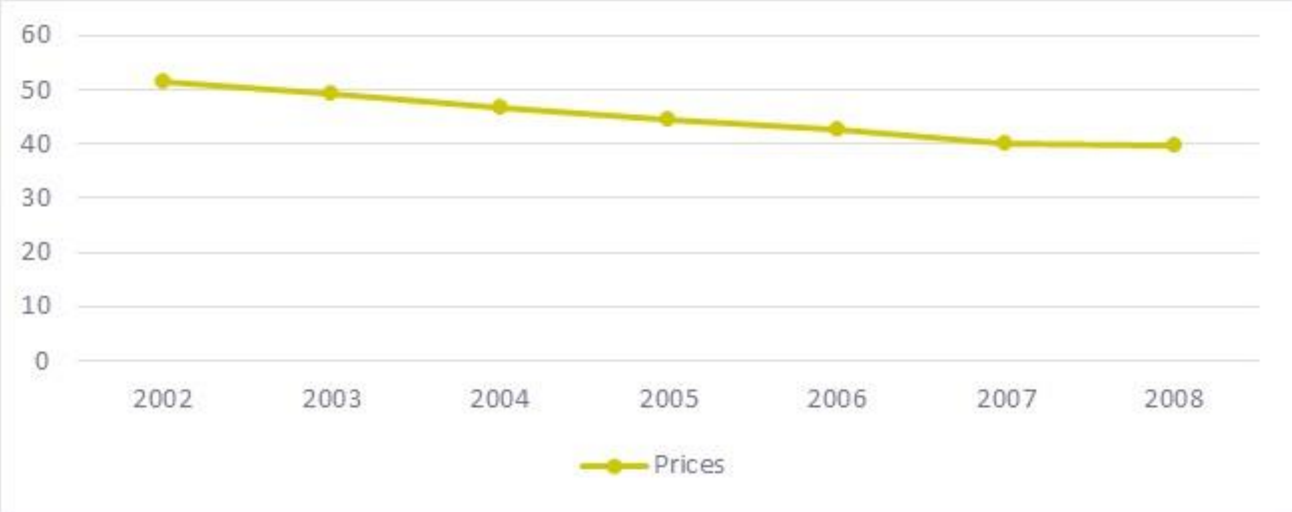
For countries that reported marginal or sporadic imports such Lebanon, Senegal and Ecuador there are differences in the trends. In the case of Lebanon import quantities remained rather stable. For Senegal import quantities slightly decreased. In Ecuador, import quantities tend to slightly increase.

Overall import prices tend to increase from 2008-2015. In the case of Malawi prices are quite fluctuant, with a sharp increase from 2008-2009 and sharp decrease from 2009-2010 and fluctuation between 668.06 and 5,042 US$/ton. For the rest of the countries import prices tended to increase. If the hypothesis were that before listing import prices decreased, listing of Monocrotophos would have caused long-term impact in import prices. However, as this hypothesis could not be confirmed, it is uncertain to affirm that listing influenced import prices.

For countries that reported marginal or sporadic imports such Lebanon, Senegal and Ecuador there are differences. Import prices in Lebanon tend to increase from 2011-2015 (only period of reported imports). Import prices in Ecuador tended to increase. For Senegal prices could not be calculated as import values US$ were not available.

Additionally, prices of Dimethoate, which was commercialised under the trade name of Cygon, were available in US$ for the period 2002-2008 and provided (expressed in US$ real prices[122]/gallon) in Table 64 in Appendix E.

Figure 3-35 Dimethoate US prices 2002-2008



For Dimethoate see also Dimethoate sub-section in section 3.4 about alternatives for Aldicarb.

Fenitrothion

According to data from the European Commission, Fenitrothion has been exported to African, Middle East, Asian, South American and European countries in 2007, 2008, 2009, 2010, 2012 and 2013 with an average of 703.86 tonnes (ranging between min. 0.72 and max. 4,096 tonnes). EU exporters were France, United Kingdom, Italy, Cyprus, Hungary, Germany and Spain. Importer partners were Cameroon, Djibouti, Algeria, Turkey, Morocco, Oman, Kenya, Kazakhstan, United Arab Emirates, Russian Federation, Argentina and Ukraine. There were no exports notified from EU countries for the years 2006 and 2011. Thus, any trend could be represented graphically and short-and long-term impacts could not be analysed.

Furthermore, data on demand and production of Fenitrothion were available for the period 2005-2010 for India. This is provided in Table 73 in Appendix E.

Indoxacarb

According to data from FAO Indoxacarb has been imported from 2008 to 2015 by 10 developing countries and economies in transition from Asia (Thailand and Malaysia), Near East (Lebanon), Africa (Madagascar, Senegal and Benin), Latin America and the Caribbean (Ecuador) and Europe (Serbia, Ukraine and Turkey) (India, 1968).

Lebanon, Madagascar, Senegal and Ecuador reported marginal imports (i.e. imported less than 1 ton) or sporadic imports (i.e. imported not all years). Thus, these imports were not considered in the current analysis Table 3.23 shows the annual growth rates (%) of import quantities of Indoxacarb (in tons) for the period 2008-2015 as well as the growth average rate of import quantities of Indoxacarb for period 2008-2015.

Table 3.23 shows the annual growth rates (%) of import quantities of Indoxacarb (in tons) for the period 2008-2015 as well as the growth average rate of import quantities of Indoxacarb for period 2008-2015.

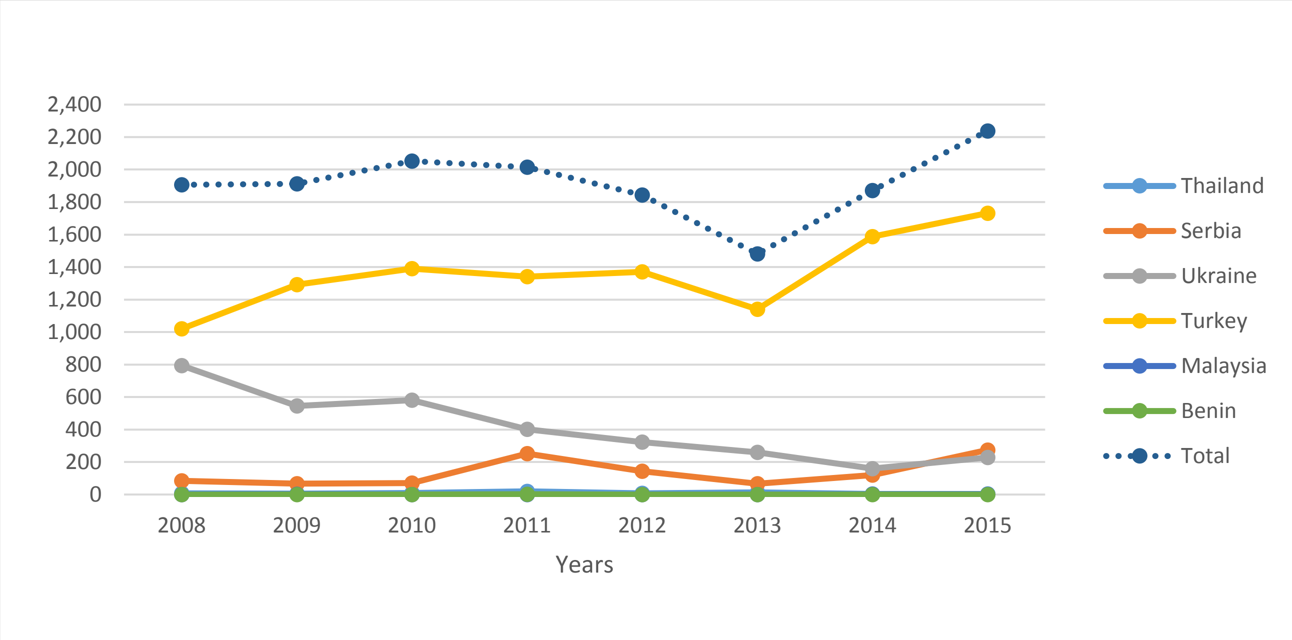
Table 3.23 Annual growth rates and geometric average of growth rate 2008-2015[54] of Indoxacarb

Years	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Annual growth rate* $_{(t\text{-}t+1)}$	0%	7 %	-2%	-8%	-20%	26%	20%
Geometric average of growth rate** $_{(2008\text{-}2015)}$ = 2%							

In periods 2010-2011, 2011-2012 and 2012-2013 import quantities decreased, however in the rest of the periods increased. For the whole period 2008-2015 import quantities increased by 2%. If the hypothesis were that before listing quantities decreased, the increase of 2% (2008-2015) would have been caused by listing of Monocrotophos. As this hypothesis is uncertain, this could not be confirmed.

Figure 3.36 and Figure 3.37 show imports in tons and average real import price (2010 US$/ton) of 6 countries for the period 2008-2015.

Figure 3-36 Indoxacarb import amounts (tons)



Source. BiPRO 2016, from data from FAO

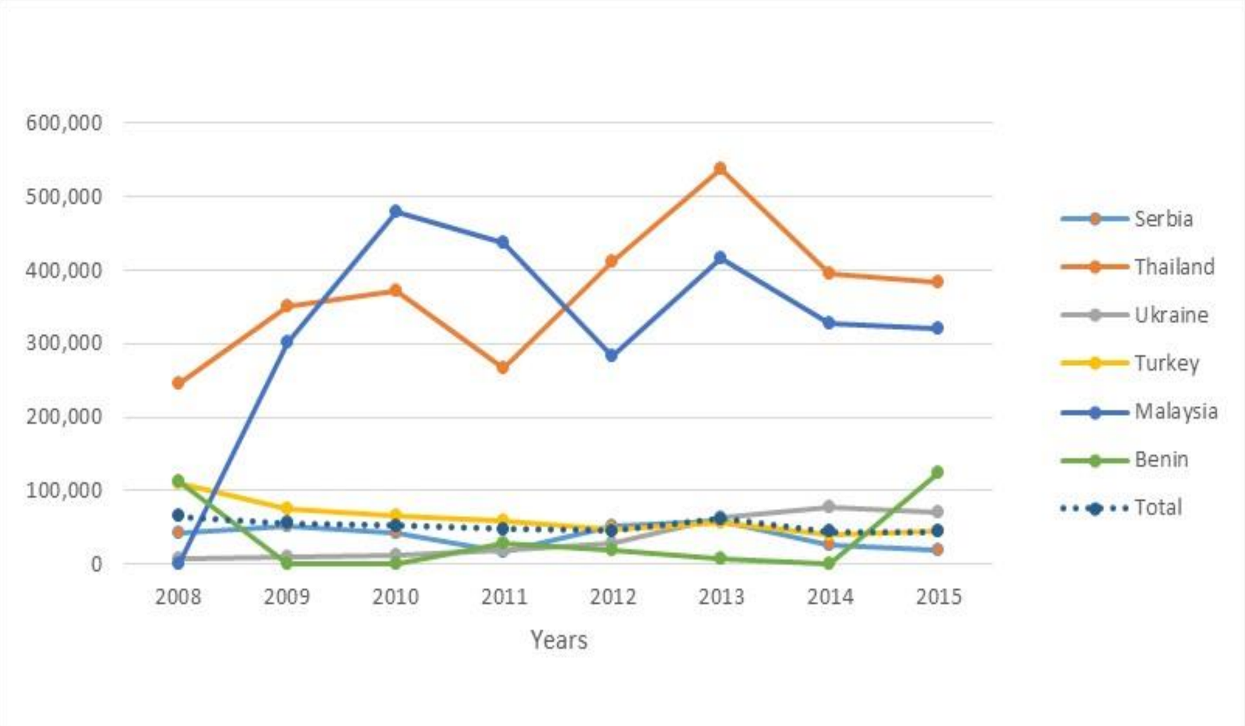
Overall import quantities tended to increase and only decreased for the period 2011-2013. If the hypothesis were that before listing quantities decreased, this increase from 2008-2015 would have been caused by listing of Monocrotophos. As this hypothesis is uncertain, this could not be confirmed.

Import quantities in Turkey seem to follow the same trend as the overall import quantities. However, Ukrainian import quantities tended to decrease. Other countries such as Benin, Malaysia and Thailand presented quite stable import quantities for the whole period 2008-2015. On the other hand, import quantities in Serbia tended to slightly increase.

For countries that reported marginal or sporadic imports such as Lebanon, Madagascar, and Senegal

54 * The annual growth rate is calculated by the formula (Q_t - Q_{t-1}/Q_{t-1}) x 100. ** The geometric average growth rate for 2008-2015 is calculated by the formula ($\prod_{t=1}^{n} annual\ growth\ rate\ t)^{1/n}$ = (annual growth rate$_{2008}$ x annual growth rate$_{2009}$ x ….x annual growth rate$_{2015}$)$^{1/8}$.

Figure 3-37 Indoxacarb average real import price (2010 US$/ton)[55]



Source. BiPRO 2016, from data from FAO

Overall import prices remained quite stable as import prices for Serbia. In the case of Thailand and Malaysia import prices tended to increase but with a strong fluctuation. In the case of Ukraine import prices tended to slightly increase, whereas in the case of Turkey import prices tended to decrease. Import prices of Benin tended to remain quite stable for the period 2009-2013, and presented a strong decrease (2008-2009) and a strong increase (2014-2015).

For countries that reported marginal or sporadic imports such Lebanon, Senegal, Madagascar and Ecuador there are differences. Ecuador only reported imports in 2015 and for Senegal import prices could not be calculated due to import values US$ were not available. For Madagascar import prices increased from 2008-2011 and decreased from 2014-2015. In the cases of Lebanon import prices tended to increase from 2011-2015 (only years that imports were reported).

Furthermore, data on demand and prices of Indoxacarb were available for the period 2005-2010 for India. This is provided in Table 74 Appendix E. Analysis of the prices from India could not be done as were not available before listing of Monocrotophos. However, Indian prices for Indoxacarb decreased from 2007-2010

Malathion

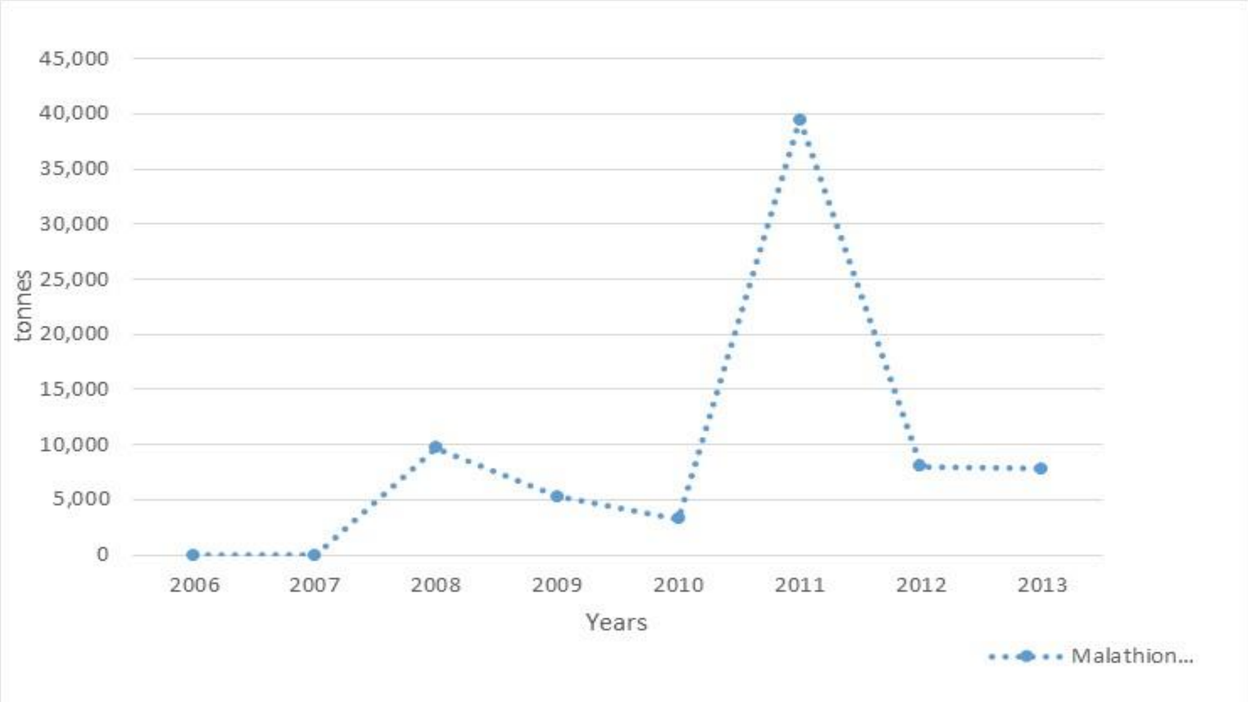
According to data from European Commission Malathion has been exported to African, Middle East, European America and Asian and South Asian countries and Oceania from 2007 to 2013 with an average of 10,509.89 (ranging between min.1.56 and max. 39,575.38 tons) (European Commission, 2016). For years 2004 and 2005 there was no reported exports of Malathion, thus those years could not be evaluated. It was exported from 8 EU countries (France, Belgium, Denmark, Spain, United Kingdom, Slovenia, Portugal and Germany). Importer partners were 59 countries[56] . Figure 3.38 presents the total exports expressed in tons of these European countries for the period 2006-2013. Malathion export quantities increased from 2006-2013. However, from 2010-2011 export quantities sharply increased and strongly decreased from 2011-2012. Import quantities increased from 2008-2015. If the hypothesis were that before listing quantities decreased, the increase from

[55] Further information on calculation of pricing is given in the methodology under section 2.2

[56] Niger, Senegal, Russia, Ukraine, Turkey, Morocco, Egypt, Kenya, South Africa, Jordan, Ethiopia, Tunisia, Oman, Afghanistan, Bangladesh, Japan, Myanmar, Taiwan, Indonesia, Malaysia, Pakistan, Hong Kong,Thailand, Singapore, USA, Australia, Canada, Mexico, Colombia, Brazil, Uruguay, Argentina, Costa Rica, Peru, Puerto Rico, Trinidad and Tobago, Belarus, Moldavia, Azerbaijan, Kazakhstan, Uzbekistan, Dominican Republic, Ecuador, Iran, Israel, South Korea, Gabon, Armenia, Serbia, Algeria, Congo, Nigeria, Haiti, Korea, Belize, Croatia, United Arab Emirates, Bolivia and Angola

2006-2013 would have been caused by listing of Monocrotophos. As this hypothesis is uncertain, this could not be confirmed.

Figure 3-38 Malathion export amounts (tons)



BiPRO 2016, from data from European Commission about export quantities in tons

Furthermore, according to information from FAO Malathion has been imported from 2008 to 2015 by 10 developing countries and economies in transition from Asia (Bangladesh, Thailand, Malaysia and Myanmar), Near East (Lebanon), Africa (Madagascar, Senegal and Malawi), Europe (Serbia) and Latin America and the Caribbean (Ecuador) (India, 1968).

Lebanon, Senegal and Ecuador reported marginal imports (i.e. imported less than 1 ton) or sporadic imports (i.e. imported not all years). Thus, these countries were not considered in the current analysis. Table 3.24 shows that the import quantities decreased for the period 2008-2015 by 3%. Thus, listing of Monocrotophos did not cause any long-term impact on import quantities of Malathion.

Figure 3.39 show imports in tons and average real import price (2010 US$/ton) of 7 countries for the period 2008-2015 (FAO, 2016b). Figure 3.40 shows the annual growth rates (%) and the growth average rate of import quantities of Malathion (in tons) for period 2008-2015.

Table 3.24 Annual growth rates and geometric average of growth rates 2008-2015[57] of import quantities of Malathion

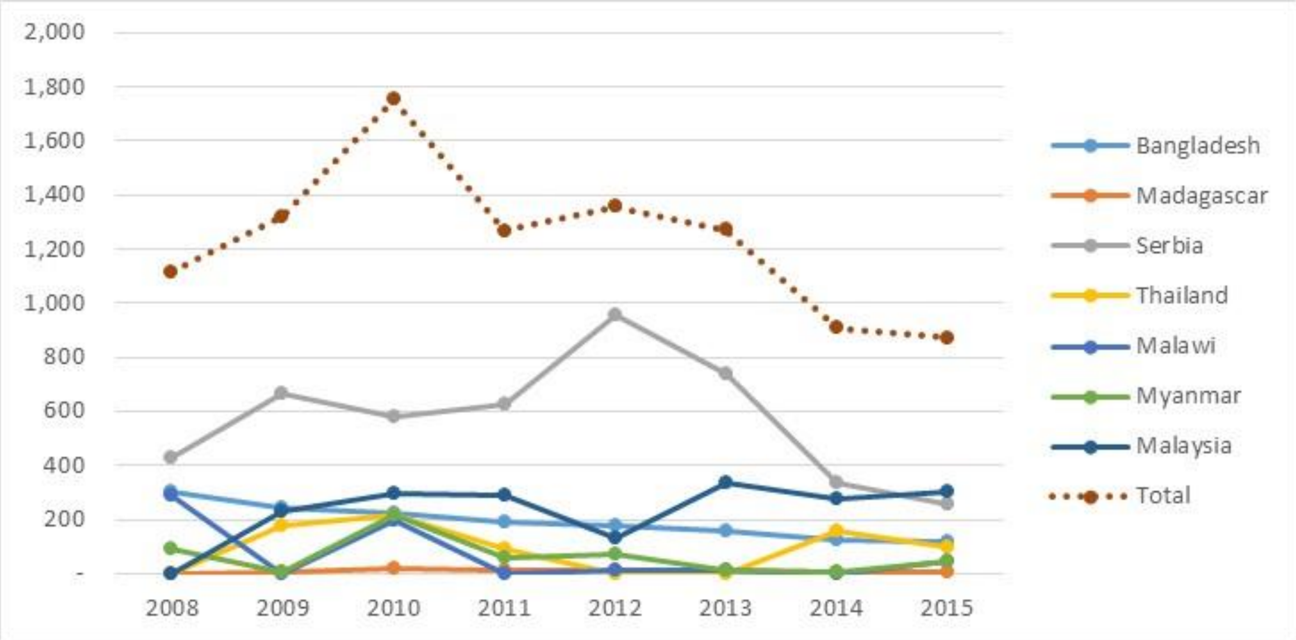
Years	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Annual growth rate* $_{(t-t+1)}$	18%	33 %	-28%	7%	-6%	-29%	-4%
Geometric average of growth rate** $_{(2008-2015)}$= -3%							

[57] * The annual growth rate is calculated by the formula (Q_t - Q_{t-1}/Q_{t-1}) x 100. ** The geometric average growth rate for 2008-2015 is calculated by the formula ($\prod_{t=1}^{n} annual\ growth\ rate\ t$) $^{1/n}$= (annual growth rate$_{2008}$ x annual growth rate$_{2009}$ x ….x annual growth rate$_{2015}$)$^{1/8}$.

Import quantities decreased for the period 2008-2015 by 3%. Thus, listing of Monocrotophos did not cause any long-term impact on import quantities of Malathion.

Figure 3.39 show imports in tons and average real import price (2010 US$/ton) of 7 countries for the period 2008-2015 (FAO, 2016b)

Figure 3-39 Malathion import amounts (tons)

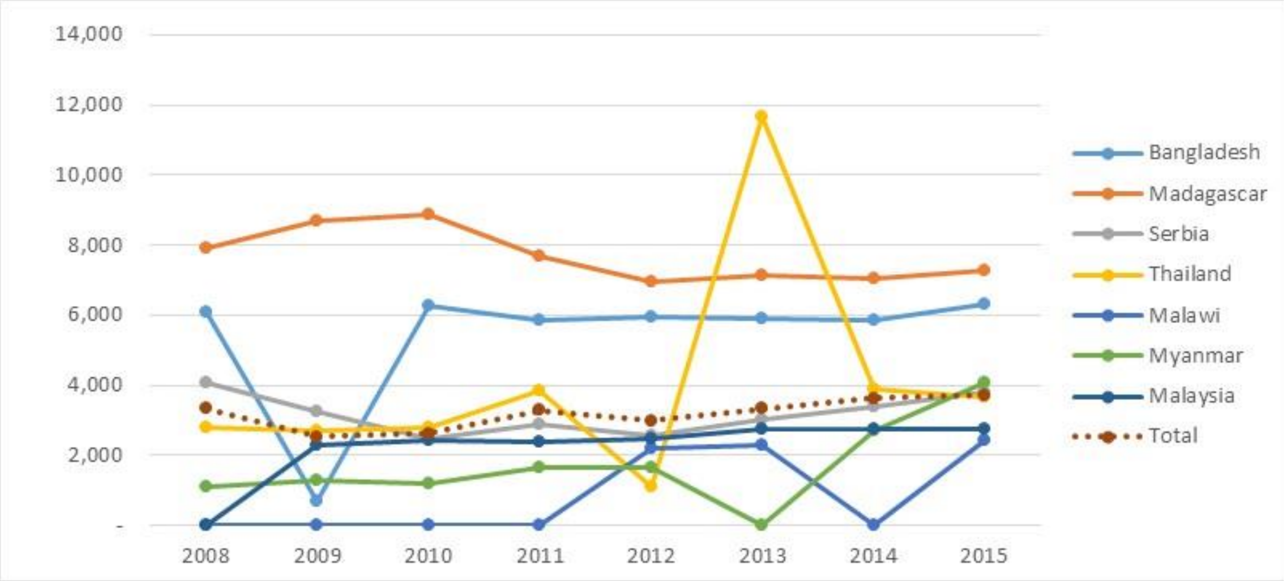


Source. BiPRO 2016, from data from FAO

Overall import quantities decreased from 2008-2015. Import quantities in Madagascar remained quite stable. However, for countries such Serbia import quantities tended to decrease presenting strong variations between years. For example, import quantities sharply decreased from 2012 to 2015. In the case of Bangladesh there is a clear trend of import quantities to decrease for the period 2008-2015. In Thailand import quantities increased from 2008-2010 and 2013-2014, and decreased for the rest of the periods. In the case of Malawi and Myanmar import quantities tended to decrease, in spite of presenting strong increases on the period 2009-2010.

For the countries that reported marginal or sporadic imports such as Lebanon, Senegal and Ecuador there are differences. Lebanon only reported imports in 2014 and 2015. Import quantities for Senegal remained quite stable for the whole period. In the case of Ecuador import quantities tended to increase slightly.

Figure 3-40 Malathion average real import price (2010 US$/ton)[58]



Source. BiPRO 2016, from data from FAO

Overall import prices tended to increase slightly. If the hypothesis were that before listing prices decreased, these increase from 2008-2015 would have been caused by listing of Monocrotophos. As this hypothesis is uncertain, this could not be confirmed. In countries like Serbia and Malaysia import prices tend to increase slightly. However, in the case of Madagascar import prices tend to decrease. Import prices in Thailand increase for the period 2008-2015 and presented a strong fluctuation for the period 2012-2014. In the case of Malawi import prices increased but presented a strong decrease in 2014. For Myanmar import prices increased also but presented a strong decrease on 2013. As not all countries followed a clear trend to increase and all trends are not uniform, it cannot be confirmed that the overall increase in prices is due to the listing of the Convention.

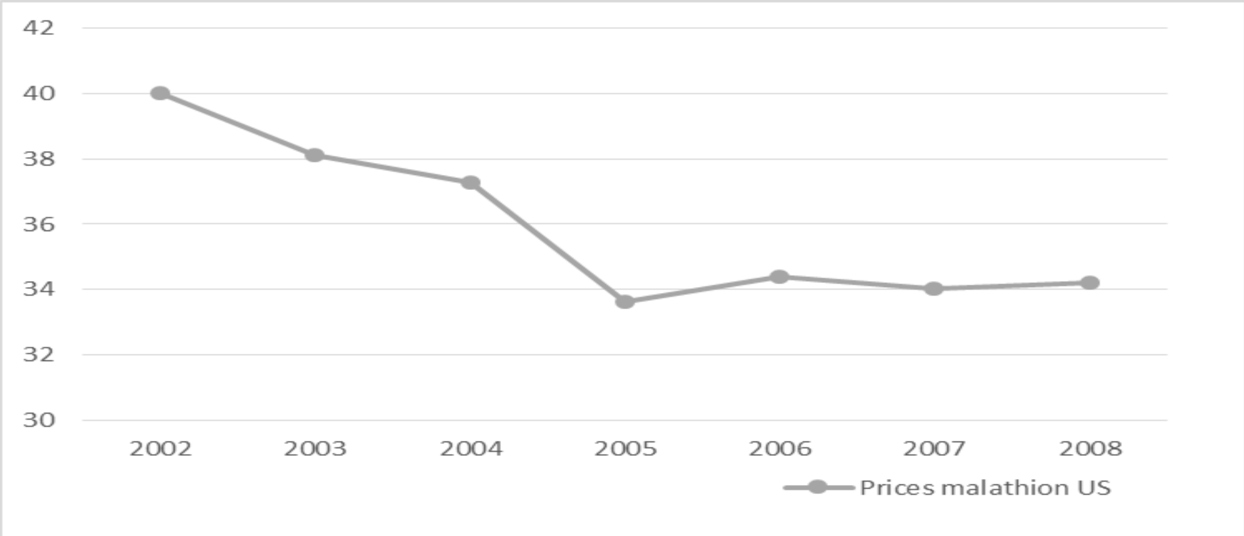
For the countries that reported marginal or sporadic imports such Lebanon, Senegal and Ecuador there are differences. Lebanon only reported imports in 2014 and 2015. Import prices for Senegal could not be calculated as import values were not available. In the case of Ecuador import prices tended to increase for the whole period 2008-2015.

Furthermore, data on demand, imports and prices of Malathion were available for the period 2005-2010 for India. This is provided in Table 75 in Appendix E. Analysis of the prices and imports from India could not be done as they were not available before listing of Monocrotophos. However, Indian prices for Malathion increased from 2005-2010.

Additionally, prices of Malathion were available in US$ for the period 2002-2008. These prices are provided (expressed in US$ 2010 real prices/gallon) in Figure 3.41. Real price average of Malathion tend to decrease from 2002-2008. It strongly decreased from 2002 to 2005 and slightly increased from 2005-2008.

[58] Further information on calculation of pricing is given in the methodology under section 2.2

Figure 3-41 Malathion average real price (2010 US$/gallon)[59]



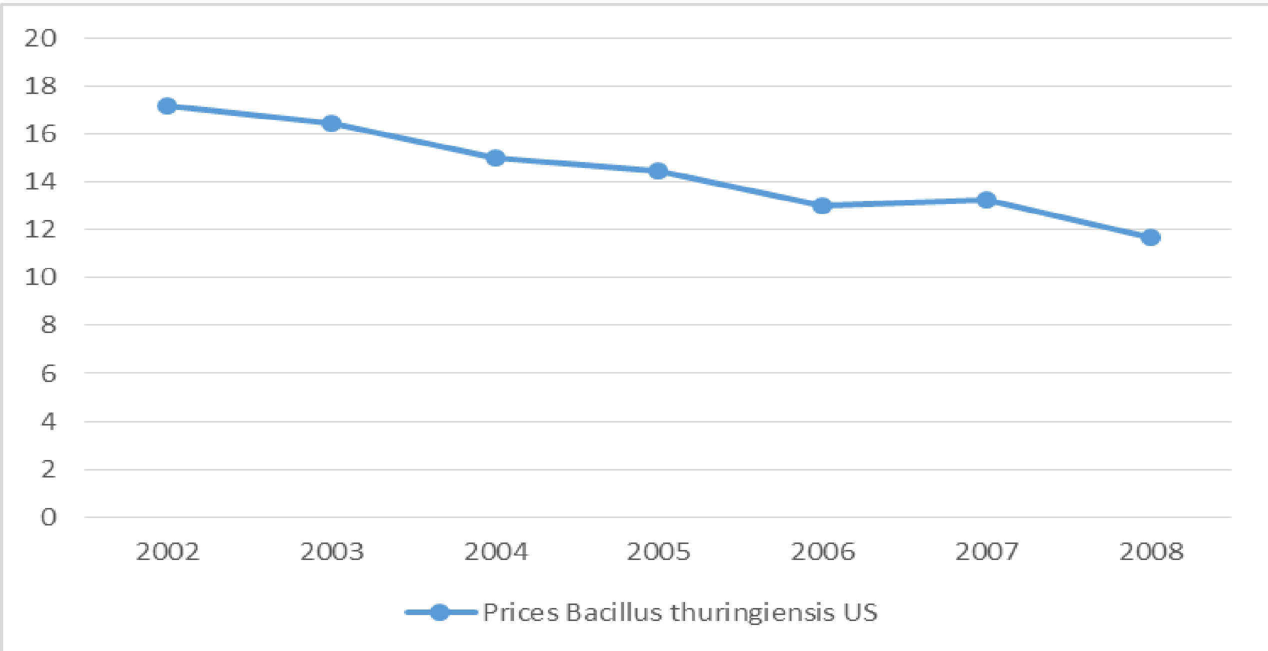
Source: BiPRO, 2016 from data from United States Department of Agriculture (USDA, 2016)

Bacillus thuringiensis

Data on demand and production of bacillus thuringiensis and prices were available for the period 2005-2010 for India. This is provided in Table 76 in Appendix E.

Analysis of the prices and imports from India could not be done as they were not available before listing of Monocrotophos. Additionally, prices of bacillus thuringiensis, which was commercialised under the trade name of Dipel were available in US$ for the period 2002-2008 and are provided in Figure 3.42. Prices followed a clear trend to decrease, thus listing of Monocrotophos in 2004 did not caused any effect on Malathion prices in US.

Figure 3-42 Bacillus thuringiensis average real price (2010 US$/gallon)



Source: BiPRO, 2016 from data from United States Department of Agriculture (USDA, 2016)

[59] Further information on calculation of pricing is given in the methodology under section 2.2

Acetamiprid data about demand in India for the period 2005-2010 was available and it is provided in Table 69 in Appendix E. In the case of Alphamethrin production volumes of Alphamethrin for India for the period 2005-2010 are provided in annex Appendix E Table 70. Imidacloprid demand in tonnes in India for years 2005-2010 are available in Appendix E Table 65.

Summary

In the case of Monocrotophos, short- term impacts could not be analysed since listing of Monocrotophos occurred in 2004 and data about imports from FAO is available for the period 2008-2015. Additionally export data from European Commission was available from 2006-2013. However, those short-term impacts were only analysed for prices of alternatives in US, if data available, from 2002-2008. Long- term impacts were assessed for seven alternatives for 2006-2013 (for exports) and 2008-2015 (for imports).

Thus, conclusions on the short-term effect that listing of Monocrotophos caused on alternative substances markets in developing countries or economies in transition could not be done. However, long-term impacts are summarised in Table 3.25. It also compares the trend on countries were both substances were imported and analysis was done (Turkey and Malaysia). Cypermethrin import quantities decreased, whereas import quantities of Monocrotophos increased. In the case of Turkey and Malaysia for both substances import quantities increased. Overall prices of Chlorpyrifos decreased, whereas import prices of Monocrotophos increased. In the case of Turkey, Chlorpyrifos import prices decreased whereas import prices of Monocrotophos increased. In the case of Malaysia import prices for both substances increased. Thus, in the case of Chlorpyrifos seems that listing of Monocrotophos did not lead to a substitution in long-term.

In the case of Cypermethrin import quantities increased as well as import quantities of Monocrotophos. In Malaysia also import quantities of both substances increased. Overall prices of both substances increased, as well as prices for both substances in Malaysia. Thus, in the case of Cypermethrin seems that listing of Monocrotophos did not lead to a substitution in long-term.

In the case of Dimethoate import quantities decreased, whereas import quantities of Monocrotophos increased. In the case of Malaysia, import quantities of Dimethoate decreased and increased for Monocrotophos. Overall import prices increased for both substances. Same is observed for prices in Malaysia for both substances. Thus, for Dimethoate seems that listing of Monocrotophos did not lead to a substitution long-term.

In the case of Indoxacarb import quantities increased for both (Indoxacarb and Monocrotophos). The same trend is observed for Malaysia for both substances. Overall import prices of Indoxacarb slightly decreased, whereas Monocrotophos import prices increased. For Malaysia, import prices increased for both substances. Thus, in the case of Indoxacarb seems that listing of Monocrotophos did not lead to a substitution in long-term.

In the case of Malathion export quantities increased. If the hypothesis were that export quantities before listing decreased, then it would have been an impact after listing. However, due to the uncertainty of this hypothesis this could not be determined. Import quantities of Malathion decreased whereas for Monocrotophos increased. For Malaysia import quantities increased for both substances. Overall import prices of Malathion increased as well as import prices of Monocrotophos. Same trend occurs to Malaysia for both substances. Thus, in the case of Malathion seems that listing of Monocrotophos did not lead to a substitution in long-term.

Table 3.25 Summary on long-term impacts for alternatives

Alternatives	Export/ import quantities and prices (2008-2015)	Prices	Impact long-term
Chlorpyrifos	Import quantities decreased Malaysia and Turkey import quantities increased	Import prices decreased Malaysia: import prices increased Turkey: import prices decreased	No impact
Cypermethrin	Import quantities increased Malaysia: import quantities increased	Import prices increased Malaysia: import prices increased	Hypothesis: if import quantities and import prices before listing

Alternatives	Export/ import quantities and prices (2008-2015)	Prices	Impact long-term
			decreased, then impact after listing. But this is uncertain
Dicofol	Export quantities (2006-2013) increased	n/a	Hypothesis: if export quantities before listing decreased, then impact after listing. But this is uncertain
Dimethoate	Import quantities decreased Malaysia: import quantities decreased	Import prices increased Malaysia import prices increased	No impact in import quantities Hypothesis: if import prices before listing decreased, then impact after listing. But this is uncertain
Indoxacarb	Import quantities increased Malaysia import quantities increased	Import prices slightly decreased Malaysia import prices increased	Hypothesis: if import quantities before listing decreased, then impact after listing. But this is uncertain No impact on import prices
Malathion	Export quantities (2006-2013) increased Import quantities decreased Malaysia import quantities increased	Import prices increased Malaysia import prices increased	Hypothesis: if export quantities and import prices before listing decreased, then impact after listing. But this is uncertain No impact on import quantities
Monocrotophos	Import quantities increased Countries increased: Malaysia and Turkey	Import prices increased Countries increased: Malaysia and Tukey	n/a

Conclusions

A total number of 18 alternatives have been identified (13 chemical alternatives and 2 non-chemical alternatives). Not all chemical alternatives can be used for all crops, and information on user countries is limited to Sahel, other African countries and India. Acetamiprid, Chlorpyrifos, Cypermethrin, Dimethoate, Dicofol, Indoxacarb, Malathion, azadirachtine, bacillus thuringiensis and Profenofos are used in a broad number of crops. However, Pyrethroids, Fenitrothion and Alpha-Fenvalerate are only used in one crop. On the other hand no crops could be identified for Alphamethrin and Carbamate.

Monocrotophos acts as insecticide and acaricide for a broad spectrum of pests and crops (e.g. cotton, citrus, olives, rice, maize, sorghum, soybeans and tobacco, rice, wheat, various types of pulses, ground nut, tea, chillies and mango). Comparing this with the uses of alternatives bacillus thuringiensis, azadirachtine, Malathion, Dimethoate, Dicofol, Indoxacarb and Chlorpyrifos are the alternatives that cover most of the uses of Monocrotophos. They are followed by Cypermethrin and Profenofos. Pyrethroids are identified to be used in tomatoes and in the case of Fenitrothion crops have not been identified.

Numerous producers have been identified for these alternatives. Some of them are global producers of pesticides. Furthermore, there are also Indian and African companies.

Based on the available information 7 alternatives are available[60] in numerous developing countries and economies in transition. For Chlorpyrifos, Dimethoate and Malathion import quantities decreased, whereas for Cypermethrin and Indoxacarb they increased and for Dicofol export quantities increased. These increases in these 3 alternatives could not be attributed to the listing of Monocrotophos due to the uncertainty of the hypothesis (import or export quantities of these alternatives decreased before listing). Furthermore, for the same period import quantities of Monocrotophos also increased. In the case of Dicofol export quantities increased after listing. Overall prices for Chlorpyrifos and Indoxacarb decreased, whereas prices of Cypermethrin, Dimethoate and Malathion increased. This increase in import prices of these 3 alternatives could not be attributed to the listing of Monocrotophos due to the uncertainty of the hypothesis (import prices of both alternatives decreased before listing). Furthermore, import prices of Monocrotophos also increased.

To sum up, it seems that the listing of Monocrotophos did not lead to a substitution by alternatives in the long-term. Even for individual countries where alternatives and Monocrotophos were available, no significant impact was observed. Furthermore, since it seems that there is a high number of alternatives for Monocrotophos, there may be high competition between alternatives, thus they may not be influenced by the listing of Monocrotophos.

3.7 Case study 4: Parathion (CAS No. 56-38-2)

Overview

Parathion is an insecticide and acaricide for various pests and crops. According to the Rotterdam Convention Decision Guidance Document, Parathion was used in Australia to protect citrus, pome fruit, stone fruit, vines, vegetables, pastures and lucerne, with the major use being in orchards. Registered uses in the European Community included apples, cereals, citrus fruit, grape, peach, pear, pome and stone fruit. Parathion is produced, traded and used in various other countries globally. Countries for which evidence of production or use of Parathion has been found are listed in the table below. Note that this list is likely to be not exhaustive.

Table 3.26 Indicative list of countries producing and using Parathion currently or in the past

Production	Use		
China [a]	Belarus [c]	Mexico [c]	Ukraine [c]
Denmark [b]	Ecuador [c]	Serbia [c]	Philippines [c]
	Kyrgyzstan [c]	South Africa [c]	USA [d]
	Macedonia [c]	Turkey [c]	

Sources:
[a)] Based on the list of basic manufacturers from the Decision Guidance Document for Parathion.
[b)] Based on the list of basic manufacturers from http://www.fao.org/docrep/w5715e/w5715e05.htm.
[c)] Based on countries reporting imports of Parathion to FAO and the assumption that at least part of the imports are used domestically and not re-exported.
[d)] Based on the US Department of Agriculture National Agricultural Statistics Service (https://www.nass.usda.gov/Quick_Stats/).

Trade names and mixtures: Ethyl Parathion 100 EC; Ethyl Parathion 500 EC; Farmoz; Pacol 4,5 (EO, 45 g/l, Aventis Optimagro); Parathion E Insecticide; Novafos E Insecticide; Oléon Bladan (EC, 93 g/l, Bayer SA); Oléoparatior (EO, 45 g/l Capiscol); Parafor ethyl (EC, 100 g/l, Capiscol); Paretox 10 (WP, 10%, Bourgeois); Rhodiatox liquide 10% (EC, 100 g/l, Flexagri); Tebing Parathion Insecticide; Ugécoil 10 (EC, 100 g/l, Sopcam-phyteurop); Ugécoil P (EC, 30 g/l, Sopcam-phyteurop) (Rotterdam Convention, 2009c).

Main purpose and functionality: Parathion is used in agriculture, horticulture, and viticulture to protect pome and stone fruit, vegetables, citrus fruits, vines and lucerne (Rotterdam Convention, 2009c).

[60] Assuming that there is no post-exporting of the imported quantities

Listing in the Rotterdam Convention: Listed in 2004 after all uses of Parathion have been completely banned in Australia and the European Community.

Production

According to the Decision Guidance Document (2005) there were at least two manufacturers from China and Denmark. A more recent publically available source listing manufacturers of Parathion has not been identified. Production quantities are not available.

Hypothesis: Listing leads to a decrease in production and/or the number of manufacturers of the substance.

- Lack of data post listing means it has not been possible to comment on the outcome of this hypothesis.

Trade

Quantity and value of imports of Parathion for the years 2008-2015 have been submitted to the FAO by 10 countries from various regions of the world. These are listed in the table below.

Table 3.27 List of countries that reported imports of Parathion in response to the FAO survey, by region

Africa	Americas	Europe	Western/Central Asia	South-East Asia
South Africa	Ecuador	Belarus	Turkey	Philippines
	Mexico	Macedonia	Kyrgyzstan	
	USA	Serbia		
		Ukraine		

Source: Amec Foster Wheeler 2016 based on data from FAO 2016.

As for Monocrotophos, data has been reported for Parathion only from 4 years after listing, so it can only indicate if Parathion is still traded in the long term.

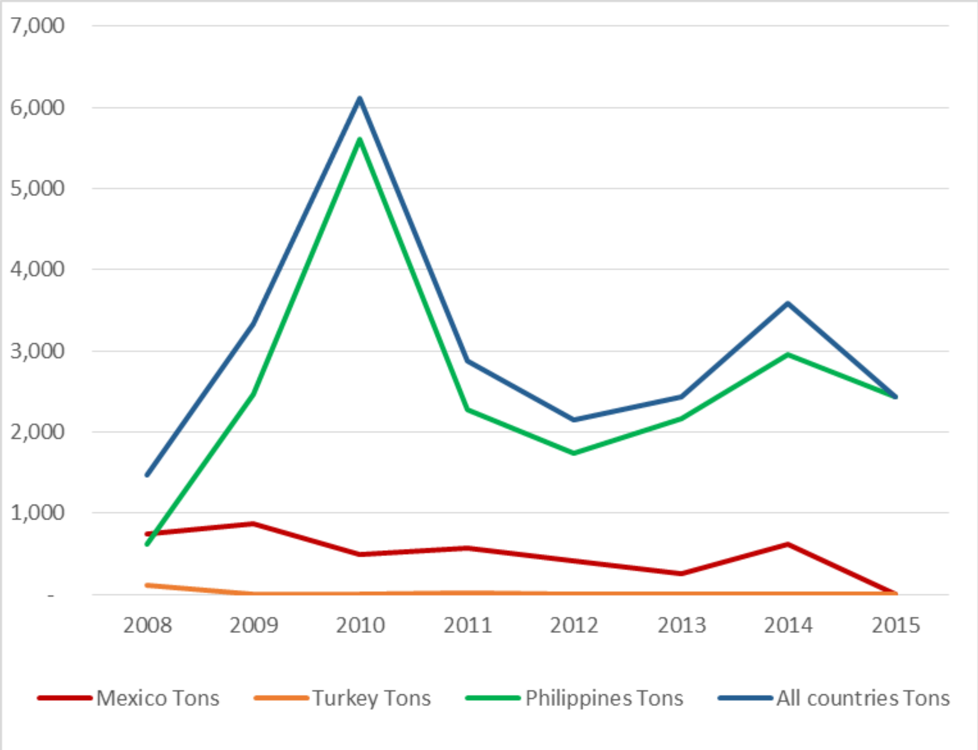
Six countries (Belarus, Ecuador, Kyrgyzstan, Macedonia, Serbia, Ukraine) report only marginal imports (<=1 ton) and only in some years. South Africa only reports a small import of 20 tons in 2010.

The remaining three countries (Mexico, Turkey, and Philippines) report significant quantities of Parathion imports after listing, as illustrated in the figure below. Turkey reports small amounts of Parathion imports from 2009 (between 0 and 15 tons), but for 2008 it still reports a significant import of 114 tons. Mexico reports larger but mostly decreasing quantities of import, which drop to zero in 2015. Both countries still imported significant amounts of Parathion years after listing, so listing did not lead to a cessation of trade. However, imports are decreasing and shrinking to marginal levels in both countries, so this could possibly reflect a hampering impact of listing on trade.

The Philippines report much larger Parathion imports which fluctuate strongly, notably with a high peak in 2010, but increase overall from 2008 to 2015. This trend does not seem to support the hypothesis that listing has decreased imports of Parathion in the long term in the Philippines, as it reported increasing imports years after listing.

The sum of imports of all countries reporting on imports of Parathion in the FAO survey is clearly dominated by the imports of the Philippines and to a smaller extend Mexico. This provides no additional insight with regard to assessing the hypothesis other than already stated for the Philippines and Mexico.

Figure 3-43 Parathion import quantity (tons) of Mexico, Turkey, Philippines and sum of all countries reporting imports, 2008-2015



Source: Amec Foster Wheeler 2016 based on data from FAO 2016.

Hypothesis: Listing reduces traded volume.

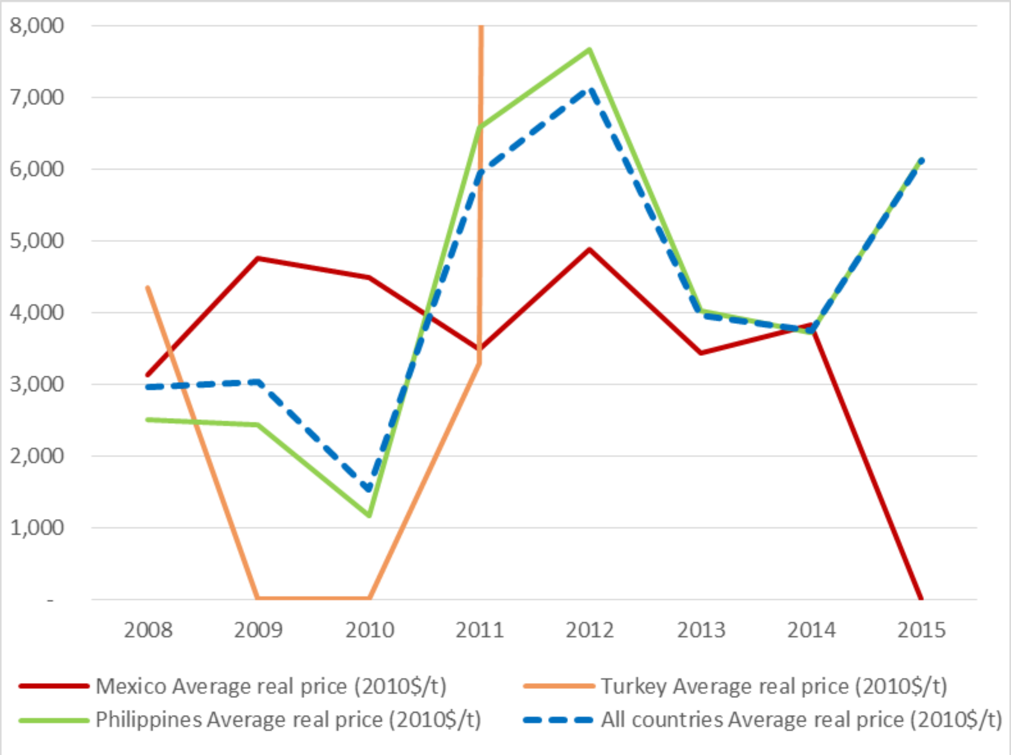
- Some evidence does exist to suggest a decrease in trade after listing of the chemical in Annex III, particularly for Turkey. The Philippines reported significant imports years after listing, which would reject the extreme case of hypothesis that listing of Parathion has led to a (near) cessation of trading of goods. Lack of data pre listing means it has not been possible to comment on the outcome of this hypothesis more generally.

Prices[61]

Average prices of imports of Parathion for the years 2008-2015 have been calculated from import quantity and value data submitted to the FAO. As discussed in the previous section, only Mexico, Turkey (only in 2008) and the Philippines have reported significant imports, so the figure below shows the real average import prices for these three countries, as well as for the sum of imports of all countries reporting imports of Parathion to the FAO.

[61] All prices have been converted to real prices (2010 USD) using the US Wholesale price index from the World Bank (http://databank.worldbank.org/data/reports.aspx?source=2&series=FP.WPI.TOTL&country=).

Figure 3-44 Parathion average real import price (2010 US$/ton) for Mexico, Turkey, Philippines and sum of all countries reporting imports, 2008-2015[62]



Source: Amec Foster Wheeler 2016 based on data from FAO 2016 for all countries except USA, which is based on data from USDA, 2016.

Overall, an increasing trend in prices can be observed for both Mexico and Philippines.[63] The strong fluctuation of prices for Turkey after 2008 may mostly be caused by the small sample they are based on, i.e. very small amounts of imports, as discussed in the previous section.

However, as the price level of Parathion for these countries before listing of Parathion in Annex III to the Rotterdam Convention is not available, no meaningful conclusions can be drawn from this data with regards to the hypothesis that listing inflates prices. Given the time between listing and the data at hand, it is not clear if the observed inflation of Parathion could be caused by listing.

Hypothesis: Listing inflates prices

- Lack of data pre listing means it has not been possible to comment on the outcome of this hypothesis.

Application/Use

Parathion has been used in a wide range of countries, as for instance indicated by the FAO import data analysed above (e.g. countries in the Americas, Europe, Africa and Asia)[64]. However, no evidence supporting or contradicting countries ceasing to use Parathion since its listing in Annex III of the Rotterdam Convention in 2004 has been found. As stated above, various countries ceased to import Parathion by 2008 or later, but no import data around the time of listing is available and it is not known if Parathion is produced domestically in those countries.

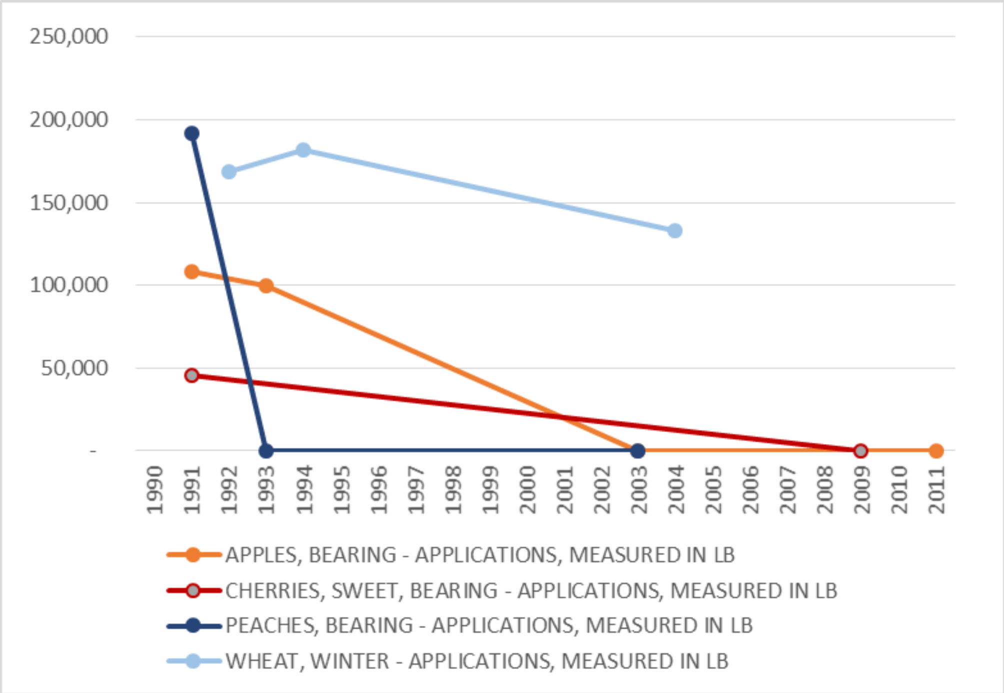
Data on the quantities of Parathion applied has been identified for the US. Data from the United States Department of Agriculture National Agricultural Statistics Service (USDA, 2016) includes application of

[62] Further information on calculation of pricing is given in the methodology under section 2.2
[63] Note that the price for Mexico only drops to zero in 2015 because imports drop to zero. Real prices increased from the first year 2008 until the last year in which there were significant imports (2014) in Mexico.
[64] Import itself does not guarantee the substance is used in the importing country as it could be fully re-exported. However it seems reasonable to assume that the majority of countries reporting imports to the FAO also use at least parts of their imports.

Parathion to a range of crops, but for most crops only one or two data points between 1990 and 1992 are provided. Hence, Parathion has been used in the US in the early nineties for a wide range of crops, but no longer-term information on the evolution of the quantities applied to these crops is available, so they are not suitable for analysis with respect to the relevant hypothesis.

Parathion application to the remaining crops[65] is plotted in the figure below. Application of Parathion to peaches and apples has ceased already before the listing of Parathion and the USA is not a Party to the Rotterdam Convention, so other factors than the Rotterdam Convention must be responsible. For sweet cherries, the data indicates that Parathion has been applied in 1991 and not anymore in 2009, after listing. However, it is not known when Parathion application to sweet cherries ceased so it is not clear if the Rotterdam Convention could have been an influencing factor. Winter wheat is the only crop to which Parathion has certainly still be applied in 2004 in the USA, but no data is available for subsequent years.

Figure 3-45 Parathion application in surveyed US states for apples and winter wheat 1990-2015



Source: Amec Foster Wheeler 2016 based on data from USDA, 2016.

Hypothesis: Listing leads to a reduction in use volumes of the substance.

- Lack of data post listing means it has not been possible to comment on the outcome of this hypothesis.

Analysis of alternatives to Parathion

A total number of 7 alternatives were identified for Parathion, 6 chemical alternatives and 1 non-chemical alternative. Chemical alternatives were Dimethoate, Fenoxycarb, Imidacloprid, Malathion, Spirotetramat and Thiacloprid. Malathion and Dimethoate can be used in a wide number of crops and pests. For the rest of the alternatives, no crops and pests were identified. For further information see Table C.7 in Appendix C. The non-chemical alternative identified was terpenoid mix. User countries identified are India and some African countries.

Numerous producers of alternatives to Parathion were identified. Some of them are global producers of pesticides. Furthermore, there are Indian, Chinese and African companies. For further information see

[65] With the exception of dry onions and sweet corn, which exhibited much smaller quantities of Parathion applied than the other crops.

Table C.8 in Appendix C.

Analysis of short- and long-term impacts on alternative substances markets

- Availability of alternative substances

Most of the chemical alternatives have been identified as alternatives of previous the case studies. Therefore, see the following sections for more information on crops, pests, countries used as well as availability and prices:

- For Dimethoate see section 3.5 and the sub-section analysis of alternatives.
- For Imidacloprid see section 3.5 sub-section analysis of alternatives.
- For Malathion and Thiacloprid see section 3.6 sub-section analysis of alternatives

As in the case of Parathion, as it was listed in the Annex III in 2004, only long-term impacts after listing could be assessed based on the data from FAO (import data) and export data from the European Commission (export quantities). However, prices in US$ from 2002-2008 (if available) were analysed by considering short-term impacts on prices of alternatives. This prices were available for Dimethoate and Malathion. For both alternatives prices decreased for 2002-2008. Thus, in US there is no short-term impact in prices after listing of Parathion.

Table 3.28 summarises the impacts for alternatives (if data was available) for Parathion after listing in the long-term. Furthermore, the only country where Parathion as well as its alternatives were reported to be imported was Serbia. However, comparison of alternatives and Parathion was not possible due to Serbia reporting marginal imports of Parathion. Nevertheless, import quantities and import prices of Dimethoate and Malathion decreased in Serbia. Overall import quantities of Dimethoate and Malathion decreased, whereas import quantities of Parathion increased. Overall prices increased for Dimethoate and Malathion as well as for Parathion. Thus, it seems that the listing of Parathion did not lead to a substitution by any of the alternatives assessed in the long-term.

Table 3.28 Impacts on alternatives for Parathion

Alternatives	Export/ import quantities (2008-2015)	Import prices (2008-2015)	Impact
Dimethoate	Import quantities decreased	Import prices increased	No impact in import quantities Hypothesis: if import prices before listing decreased, then impact after listing. But this is uncertain
Malathion	Export quantities (2006-2013) increased Import quantities decreased	Import prices increased	Hypothesis: if export quantities and import prices before listing decreased, then impact after listing. But this is uncertain No impact on import quantities
Parathion	Import quantities increased	Import prices increased	n/a

Conclusions

A total of 7 alternatives were identified for Parathion, 6 chemical alternatives (Dimethoate, Fenoxycarb, Imidacloprid, Malathion, Spirotetramat and Thiacloprid) and 1 non-chemical alternative (terpenoid mix). Most of the chemical alternatives have been identified as alternatives of previous substances, i.e. Dimethoate, Imidacloprid, Malathion and Thiacloprid. User countries identified were India and African countries. Malathion and Dimethoate can be used in a wide number of pests and crops. However, for the rest of the alternatives crops and pest could not be identified.

Parathion is an insecticide and acaricide for various pests and crops (e.g. citrus, pome fruit, vines, apples, cereals, grape, peach, pear, pome and stone fruit vegetables, pastures and lucerne, with the major use being in orchards). Comparing those uses with uses of alternatives, which information is available, Malathion and Dimethoate are the alternatives that cover more uses of Parathion.

Numerous producers of these alternatives were identified. Some of them are global producers of pesticides. Furthermore, there are Indian, Chinese and African companies

Based on the available information, 2 alternatives (Malathion and Dimethoate) are available in numerous developing countries and economies in transition66. No long-term impact after the listing of Parathion was observed in developing countries and economies in transition. In the case of Dimethoate, import quantities decreased and import prices increased. Malathion import quantities decreased, however, import prices and export quantities increased. Considering the hypothesis that import prices and export quantities were decreasing before listing, the increases from 2008-2015 would have been due to listing of Parathion. As this hypothesis is uncertain, this could not be confirmed. Furthermore, import prices and quantities of Parathion increased too. Thus it seems that the increase in export quantities and import prices of Malathion as well as import prices of Dimethoate is caused by other reasons than listing under the Convention.

To sum up, 2 alternatives are available in developing countries and economies in transition to Parathion. For these alternatives import quantities and prices were not affected by the listing of Parathion for the long-term. Furthermore, based on the available information these 2 alternatives seem to be the most suitable for Parathion as they cover numerous of its uses. Additionally other alternatives are available in African countries, but crops and pests were not identified.

[66] Assuming that imports will not be exported.

4. Review of alternatives for recommended chemicals

This section provides a review of alternatives to those chemicals which are expected to be considered by COP-8 for listing in Annex III. Those are chemicals for which COP-7 failed to reach consensus on their listing in Annex III or those which have recently been recommended by the Chemical Review Committee for listing.

The review covers chrysotile asbestos, certain severely hazardous pesticide formulations containing Paraquat, Trichlorfon and certain severely hazardous pesticide formulations (SHPF) containing Fenthion.

The review is focussing on the availability and the price of the alternatives. As far as data are available the analysis is done for representative markets in developing countries and countries with economies in transition. Where data have been available it also covered the countries that opposed the listing of chrysotile asbestos.

The review also analysed the availability and use of non-chemical alternatives including the availability of information on those non-chemical alternatives in developing countries and countries with economies in transition and the countries that opposed the listing of chrysotile asbestos. Countries which opposed were Russia, Kazakhstan, India, Kyrgyzstan, Pakistan, Cuba and Zimbabwe.

Market data involve producers, export/import quantities and import prices.

Furthermore, in the case of chrysotile asbestos prices of alternatives in Vietnam and South Africa are assessed as prices for most of the alternatives were available.

Data on Indian market, and prices on US market were assessed were available.

4.1 Chrysotile asbestos

Overview

The most relevant use of chrysotile asbestos under the PIC Convention is the use as chrysotile asbestos-cement products, roof sheet and tiles. Therefore, the assessment of alternatives is focussing on alternatives for these “open” construction uses.

Analysis of alternatives to chrysotile asbestos

Information on availability of alternatives has been retrieved from reported notifications to the Secretariat of Final Regulatory action to ban or severely restrict a chemical from Australia and the European Commission), the Draft DGD approved by CRC2, supporting documentation from the European Commission provided to the Secretariat, and recent documents provided by South Africa, Vietnam, Brazil and Thailand. In addition it comprises information from a WHO workshop held in 2005[67], the International Ban Asbestos Secretariat[68], and a report prepared jointly by the European Commission and Vietnam for the discussions at COP7 in 2015.

The most recent summary of alternatives as compiled for COP7 is provided in Table 4.1.

Table 4.1 Chrysotile asbestos alternatives in some countries

Countries	Alternatives Identified
EU	Cellulose fibres, Polyvinyl alcohol (PVA) fibres, P-aramid fibres
Chile	Cellulose fibres

[67] UNEP/FAO/RC/CRC.2/INF/5
[68] http://www.ibasecretariat.org/

Countries	Alternatives Identified
Canada	Cellulose fibres, Polyvinyl alcohol (PVA) fibres, P-aramid fibres, Polypropylene (CAS No. 9003-07-0)
Mauritius	Glass wool, Man made mineral fibres
Japan	Man-made mineral fibres (Glass fibre, Glass wool, Rock wool, Slag wool), Natural mineral fibre (Sepiolite, Wollastonite), Aramid fibre, Vynylon fibre,Pulp, Ceramic fibre, Carbon fibre,
Bulgaria	Polyvinyl alcohol (PVA), Polyacryl nitryl (PAN), Aramid fibre, Fibreglass, Glass wool, Rock wool, Carbon fibre, Graphite fibre, Wollastonite
Australia	aramid (kevlar), para-aramid, moulded aramid, fibreglass, polytetrafluoroethylene, polyethylene, polyvinylchloride, vinyl compositions, semi-metallics, steel fibres, ductile iron, aluminium silicates, carbon/graphite (fibres/composites), cellulose/vegetable fibres/cork composites, refractory ceramic fibres/glass, phosphate, ashphalt, mica, woolastonite, mineral fibres/wool, titanate fibres

Source: http://mutrap.org.vn/index.php/en/library/technical-reports/finish/13/1265

WHO in 2005 prioritised materials according to hazards[69], and the International Ban Asbestos Secretariat[70] differentiated alternatives by use category (roofing/flat screen).

Besides cellulose, cotton, jute, bamboo, coconut, pineapple have been reported to be used as natural organic fibres on roof sheet by Vietnam and South Africa (Vietnam Roofsheet Association, 2016), (South Africa, 2014).

A detailed compilation of information from WHO and the International Ban Asbestos Secretariat is provided in Table 24 in Appendix D.

As provided in Table 4.2 there is a broad number of alternatives to chrysotile asbestos used by different countries (EU, Chile, Canada, Mauritius, Japan, Bulgaria and Australia) as well as a wide list of natural fibres, natural minerals, synthetic fibres, etc identified as alternatives by various sources.

National and global suppliers of alternatives to chrysotile asbestos are present in markets in developing countries and economies in transition some information sources provide additional information on quality issues, capacity and prices.

In an article published in Journal da Unicamp (Gonçalves da Silva et al, 2010), it was concluded that in Brazil the supply of alternatives has already reached an advanced stage and can be completed in a very short time without downstream supply problems in the fibre-cement industry, and non-expected changes in prices of alternative products.

Chile reported about successful similar quality replacement of asbestos in panels and sheeting for dwellings in Chile with other fibres such as cellulose.

According to Virta (2006) and (Shen, Lin, & Zhang, 2006) (Reported in New Zealand, 2016) cellulose has been the most common substitute for asbestos in fibre-cement products in the early 2000.

Vietnam reports about successful exports of non-asbestos roof sheet to Japan and Korea, by Fuji Company (export to Japan in 2007) and Tân Thuận Cường (TTC) Company [71] (export to Korea since 2008 (17).

However, there is ongoing debate about the technical properties and the prices of the alternative products.

Thailand reported about a lower lifespan and higher costs (1.2-1.5 times) for substitutes than for chrysotile asbestos (7, 8).

Publications from Brazil report that artificial fibres are 30% to 40% more expensive, that banning of asbestos use would be likely to put pressure on Brazil's international balance of payments (because of importation of

[69] UNEP/FAO/RC/CRC.2/INF/5
[70] http://www.ibasecretariat.org/
[71] Adapted with the standard JIS A 5430: 2004

synthetic fibres), and that local industry was unable to provide high-quality non-asbestos products and technology[72].

According to recent information from South Africa man-made mineral fibres (MMMF) such as metal, carbon and refractory ceramic fibres have a narrow range of specialist applications, but provide acceptable performance levels as compared to asbestos (South Africa, 2014). Other speciality fibres, such as silicon carbide whiskers, have specific requirements for particular fibre characteristics and the fibres used are thus not strictly a replacement for asbestos (South Africa, 2014).

Market data on alternatives to chrysotile asbestos

Information on market prices is limited. In Brazil the price per ton of asbestos fibre produced by the company Sama was reported to raise by 20% between the first and second semester of 2008, according to the National Department of Mineral Production (DNPM) (Gonçalves da Silva et al, 2010).Whereas according to (Shen, Lin, & Zhang, 2006) cellulose was the established alternative to asbestos-cement, without any significant performance or cost concerns.

Similarly information on market shares is scarce. In the case of South Africa roofing products (corrugated metal sheeting (galvanised and coated), concrete roof tiles and pressed metal tiles) and flat sheet products (Gypsum board, vermiculite board and plastic products provide a superior value-for-money in comparison to (asbestos) fibre cement products, (South Africa, 2014). In South Africa asbestos cement market share of new installations in 2002 were less than 10% for roofing products and less than 5% for flat sheet products, (South Africa, 2014). In China (Shen, Lin, & Zhang, 2006) (Reported in New Zealand, 2016) alternative fibre cement was at 8%.

More detailed market information on alternatives has recently been provided.

Table 4.2 Performance and market data for industrial alternatives to chrysotile asbestos

Alternative	use	lifespan	cost	Production (m^3)	Market share (%)	Characteristics	Ref.
Baked tiles	*roofing*	30-50	medium/high income	2013: 34.02 million m3	15-16 in Vietnam	*natural and good sound -heat insulation material*	Vietnam Roofsheet Association, 2016
Aluminium	roofing	>30	medium/high income	not available	>35 in Vietnam	poor heat-sound insulation and it is unstable to aggressive environment	Vietnam Roofsheet Association, 2016
Plastic	roofing	10 to 20	medium/high income	28.2 million m3	2 in Vietnam	better heat-sound insulation than aluminium; poor resistance to solar radiation	Vietnam Roofsheet Association, 2016, (South Africa, 2014)
Synthetic organic fibres (aramid, PVA, Polyamides and polyacrylonitrile)	roofing	10-20 50 year lifespan	Medium price AC roof sheet is 50% cheaper[73] than 1m2 of PVA roof (in Vietnam)	0.2 million	not available	PVA cement roof sheet has low demand and short lifespan, it is expensive, the technology is still under development, the final product has not adapted to local climate conditions	Vietnam Roofsheet Association, 2016, (South Africa, 2014)
Corrugated Iron & Coloured IBR Sheeting	roofing	durable	1.20US$[74]to 2.40 US$ per sq. meter in South Africa	not available	51% in South Africa	high maintenance, lightweight and easy to install	(South Africa, 2014)
Concrete roof tiles	roofing	expensive	2.85 US$[91]per sq. meter in South Africa	not available	31% 31,978,931.52 US$) in South Africa	looks good and is cost-effective	(South Africa, 2014)

[72] http://www.pic.int/
[73] In Vietnam the cost of 1m2 of AC roof sheet is around 1.2 – 1.5 USD/m2
[74] Calculated with an exchange rate of 1US$ = 13.29R https://treasury.un.org/operationalrates/OperationalRates.php

Alternative	use	lifespan	cost	Production (m³)	Market share (%)	Characteristics	Ref.
(Coated) pressed metal tiles	roofing	not available	4.21US$[91] per sq. meter in South Africa	not available	3 4,514,672.68 US$ in South Africa	n/a	(South Africa, 2014)
Gypsum Board and Vermiculite Board	Flat sheet products	not available	1.22US$[91]per sq. meter in South Africa	not available	not available	n/a	(South Africa, 2014)
Corrugated Metal Roofs (galvanised and coated)	*roofing*	*¼-1/3 than chrysotile-cement*	not available	not available	not available	*Costly maintenance, less acoustic and thermal insulation*	(South Africa, 2014)
Fibre cement, Masonite and Isowhite Board	Flat sheet	not available	1.24US$, 1.29US$ and 1.46US$ [91]per sq. meter in South Africa	not available	not available	n/a	(South Africa, 2014)
Plant fibres and natural organic fibres	Roofing	<10 years	not available	10%	not available	flammable, perishable home for harmful creatures	Vietnam Roofsheet Association, 2016, (South Africa, 2014)

The following table assesses prices, characteristics and lifespan of the alternatives for roofing in order to identify most promising ones.

Table 4.3 Assessment of alternatives to chrysotile asbestos

Alternatives Vietnam	Use	Prices*	Lifespan**	Characteristics***
Baked tiles	Roofing	+	+	++
Aluminium	Roofing	+	+	-
Plastic	Roofing	+	-	+
Synthetic organic fibres (aramid, PVA, Polyamides and polyacrylonitrile)	Roofing	-	-	-
Alternatives South Africa		Prices	Lifespan	Characteristics
Corrugated Iron & Coloured IBR Sheeting	Roofing	+	+	+
Synthetic organic fibres (aramid, PVA, Polyamides and polyacrylonitrile)	Roofing	+	-	n/a
Concrete roof tiles	roofing	-		+
(Coated) pressed metal tiles	roofing	n/a	-	n/a

Alternatives Vietnam	Use	Prices*	Lifespan**	Characteristics***
Gypsum Board and Vermiculite Board	Flat sheet	+	n/a	n/a
Corrugated Metal Roofs (galvanised and coated)	roofing	+	n/a	-
Fibre cement, Masonite and Isowhite Board	Flat sheet	+	n/a	n/a
Plant fibres and natural organic fibres	Flat sheet	n/a	-	-

*low price (++), medium price (+), high price (-). ** High lifespan (++), medium lifespan (+) and low lifespan (-). Good characteristics (+) and bad characteristics (-)

Conclusions

There are a wide number of alternatives available for chrysotile asbestos in numerous developing countries and economies in transition (e.g. Vietnam, Thailand, Brazil, South Africa and Chile). National and global suppliers of alternatives to chrysotile asbestos are present in markets in developing countries and economies in transition. Prices differ from different alternatives according to information provided by Vietnam and South Africa.

Considering prices, lifespan and characteristics baked tiles as well as corrugated iron & coloured IBR seem to be considered the most promising solutions for roofing, but both are more expensive than asbestos.

Gypsum Board and Vermiculite Board, and Fibre cement, Masonite and Isowhite Board seem to be relevant for flat screen without sufficient information for comparison.

There seems to be urgent need for further price and performance data for other alternatives, including those considered sustainable from an ecological point of view.

4.2 Severely hazardous pesticide formulations (SHPFs) of Paraquat

Overview

Paraquat is a pesticide used as herbicide for use on bananas, citrus, cacao, coconut trees, coffee tree, oil palm, plantain, rubber tree, tea shrubs, avocado, trees, cashews, mango trees, papaya trees, sugar cane, cotton, maize, rice, sorghum, non-cultivated land, industrial land, railroads and roadsides for the controls of weeds such as grass and dicotyledonous plants.

Analysis of alternatives for severely hazardous pesticide formulations (SHPFs) of Paraquat

For Paraquat, a total number of 19 alternatives have been identified during literature search. These comprise 3 chemical alternatives (Glyphosate, Glufosinate and Indaziflam), pine oil or coconut oil extracts as non-chemical alternative, and various alternative weed management practices.

Glufosinate and Indaziflam are commercialised and used in African countries as an alternative to Paraquat, but no data could be identified about exports, imports or prices, so that further analysis on the availability could not be done. For pine oil or coconut oil extracts it was not possible to identify producers and user countries.

Glyphosate

Glyphosate is a non-selective, systemic, post-emergence herbicide used to control annual and perennial plants including grasses, sedges, broadleaf weeds and woody plants. It is used for crops, orchards, glasshouses, plantations, vineyards, pastures and forestry. It is used for pre-harvest desiccation of cotton, cereals, peas, beans, and other crops; for root sucker control; and for weed control in aquatic areas (PANAP, 2016).

According to FAO (Neumeister & Isenring, 2011) the use of Glyphosate is an option for weed control in bananas but should not be perceived as a solution for all weed problems.

The pesticide Glyphosate is registered and authorised for sale in the CILSS countries (Burkina Faso, Cape Verde, Chad, Gambia, Guinea-Bissau, Mali, Mauritania, Niger and Senegal)[75]. It is used on banana crops against weeds in Burkina Faso. In 2009, there was 311 registered formulations containing Glyphosate in Malaysia (PANAP, 2016). It is commercialised under the trade name of Roundup and a wide number of trade names (generic formulations) such as Bright-Up, Conto-Up, Roundsate, etc (PANAP, 2016). In 2012 it was commercialised by Monsanto and other producers (PANAP, 2016). It has been commercialised by Syngenta (global), Nufarm (India local / export) and PI Industries Ltd in India. In Pakistan is commercialised under Hold Up 480 g/l SL(41% w/w)(against Citrus annual & perennial weeds); Lasher 48% SL (against grasses, broad leaf weeds & sedges in citrus); Dominate 62% SL (against annual & perennial weeds in citrus), Carpet 75.7% SG (against citrus garden weeds as post emergence), Gluconal 48% WSC (against citrus fruit orchards weeds), Mera 71% SG (against annual & perennial weeds in citrus) and Glycel 48% SL (against annual & perennial weeds in citrus).

Alternative weed management practices

Information on non-chemical alternative weed management practices have been identified e.g. for palm oil, coffee and banana plantations from developing countries and economies in transition in Africa (Burkina Faso, Ethiopia, Tanzania (Latin America (Brazil, Ecuador and Guatemala, Colombia), and Asia (Indonesia, Papua New Guinea) as well as from global players such as Chiquita, Dole, Unilever, and Volcafe, as well as the Food and Agriculture Organisation of the United Nations (FAO).

According to Neubert & Knirsch weeds can generally be controlled effectively through an appropriate crop rotation, trap crops and good soil management (Neubert & Knirsch 1996).

Reported management practices for pest control comprise the following specified in Table 4.5.

Table 4.4 Management practices for pest control

Alternative management practice	Countries	Practices	Reference
Manual weeding	Indonesia, Brazil, Papua New Guinea, Ecuador and Guatemala, Latin America, Colombia, US, FAO	Range from hand weeding to line trimmers, thermal weeders, and tractor mounted cultivators or mowers; comprises hoeing, mowing, and cutting, off-barring and hilling-up, regular cleaning of farm tools, shading, burning/flaming, grazing	(Menet 2002), (PAN UK 1998), (Mercado 2002), US (Ashford & Reeves 2001), Neumeister & Isenring, 2011).
Cover plants (leguminous ground covers), mulching, green manure, mulches,	Indonesia, Brazil, Papua New Guinea, Ecuador and Guatemala, Costa Rica, Burkina Faso, Chiquita and Dole, FAO Tanzania, Ethiopia,	Cover crop grown in-between two cash crops. Legume cover crop sown in the inter-row of a row crop Green manuring is the plowing under or soil incorporation of any green manure crops (e.g. Azolla, Cowpea, Lablab, Mustard, Sesbania, Soybean, Sun hemp, Sweet clover, and Pigeon pea) Mulching: using cut grass, straw, chipped plant material, seaweed, etc., to smother weeds, act as a barrier against pests, retain soil moisture, reducing the impacting of soil from heavy rain, maintain a more even soil temperature, and reduce erosion)	Vietnam Roofsheet Association, 2016, (Neumeister & Isenring, 2011), (Gonçalves da Silva et al, 2010), Nishimoto (1994)

[75] UNEP-FAO-RC-CRC.8-9-Rev.1

Alternative management practice	Countries	Practices	Reference
		Good results have been achieved with watermelons in West Africa, cowpeas in India, with sweet potatoes or Geophila repens. (17)	
Shade trees	Tanzania, Chiquita and Dole, Ethiopia	n/a	Nishimoto (1994), (Neumeister & Isenring, 2011), UNEP/FAO/RC/CRC.11/7
Mowing	Indonesia, Brazil, Papua New Guinea, Ecuador and Guatemala	n/a	World Bank, 2016
Rolling and crimping	Ethiopia	In Ethiopia used in coffee.	ISC, 2016
Irrigation techniques and weeding	Tanzania	n/a	(Jansen 2005), Neumeister & Isenring, 2011)
Biological control	n/a	Introducing and promoting natural enemies and pathogens	ISC, 2016
Soil tillage	n/a	Conventional or conservation in which the crop is sown in the stubble of the previous crop	(Neubert & Knirsch 1996).
Crop rotation	n/a	Alternation between cereal/ broad leave; summer/winter crops. Crop families: allium (garlic, leek), cucurbit (melons, pumpkin), crucifer (broccoli, cabbage), legume (beans, peanut), aster (lettuce, artichoke), solanaceous (tomatoes, potatoes), grains and cereals (rice, corn), carrot family (carrot, celery), root crops (cassava, yam), mallow family (cotton and okra)	(Neubert & Knirsch 1996).
Intercropping	n/a	Growing two or more crops at the same time in the same field in terms of mixed or multiple cropping, relay cropping, row intercropping, strip cropping, field strip cropping	World Bank, 2016

In addition there are a number of further management practices such as crop genotype choice, solarisation (PANAP, 2016), soil management (manipulating soil temperature and moisture and ph-content) (Neubert & Knirsch 1996), alternative flooding, seed bed preparation or timed fertilisation, trap crops (Neubert & Knirsch 1996), etc.

A detailed list of alternative weed management practices is provided in Table D.3 Appendix D.

Market data for chemical alternatives for severely hazardous pesticide formulations (SHPFs) of Paraquat

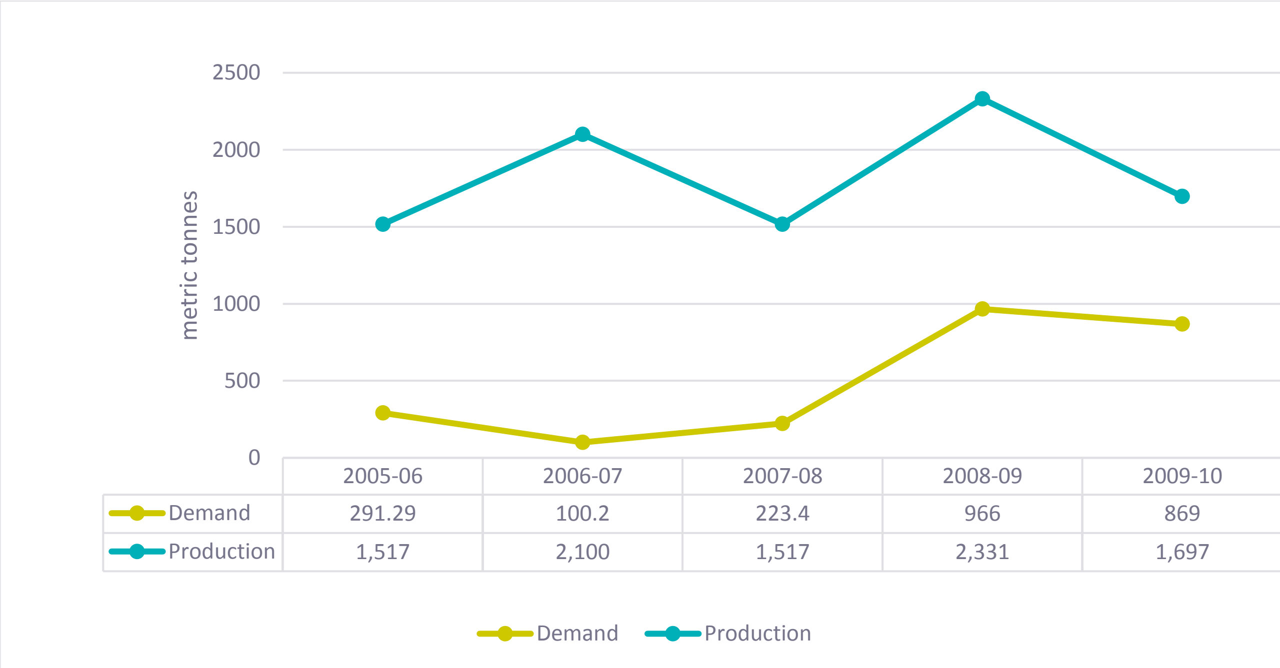
For none of the three chemical alternatives (Glyphosate, Glufosinate and Indaziflam) it has been possible to identify concrete market data on export and imports to developing countries and economies in transition, although FAO data suggest that Glyphosate is used, and Jaksch is reporting that the herbicide used most often was Glyphosate (Jaksch 2002 [26]). No data on exports from the EU was available for any of the three alternatives.

Furthermore, according to PAN AP in 2012 global production capacity was 1.1 million tonnes and global demand was around 0.5 million tonnes. Most of production takes place in China (its capacity was 0.8 million tonnes and exported 0.3 million tonnes) (PANAP, 2016). In 2009, China represented 40% of the production capacity of the global total (PANAP, 2016). Monsanto was the only producer of Glyphosate, but when the patent expired wider number of companies started also to produce it. For example, Indian (Excel Crop Care Limited) and Chinese companies (Shandong Binnong Technology Co. Ltd, Shanghai Hujiang Biochemical Co. Ltd., Shandong Qiaochang Chemical Co. Ltd and Zhenjiang Jiangnan Chemical Factory) manufacture/export their products to Pakistan. Furthermore, HELB Pesticides & Chemicals Co (Egyptian company) exports and manufacture their products to Pakistan[76].

Pine oil or coconut oil extracts has a relatively high initial purchase price, which generally makes it financially non feasible for small farmers.

Glyphosate is used and produced in India. Figure 4.1 represents the demand and production in tonnes of Glyphosate in India for the period 2005-2010. It shows that from the period 2005-2010 production and demand tended to increase. Only periods that production decreased was from 2007-2008 and from 2009-2010. Demand decreased only in 2006-2007 and 2009-2010. Demand in India in 2009-10 constituted 51.20% with the remaining stock being exported or stockpiled.

Figure 4-1 Demand and production of Glyphosate in India



	2005-06	2006-07	2007-08	2008-09	2009-10
Demand	291.29	100.2	223.4	966	869
Production	1,517	2,100	1,517	2,331	1,697

BiPRO, 2016. Data from, source: http://ppqs.gov.in/PMD.htm#statewise

Prices of Glyphosate were available for the period 2002-2008 from the USA for products traded under the name Roundup ® as presented in Figure 4.2. Prices presented a trend to decrease for the period 2002-2008. It only increased in 2008.

[76] UNEP/FAO/RC/CRC.8/5*

Figure 4-2: Glyphosate real price (2010 US$/gallon) in India[77]

BiPRO 2016, Source: https://www.nass.usda.gov/Quick_Stats/

Market data for non-chemical alternatives for severely hazardous pesticide formulations (SHPFs) of Paraquat and alternative management practices

It was not possible to identify quantitative market data for alternative weed management practices, but there are some qualitative assessments regarding its feasibility and relative effects compared to pesticide use.

According to information gathered by the Secretariat for the DGD draft for Paraquat, chemical and non-chemical strategies, including alternative technologies are available, depending on the individual crop-pest complex under consideration, the national circumstances and local conditions of use[78].

Costa Rica reported better growth and yield for oil palm plantation using legume ground covers compared to monocropped systems (Madeley (2002)) (ISC, 2016).

For Ethiopia, it was concluded that mechanical processes are as effective in coffee plantations as herbicides, but considerably cheaper and do not lead to weed resistance (UNEP/FAO/RC/CRC.11/7).

PAN emphasized the additional benefit of crop cover for nitrogen fixation (PAN UK 1998).

Chiquita and Dole reported about reduction in herbicide use by 80% through Integrated Crop Management practices. They concluded that manual weed control linked with increased costs, but that production had not suffered and costs had been saved (ISC, 2016).

Ashford & Reeves stated that for the US mechanical removal of cover crops was shown to be more economical than the use of Paraquat (Ashford & Reeves 2001).

It however has to be admitted that weeding has to be applied many times. Reported frequency ranges from 34-to 45 times per year or about every 40 days (Mercado 2002) (17).

Conclusions

Three chemical alternatives (Glyphosate, Glufosinate and Indaziflam) were identified. Pine oil or coconut oil extracts, and various alternative weed management practices were identified as non-chemical alternatives. Based on the information available, marked data could be only assessed for Glyphosate. As patent of

[77] Further information on calculation of pricing is given in the methodology under section 2.2
[78] UNEP-FAO-RC-CRC.8-9-Rev.1

Glyphosate was owned only by Monsanto, it was the only producer of the substance. Currently, patent is expired and there a wide number of companies producing Glyphosate as a generic formulation. In 2012, it was mainly produced in China, but other producer countries like India has been also identified. In the case of India, production and demand increased from periods 2005-2010. Prices in US decreased from the period 2002-2008 (except year 2008). Glufosinate and Indaziflam are used in African countries but no data have been identified.

To the contrary there is abundant information from several developing countries and economies in transition around the world, as well as from some international companies, which are successfully using alternatives weed management instead of Paraquat and stopped or strongly reduced its use.

Paraquat is herbicide used on wide number of crops (e.g. bananas, citrus, cacao, coconut trees, coffee tree, oil palm, plantain, rubber tree, tea shrubs, avocado, trees, cashews, mango trees, papaya trees, sugar cane, cotton, maize, rice and sorghum) for the controls of weeds such as grass and dicotyledonous plants. Comparing those uses with alternatives' uses, Glyphosate is used in numerous crops (e.g. orchards, glasshouses, plantations, vineyards, pastures, forestry, cotton, cereals, peas, beans, and other crops). On the other hand alternative weed management practices cover uses of Paraquat. For example, crop rotation is also used in rice, corn, cotton. And rolling and crimping is used in coffee.

Alternative weed management practices seem to be a good option for management of weeds, as it is applied successfully in some regions. Glyphosate is an herbicide that can cover numerous uses of Paraquat. However, regarding the human and environmental hazards of Glyphosate seems that alternative weed management practices are more suitable. Additionally, Glufosinate, pine oil extract and coconut oil extract and Indaziflam were identified, but no information was available on trade data.

4.3 Severely hazardous pesticide formulations (SHPFs) of Fenthion

Overview

Fenthion is a pesticide used as insecticide/avicide/acaricide.

According to reported data its use is different according to regional needs.

In Chad, Mauritania, Niger and Gambia it has been reported to be against granivorous birds, whereas in Australia, New Zealand Norway, EU, and in Cape Verde, Madagascar, and Morocco it has been reported to be used as insecticide.

Analysis of alternatives for severely hazardous pesticide formulations (SHPFs) of Fenthion

In the course of this review a total of 13 alternatives have been identified for Fenthion, 5 chemical alternatives and 8 non-chemical alternatives.

Chemical alternatives to insecticide use comprise chemicals such as Thiamethoxam, Deltamethrin, Imidacloprid and Thiacloprid. For further information on crops, pest, trade names and user countries see Table D.4 in Appendix D.

Some producers were identified and are provided in Table 28 in Appendix D. Most of them are global companies, Indian companies or companies present at African markets.

Furthermore, Cyanophos was the only chemical alternative identified for avicide use, which was identified to be registered in Tanzania (World Bank, 2016),ISC, 2016.

Non-chemical alternatives such as trapping nets, alarms, noise, slingshot, nest removal /destruction campaign, date of seeding, alternate crops, variable choice, etc., has been identified against bird's pest (avicide) in Georgia and in Chad and Mauritania as well as in other Sahel countries[79],[80].

[79] UNEP/FAO/RC/CRC.8/5/Add.2*
[80] UNEP/FAO/RC/CRC.1/27.rev.1

Please note that this review may not have the same level of detail and comprehensiveness as a research project focussed exclusively on Fenthion alternatives that is currently run in parallel to this work.

Market data for chemical alternatives of severely hazardous pesticide formulation (SHPFs) of Fenthion

Thiamethoxam

According to information from Food and Agriculture Organisation of the United Nations (FAO, 2016b) Thiamethoxam has been imported from 2008 to 2015 by 10 developing countries and economies in transition from Africa (Malawi), Asia (Bangladesh, Malaysia, Myanmar and Thailand), Near East (Lebanon), Europe (Serbia, Ukraine and Turkey), Latin America and the Caribbean (Ecuador) (FAO, 2016b). Ukraine reported imports of Thiamethoxam together with Clothianidin.

Lebanon, Malawi and Ecuador reported marginal imports (e.g.imported less than one ton) or sporadic imports (e.g.imported not all years). Thus, these imports were not considered in the current analysis. Table 4.5 and Figure 4.4 show imports of Thiamethoxam (tons and real prices (2010 US$/ton)) of 7 countries for the period 2008-2015 (FAO, 2016b)

Figure 4.3 and Figure 4.4 shows the annual growth rates (%) and geometric average of growth rate of import quantities of Thiamethoxam (in tons) for the period 2008-2015.

Table 4.5 Annual growth rates and geometric average of growth rate 2008-2015[81] of Thiamethoxam import quantities

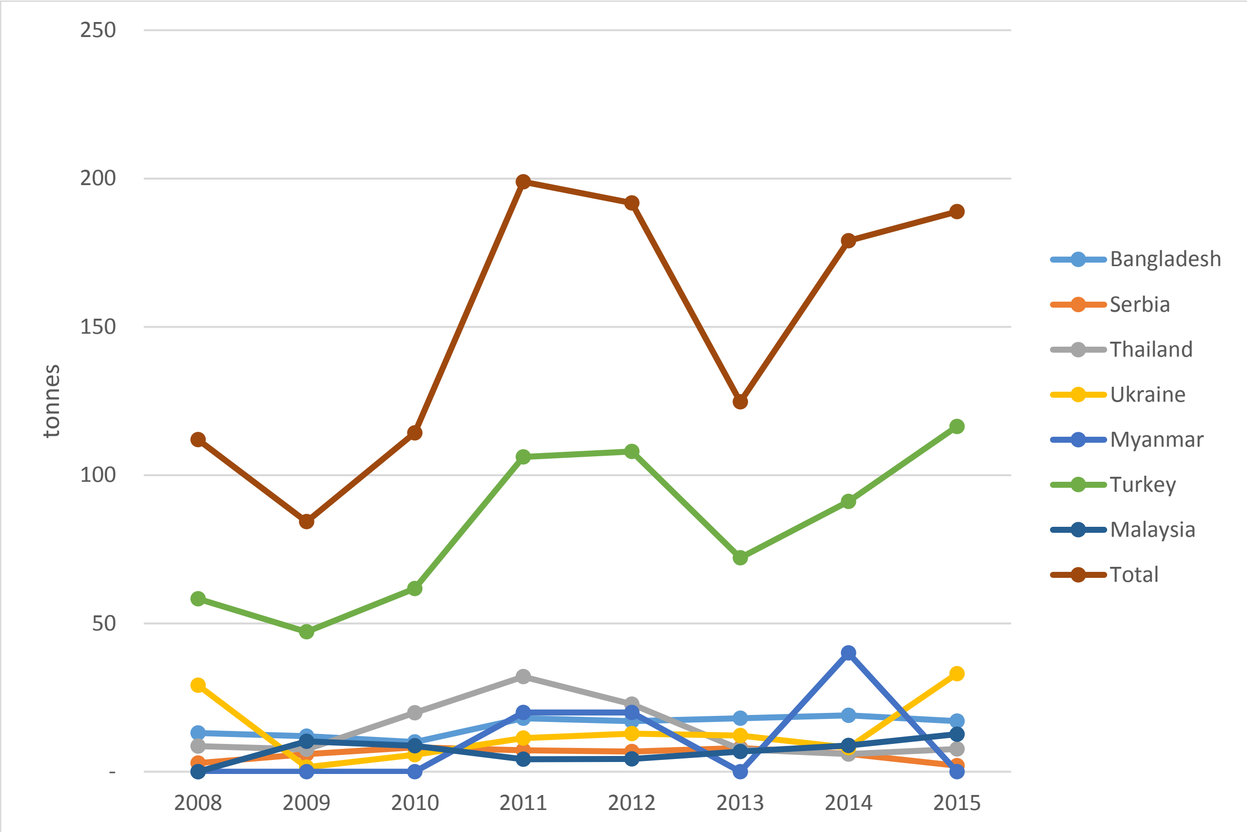
Years	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Annual growth rate* $_{(t-t+1)}$	33%	-26 %	-43%	4 %	54%	-30%	-5%
Geometric average of growth rate ** $_{(2008-2015)}$= -7%							

Annual growth rates decreased for all periods except for 2008-2009, 2011-2012 and 2012-2013. Major decrease was in the period 2011-2012 (-43%) and major increase on 2012-2013 (54%). Import quantities decreased for the whole period 2008-2015 (-7%).

Figure 4.3 and Figure 4.4 show imports of Thiamethoxam (tons and real prices (2010 US$/ton)) of 7 countries for the period 2008-2015 (FAO, 2016b).

Figure 4-3 Thimethoxam import amounts (tons)

[81] * The annual growth rate is calculated by the formula (Q_t - Q_{t-1}/Q_{t-1}) x 100. ** The geometric average growth rate for 2008-2015 is calculated by the formula ($\prod_{t=1}^{n} annual\ growth\ rate\ t$) $^{1/n}$= (annual growth $rate_{2008}$ x annual growth $rate_{2009}$ x ….x annual growth $rate_{2015}$)$^{1/8}$.



Source. BiPRO 2016, from data from FAO, 2016b

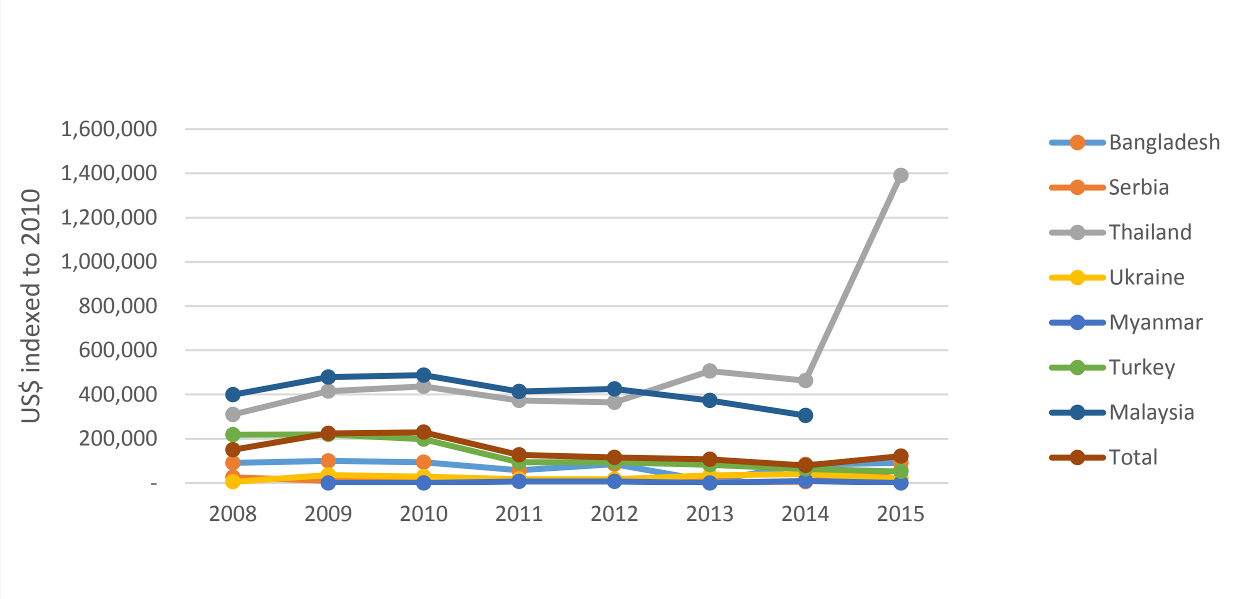
Overall imports tended to increase for the period 2008-2015. However it seems that the overall import quantities are leaded by the import quantities of Turkey as they follow the same exact trend. In the case of Thailand, Myanmar and Ukraine, import quantities fluctuate and to not have a clear trend. On the other hand in the cases of Malaysia and Serbia import quantities remain quite stable for the whole period 2008-2015.

For countries that reported marginal/sporadic imports there is some differences. In the case of Lebanon, it only reported imports for 2012, 2013 and 2015. For these years imported quantities slightly decreased. Malawi reported only in 2012 and 2014. Import quantities in 2014 were smaller than 2012. In the case of Ecuador import quantities slightly decreased.

Overall prices tended to decrease for the period 2008-2015, even there were period that prices increased a little (2008-2010 and 2014-2015). All countries follow same trend of decreasing prices, except for Thailand, which in 2015 prices sharply increased.

For the countries that reported marginal/sporadic imports there are some differences. In the case of Malawi it was not possible to calculate import prices, due to non-availability of US$ import values. For Lebanon, for the years that US$ import values were reported (2012 and 2014) prices slightly decreased. In the case of Ecuador prices increased.

Figure 4-4 Thiamethoxam average real import price (2010 US$/ton)[82]



Source. BiPRO 2016, from data from FAO, 2016b

Deltamethrin

For Deltamethrin no data on exports and imports could be identified. However, demand and production, prices in India for years 2005-2010 are available and provided in Appendix E (India, 2016b).

Figure 4-5 Prices decreased form 2007-2010, which was the only period available. There was no demand of Deltamethrin for 2005-2007, but from 2007 to 2010 demand started growing. On the other hand, production tended to decrease from 2005-2010. Comparing demand and production, production level is higher than demand level for the period 2005 2008, and after 2008 demand starts to be higher than production. Thus, it seems that as production is higher than demand for the period 2005-2008, India might have been exported this stock or stockpiled.

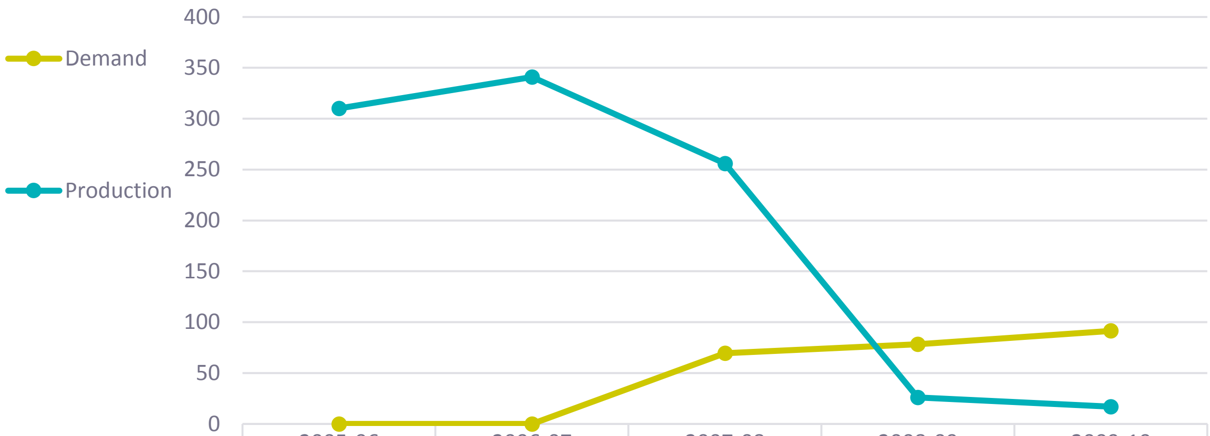
Table 4.6 Market data of Deltamethrin in India

Years	2005-06	2006-07	2007-08	2008-09	2009-10
Prices[91] (US$) indexed 2010	-	-	7.64 US$	6.60 US$	6.45 US$

Source: http://ppqs.gov.in/PMD.htm#statewise

[82] Further information on calculation of pricing is given in the methodology under section 2.2

Figure 4-5 Demand and production of Deltamethrin in India



	2005-06	2006-07	2007-08	2008-09	2009-10
Demand	0	0	69.48	78.435	91.42
Production	310	341	256	26	17

BiPRO 2016. Source: http://ppqs.gov.in/PMD.htm#statewise

Imidacloprid

For Imidacloprid no data on exports and imports could be identified. However, demand and prices in India for years 2005-2010 are available. Furthermore prices in US$ for Imidacloprid were also available for 2002-2006. In India demand increased for all periods except for 2007-2008, and prices decreased in 2007-2008 and decreased in 2009-2010 (only periods available). Prices in US decreased for the whole period from 2002 to 2006. For further information see Table 65 and Table 66 in Appendix E

Market data for non-chemical alternatives of severely hazardous pesticide formulation (SHPFs) of Fenthion

In Mauritania total cost of **nest removal campaigns** were 57,113.44 US$[83] for the years 2006, 2010, 2011 (PANAP, 2016). Alternative methods against granivourous birds represent less than half of the amount of Fenthion treatment. For example from years 2002-2012 the total costs on Fenthion and alternative methods were as represented in Table 4.7.

Figure 4-6 shows that 69% of the costs were due to Fenthion use followed by non-chemical alternatives like trapping nets.

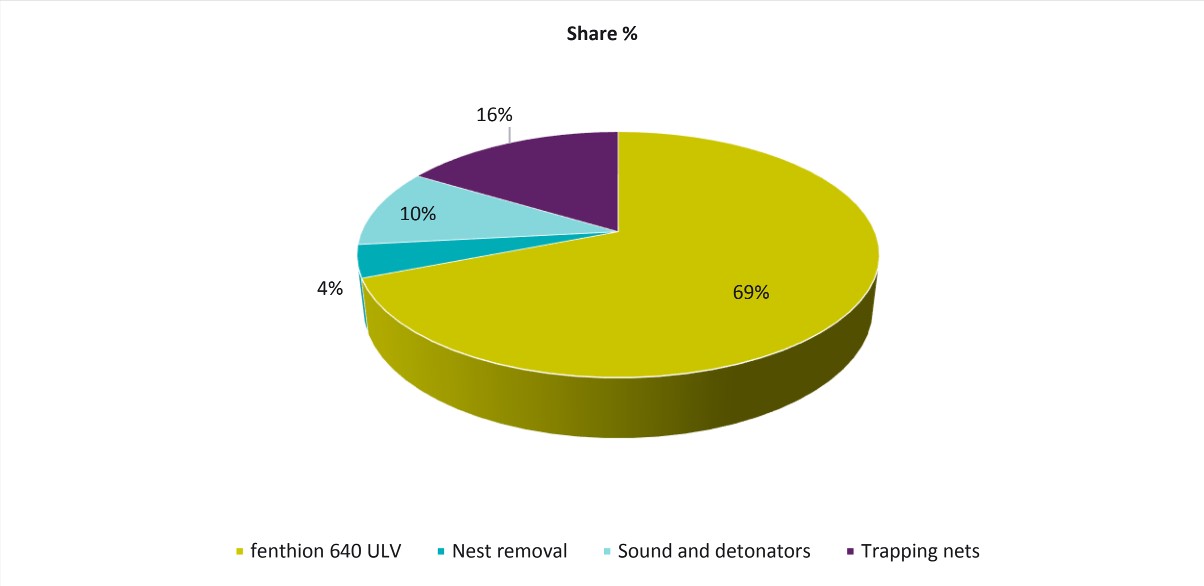
Table 4.7 Expenses on methods against granivorous birds

Method	Cost
Fenthion 640 ULV	7,100,840.33US$
Nest removal (campaigns 2008,2010 and 2011)	439,775.91 US$
Sound and detonators	1,058,823.52 US$

[83] Converted from UM to US$ (1$ US = 357 UM) https://treasury.un.org/operationalrates/OperationalRates.php

Method	Cost
Trapping nets	1,686,274.5 US$
TOTAL	10,285,714.28 US$

Figure 4-6 Pecentage of expenses of each methods on the total expenses



Conclusions

Four chemical and eight non-chemical alternatives have been identified for Fenthion, which are available in numerous developing countries and economies in transition. Chemical alternatives identified are used as insecticides and against birds, whereas the non-chemical alternatives identified are only used against birds. Chemical alternatives were available in African countries and India. For Cyanophos, based on the available information, it was identified as being registered only in Tanzania.

Some producers of alternatives were identified. Most of them are global companies, Indian companies or companies present at African markets.

Based on the available information prices and import quantities, assessment of chemical alternatives was done for Thiamethoxam. In the case of Deltamethrin and Imidacloprid market data was only assessed for India and US. In the case of Cyanophos, the assessment of market data was not possible, because of non-availability of market data. Data on quantities exported from the EU were not available for any of the chemical alternatives.

Thiamethoxam is the chemical alternative that can be applied in major number of crops and pests, considering the information available. Thiamethoxam is available[84] in 10 developing countries and economies in transition. Overall imports tended to increase for the period 2008-2015. However it seems that the overall import quantities are leaded by the import quantities of Turkey as they follow the same exact trend. For countries such Thailand, Myanmar and Ukraine, import quantities fluctuate and to not have a clear trend, whereas for Malaysia and Serbia import quantities remain quite stable for the whole period 2008-2015. Overall prices tended to decrease for the period 2008-2015 as well as prices for all countries, except for Thailand, which in 2015 prices sharply increased.

For Deltamethrin, assessment was performed only for India (only available market data). In India, production level is higher than demand level for the period 2005-2008, and after 2008 demand starts to be higher than production.

[84] Assuming that import are not being re-exported.

In the case of Imidacloprid Indian demand increased for all periods except for 2007-2008, and prices decreased in 2007-2008 and decreased in 2009-2010, only periods available. Prices in US decreased for the whole period from 2002 to 2006.There is also numerous non-chemical alternatives that are applied in developing countries and economies in transition in African countries- especially in Chad, Madagascar and Mauritania for control of birds. In this country, nest removal, sound and detonators and trapping nets campaigns are applied. In Mauritania, trapping nets represented 16.39% of the total costs of the campaigns to control granivorous birds from 2002-2012. By considering the advantages and disadvantages as well as level of implementation of the non-chemical alternatives for control of birds, it seems that the more promising one is Traditional/Japanese trapping nets. In spite of its disadvantages, it provides good results and it is well implemented in Madagascar. The other non-chemical alternatives are implemented locally or not implemented.

To sum up, it seems that the most promising alternatives to Fenthion (Thiamethoxam and Traditional/Japanese trapping nets) are available in some developing countries and economies in transition. Thiamethoxam covers insecticide use of Fenthion and Traditional/Japanese trapping nets covers avicide use of Fenthion.

4.4 Trichlorfon

Overview

Trichlorfon is a pesticide used as insecticide.

It is used in Brazil on alfalfa, apple, avocado, banana, beans, broccoli, cabbage, sugar cane, cantaloupe, carnation, carrot, cashew nuts, cauliflower, chicory, citrus, cocoa, coconut, coffee, corn, cotton, count fruit, cucumber, custard apple, eggplant, figs, grapes, guava, lettuce, mango, melon, pastures, peanuts, pear, peach, peas, peppers, persimmon, pineapple, plum, potato, prunes, pumpkin, quince, rice, roses, rubber tree, soybeans, squash, sunflower, tomatoes, watermelon and wheat; and in the EU it is used on tomatoes against lepidopteron insects[85,86,87].

Analysis of alternatives for Trichlorfon

A total of 32 alternatives have been identified for Trichlorfon, 20 chemical alternatives and 12 non-chemical alternatives. Detailed information on dose application, crops used and pests used against as well as countries where chemical alternatives are known to be used is provided in Table 29 Appendix D.

Non-chemical alternatives identified for Trichlorfon were the biological insecticide Bacillus thuringiensis and 11 cultivation practices (e.g. crop rotation, intercropping, etc.). For further information on this see Table 30 Appendix D.

Numerous producers were identified for alternatives to Trichlorfon. For further information see Table 31 in Appendix D.

Market data for alternatives to Trichlorfon

Acephate

According to data provided by the European Commission Acephate has been exported from France to African countries (Ivory Coast, Algeria, Kenia, Senegal, South Africa and Morocco) from 2006 to 2008 and from 2010 to 2012 (with an average of 9.93 tonnes, ranging min. 0.08 tonnes and max. 43.67 tonnes) (European Commission, 2016). No exports were notified for the same countries in 2009. The following graph shows these exports of Acephate for 2006 to 2008 and from 2010 to 2012.

[85] UNEP/FAO/RC/CRC.8/5*
[86] UNEP/FAO/RC/CRC.8/5/Add.1*
[87] UNEP/FAO/RC/CRC.8/5/Add.2*

Figure 4-7 Acephate export amounts (tonnes)

BiPRO 2016, from data from European Commission about export quantities in tonnes

From the period 2006 to 2008 there is a significant increase in export quantities with a geometric average growth rate of 663%. Growth rates for periods 2006-2007 and 2007-2008 were 1,664% and 230%.

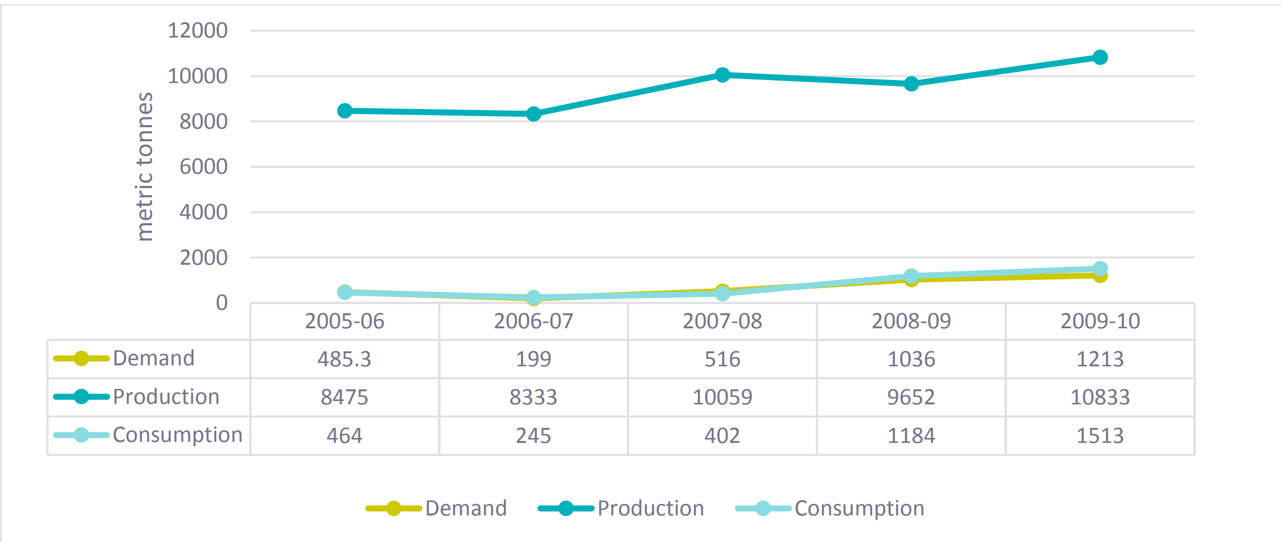
Furthermore, data on demand, production and prices of Acephate in India for the period 2005-2010 is provided in Table 4.8 and Figure 4-8 . Prices in India increased from 2005-2009, and decreased in 2009-2010. Production and demand in India tended to slightly increase for the whole period 2005-2010. For the whole period production levels are higher than demand, thus this stock could be exported or stockpiled.

Table 4.8 Price of Acephate in India

Years		**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**
Prices[91]Acephate WP indexed 2010.	**75%**	5.52 US$	6.33 US$	7.86 US$	9.49 US$	7.77 US$

Source: http://ppqs.gov.in/PMD.htm#statewise

Figure 4-8 Demand, consumption and production of Acephate in India



Additionally, prices of Acephate, which was commercialised under the trade name of Orthene were available in US for the period 2002-2008. These prices are provided (expressed in US$ real prices 2010[88] /gallon) in Table 4.9.

Table 4.9 Prices of Acephate in US from 2002-2006

Years	2002	2003	2004	2005	2006	2007	2008
Prices US$	17.74	17.24	15.99	14.74	14.01	13.58	11.98

Source: https://www.nass.usda.gov/Quick_Stats/

Clothianidin

According to data provided by FAO Clothianidin has been imported from 2008 to 2015 by 4 developing countries and economies in transition from Europe (Serbia) and Asia (Thailand, Malawi and Malaysia) (FAO, 2016b). Clothianidin was also reported to be imported together with Thiamethoxam by Ukraine (these imports are considered in market data of Thiamethoxam as they were reported as Thiamethoxam imports by this country. Malaysia and Malawi reported marginal imports (imported not all years or less than one ton). Thus, these imports were not considered in Table 4.10. Figure 4.9 and Figure 4-10 show imports of Clothianidin in tons and average real import price (2010 US$/ton) of 2 countries for the period 2008-2015 (FAO, 2016b).

Table 4.10 shows the annual growth rate for each year and the geometric average growth rate for 2008-2015.

Table 4.10 Annual growth rates and geometric average growth rate[89] of import quantities of Clothianidin

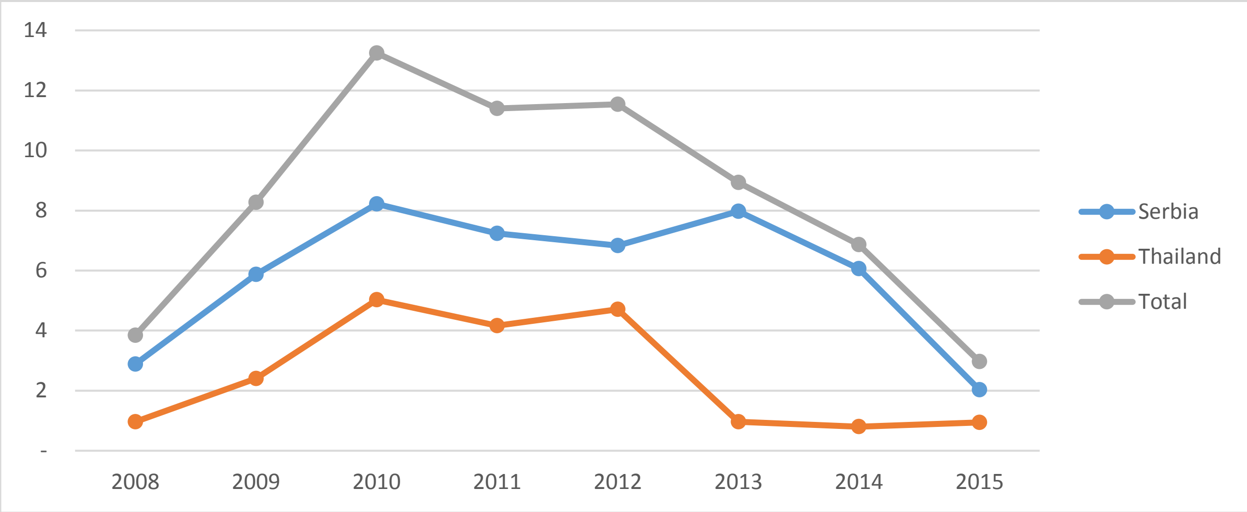
Years	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Annual growth rate* $_{(t\text{-}t+1)}$	116%	60 %	-14%	1 %	-23%	-23%	-57%
Geometric average of growth rate ** $_{(2008\text{-}2015)}$= **-4%**							

Import quantities decreased 4% for the whole period 2008-2015. For all years import quantities decrease except for periods 2008-210 and 2011-2012.

Figure 4.9 and Figure 4-10 show imports of Clothianidin in tons and average real import price (2010 US$/ton) of 2 countries for the period 2008-2015 (FAO, 2016b).

[88] http://databank.worldbank.org/data/reports.aspx?source=2&series=FP.WPI.TOTL&country
[89] * The annual growth rate is calculated by the formula (Q_t - Q_{t-1}/Q_{t-1}) x 100. ** The geometric average growth rate for 2008-2015 is calculated by the formula ($\prod_{t=1}^{n} annual\ growth\ rate\ t$) $^{1/n}$= (annual growth rate$_{2008}$ x annual growth rate$_{2009}$ x ….x annual growth rate$_{2015}$)$^{1/8}$.

Figure 4-9 Clothianidin imports (tons)



Source. BiPRO 2016, from data from FAO, 2016b

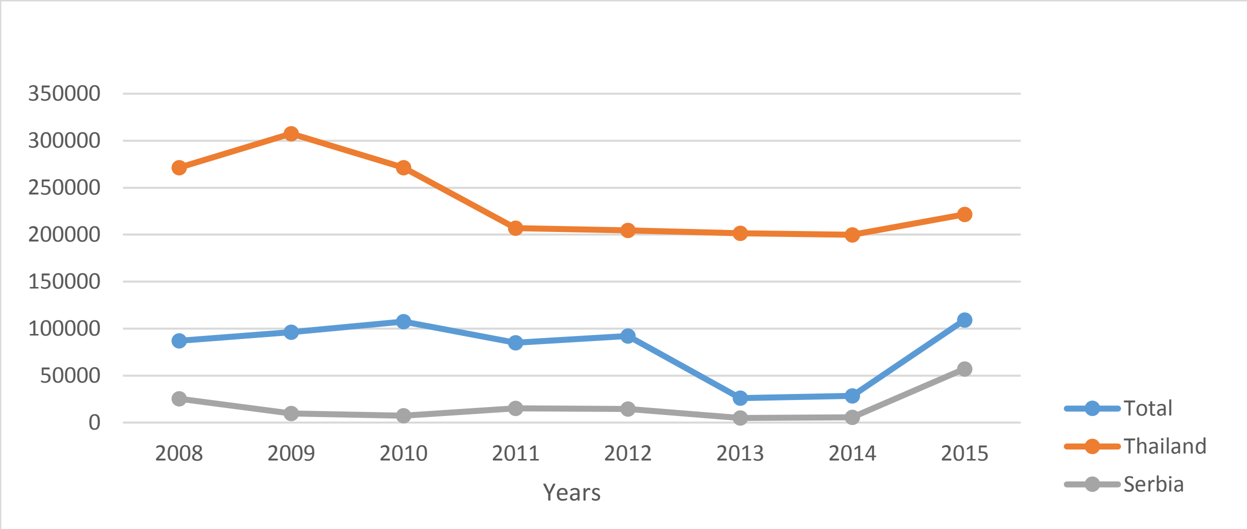
In general import quantities decreased from 2008-2015. However, import quantities tended to increase from 2008 to 2010 and to decrease from 2010 to 2015 (with the exception of year 2012 that showed a minor increase). For Thailand import quantities increased from 2008 to 2010 and 2001-2012 and decreased in 2010-2011 and from 2012 to 2014. In the case of Serbia, import quantities increased from 2008 to 2010 and 2012-2013, and decreased from 2010 to 2012 and 2013-2015.

For the countries that marginal/sporadic imports were reported there was some differences. Malawi did not provided data on imports and Malaysia reported less than 1 ton for only year 2014.

Overall prices do not follow a clear trend. Prices slightly increased from 2008-2010, 2011-2012 and 2013-2015, decreased from 2010-2011 and 2012-2013. For Serbia prices remained quite stable from 2008-2014, followed by a significant increase in 2014-2015. For the period 2013-2015 overall prices and prices from Serbia seem to follow the same trend. In the case of Thailand, prices tended to decrease, despite there were slightly increases from 2008-2009 and 2014-2015.

For the countries that marginal/sporadic imports were reported there was some differences. Malawi did not provided data on imports and Malaysia reported only import values only for 2014.

Figure 4-10 Clothianidin average real import price (2010 US$/ton)[90]

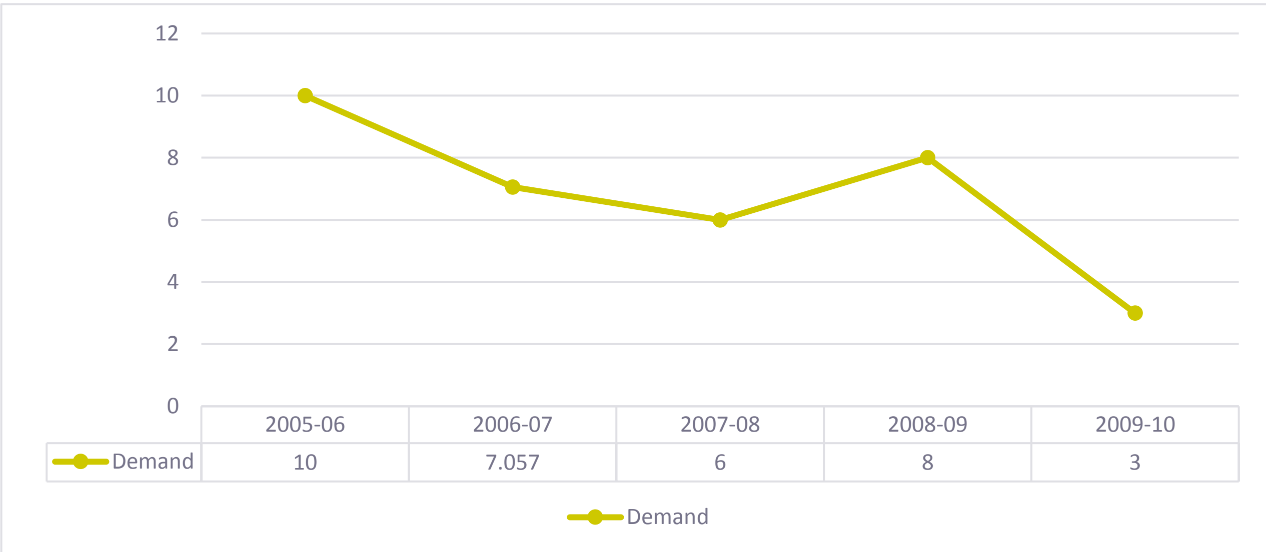


Source. BiPRO 2016, from data from FAO, 2016b

Cyfluthrin

There was no data on import and export of Cyfluthrin, however demand of Cyfluthrin was available for India. Figure 4-10 shows Indian demand of Cyfluthrin for the period 2005-2010.

Figure 4-11 Market data of Cyfluthrin in India



Source: http://ppqs.gov.in/PMD.htm#statewise

Additionally, prices of Cyfluthrin, which was commercialised under the trade name of Baythroid were available for US for the period 2002-2008. These prices are provided (expressed in US$ real prices 2010[91]/gallon) in table 4.11.

[90] Further information on calculation of pricing is given in the methodology under section 2.2
[91] http://databank.worldbank.org/data/reports.aspx?source=2&series=FP.WPI.TOTL&country

Table 4.11 Prices of cyflutrin in US from 2002-2006

Years	2002	2003	2004	2005	2006	2007	2008
Prices	55.9	51.8	45.59	44.4	41.81	38.93	31.18

Source: https://www.nass.usda.gov/Quick_Stats/

D-trans Alletrin

There was no data on import and export of D-trans Alletrin, however D-trans Alletrin demand was available for India. Figure 4-12 shows Indian demand for the period 2005-2010. Demand for the period 2005-2010 was quite fluctuant for the whole period, presenting sharply decreases from 2005-2007 and 2008-2010 and strong decreases from 2007-2008. Overall demand for 2005-2010 tended to decrease.

Figure 4-12 Demand of D-trans Alletrin in India

Source: http://ppqs.gov.in/PMD.htm#statewise

Lambda-Cyhalothrin

According to data from FAO Lambda-Cyhalothrin has been imported from 2008 to 2015 by 14 developing countries and economies in transition from Asia (Bangladesh, Myanmar, Malaysia and Thailand), Africa (Burundi, Benin, Madagascar, Senegal and Malawi), Near East (Lebanon), Europe (Ukraine, Turkey and Serbia) and Latin America and the Caribbean (Ecuador) (FAO, 2016b). Madagascar reported that the commercial name of the imported Lambda-Cyhalothrin is Lambda-Cyhalothrin 5 EC (50 g/L). Furthermore, Ukraine reported imposts of Lambda-Cyhalothrin together with Cypermethrin. This import was included in Lambda-Cyhalothrin analysis, as Ukraine included this import as Lambda-Cyhalothrin.

Lebanon, Senegal and Ecuador reported marginal (i.e. those less than one ton) or sporadical (i.e. in selected years only) imports. Thus, these imports were not considered in Table 4.12. Overall import quantities increased from 2008-2015 (11%). For all periods there are increases, except for periods 2011-2012 and 2014-2015. Figure 4.13 and Figure 4-14 show imports of Lambda-Cyhalothrin in tons and average real import price (2010 US$/ton) of 11 countries for the period 2008-2015 (FAO, 2016b).

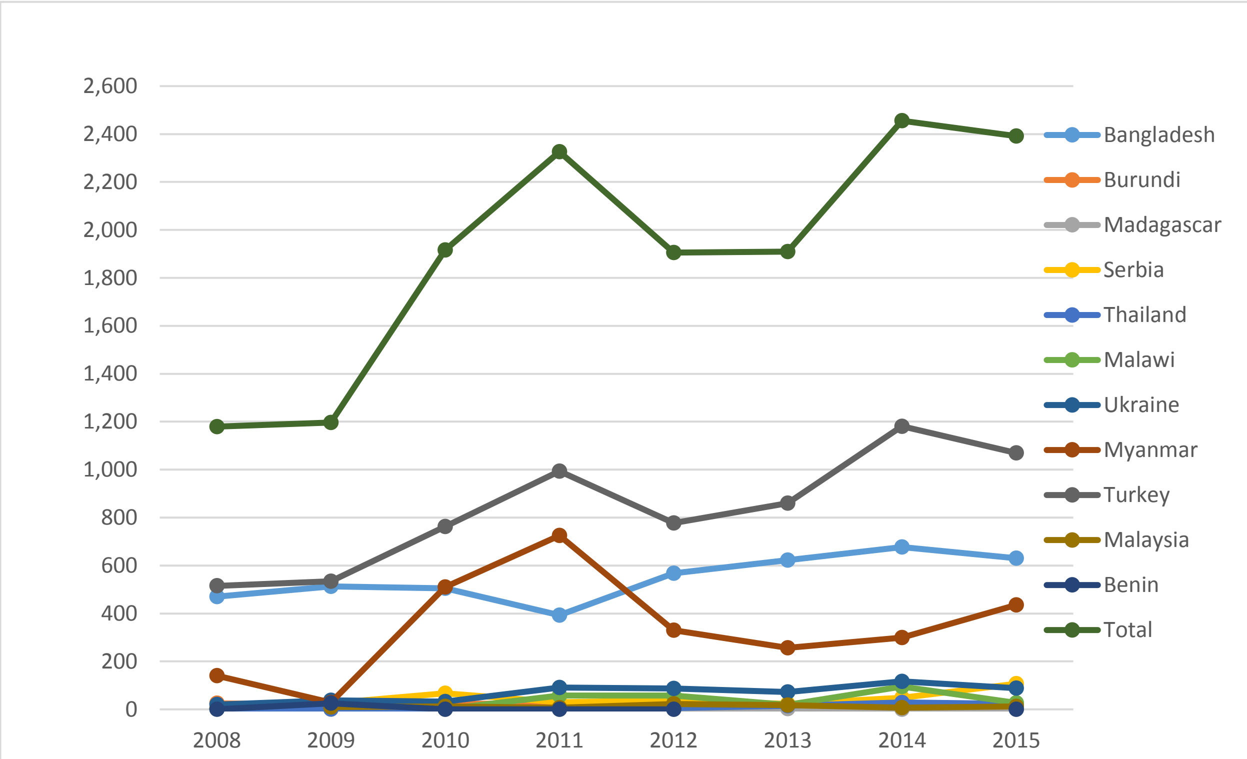
Table 4.12 shows the annual growth rate for each year and the geometric average growth rate of import quantities (in tons) of Lambda-Cyhalothrin for the period 2008-2015.

Table 4.12 Annual growth rates and geometric average growth rate 2008-2015[92] of import quantities of lambda cyhalothrin

Years	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Annual growth rate* $_{(t\text{-}t+1)}$	1%	60 %	21%	-18%	0%	29%	-3%
Geometric average of growth rate $^{**}_{(2008\text{-}2015)}$ **= 11 %**							

Overall import quantities increased from 2008-2015 (11%). For all periods there are increases, except for periods 2011-2012 and 2014-2015. Figure 4.13 and Figure 4-14 show imports of Lambda-Cyhalothrin in tons and average real import price (2010 US$/ton) of 11 countries for the period 2008-2015 (FAO, 2016b).

Figure 4-13 Lambda-Cyhalothrin imports (tons)



Source. BiPRO 2016, from data from FAO, 2016b

Overall import quantities increased from 2008-2015. Major increase occurred from 2009-2011.The same trend to increase is seen for quantities in Turkey and Bangladesh. Quantities for Myanmar in 2015 increased slightly compared to quantities in 2008. On the other hand for some countries like Burundi, Madagascar, Serbia, Thailand, Malawi, Ukraine, Malaysia and Benin import quantities were quite stable.

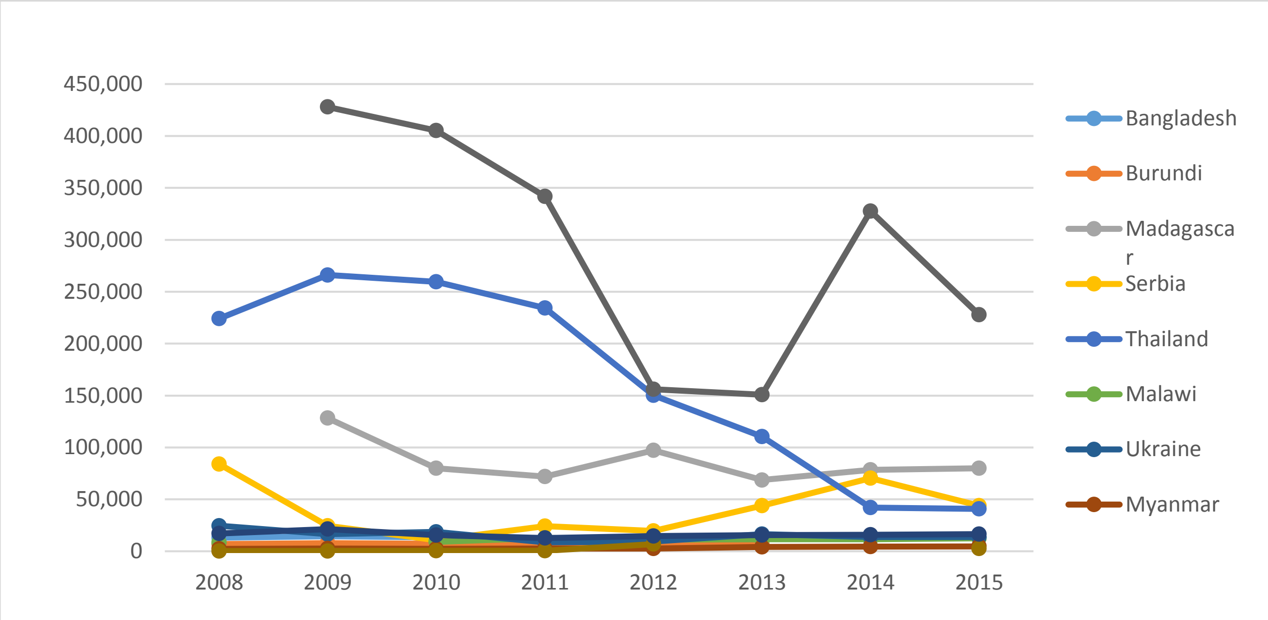
[92] * The annual growth rate is calculated by the formula (Qt - Qt-1/Qt-1) x 100. ** The geometric average growth rate for 2008-2015 is calculated by the formula ($\prod_{t=1}^{n} annual\ growth\ rate\ t)^{1/n}$ = (annual growth rate$_{2008}$ x annual growth rate$_{2009}$ x ….x annual growth rate$_{2015}$)$^{1/8}$.

For countries that reported marginal/sporadic imports there were differences. In the case of Lebanon and Ecuador, import quantities were quite stable. Senegal only reported import quantities (less than 1 ton) from 2008, 2009, 2012 and 2015.

Overall, prices seem to be quite stable for the whole period. The same stability is observed in countries such as Burundi, Thailand, Malawi, Ukraine, Myanmar and Benin. On the other hand, for Bangladesh and Madagascar prices presented a clear trend to decrease. For Malaysia prices decreased from 2009 to 2013, increased in 20013-2014 and fell in 2014-2015. For Serbia prices did not follow any clear trend, but comparing 2008 prices with 2015 prices they decreased.

For the countries that reported marginal/sporadic imports there are some differences. Since Senegal did not provided US$ import values, prices could not be calculated. In the case of Lebanon, prices increased from 2011-2015 (only period imports reported). For Ecuador, prices increased from the period 2008-2015.

Figure 4-14 Lambda-Cyhalothrin average real import price (2010 US$/ton)[93]

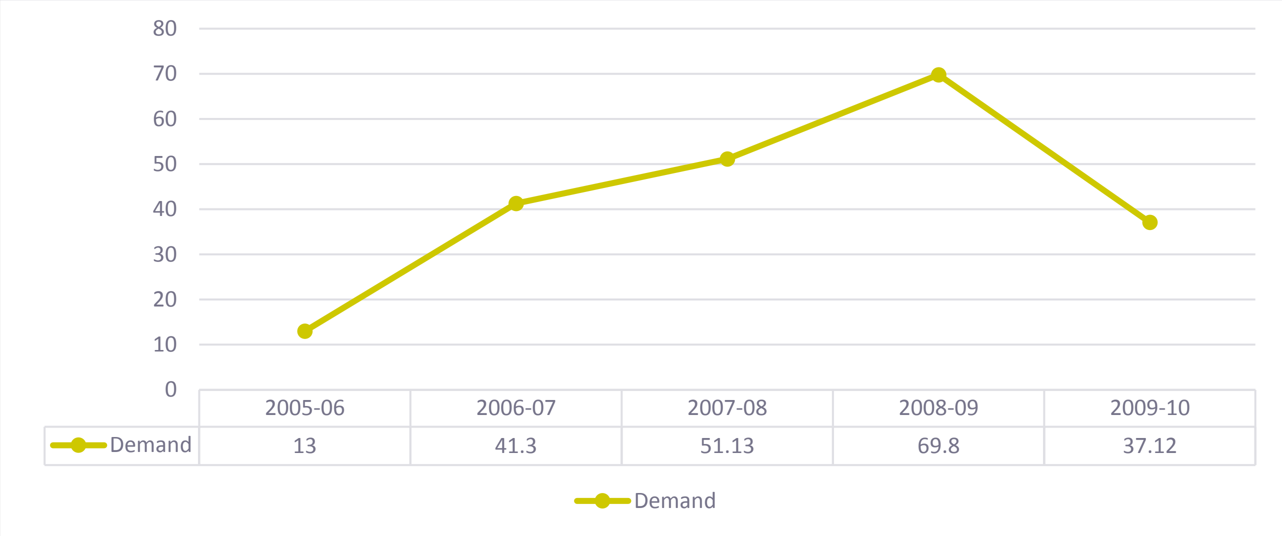


Source. BiPRO 2016, from data from FAO, 2016b

Furthermore, data on demand Lambda-Cyhalothrin in India for the period 2005-2010 is provided in the Figure 4-15, this demonstrates that demand in India increased from 2005 to 2009 and started to decrease in 2010.

[93] Further information on calculation of pricing is given in the methodology under section 2.2

Figure 4-15 Demand of Lambda-Cyhalothrin in India



Source: http://ppqs.gov.in/PMD.htm#statewise

Phosmet

Prices of Phosmet were available in US for the period 2002-2008. These prices are provided (expressed in US$ real prices 2010[94]/gallon) in Table 4.13.

Table 4.13 Prices of Phosmet in US from 2002-2008.

Years	2002	2003	2004	2005	2006	2007	2008
Prices	10.28 US$	9.89 US$	9.38 US$	9.76 US$	9.46 US$	9.67 US$	8.69 US$

Source: https://www.nass.usda.gov/Quick_Stats/

Spinosad

According to data from FAO, Spinosad has been imported from 2008 to 2015 by 9 developing countries and economies in transition from Asia (Bangladesh, Malaysia and Thailand), Africa (Madagascar and Senegal), Europe (Serbia and Turkey), Latin America and the Caribbean (Ecuador) and Near East (Lebanon) (European Commission, 2016).

Lebanon, Madagascar, Senegal, Malaysia and Ecuador reported marginal (i.e. those less than one ton) and sproadical imports (i.e. in selected years only) thus the data on imports were not considered in Table 4.14. Overall import quantities increased from 2008-2015 (4%). For all periods import quantities increased except from 2008-2009, 2012-2013 and 2013-2014.

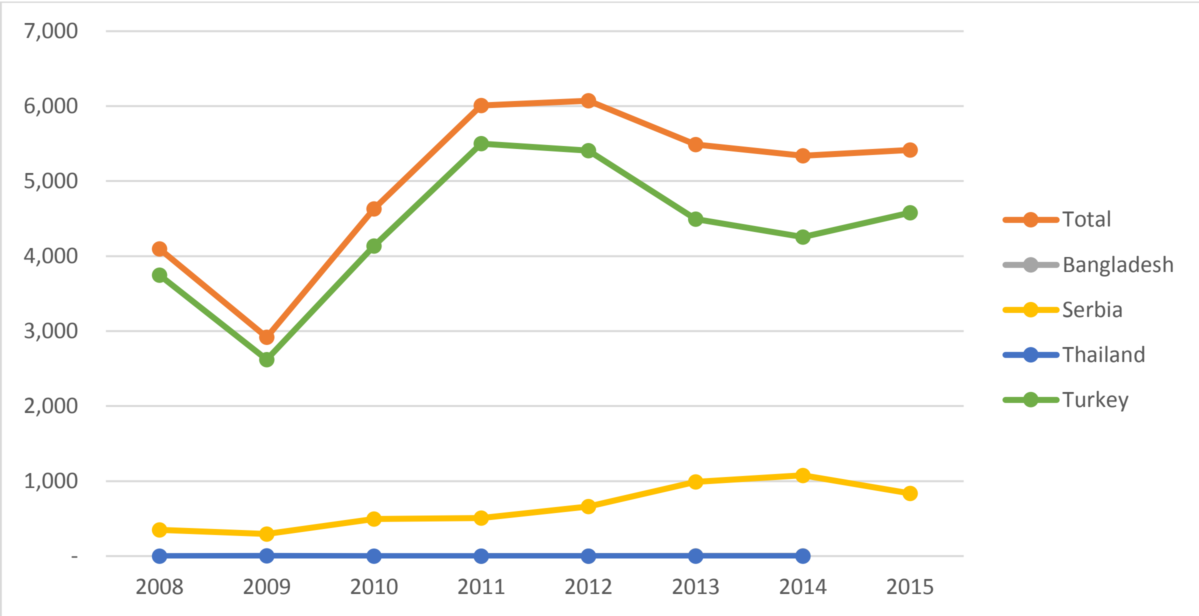
Figure 4.16 shows that overall imports seem to be influenced by imports from Turkey. Total imports (all countries assessed) and imports in Turkey followed the same trend to increase over the period 2008-2015, despite a strong decrease in 2008-2009. On the other hand, import quantities in Serbia slightly increased, while in Thailand they remained quite stable. For the countries that reported marginal / sproadical imports there are some differences. In the case of Lebanon, Senegal, Madagascar and Malaysia these imports decreased.

Figure 4.17 shows that prices in the main importing countries Serbia and Turkey seem to be quite stable. On the other hand, prices for Bangladesh tended to increase. In the case of Thailand there was a strong decrease of prices from 2008-2014. For Senegal import prices could not be calculated as US$ import prices were not

[94] http://databank.worldbank.org/data/reports.aspx?source=2&series=FP.WPI.TOTL&country

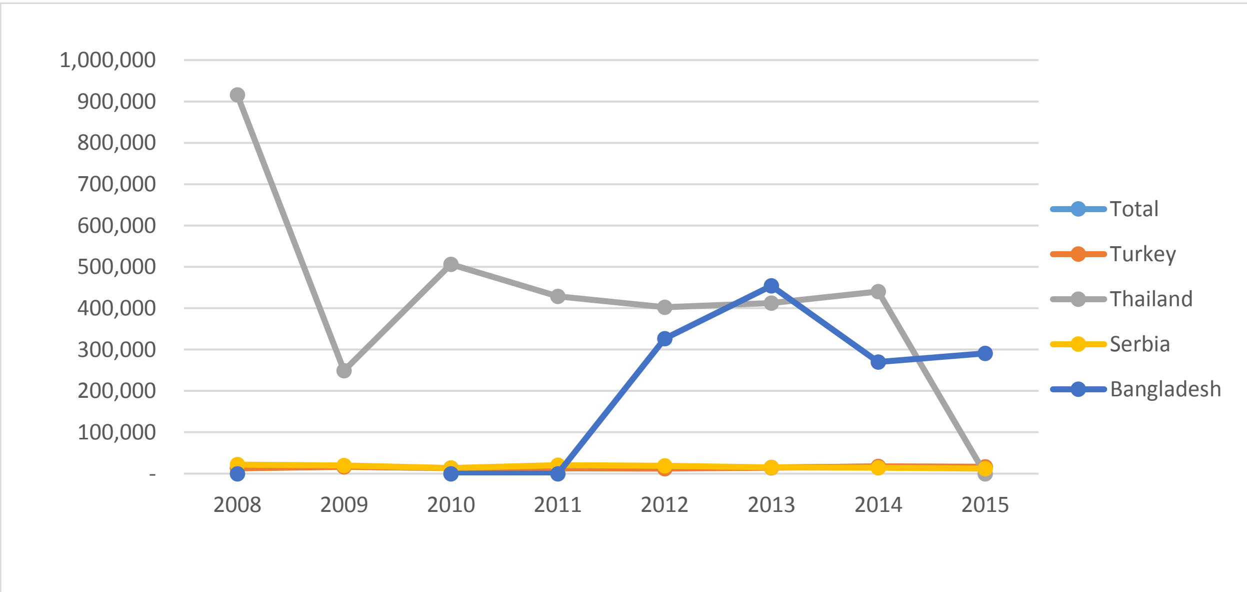
available. In the case of Malaysia prices decreased from 2009-2015. For Lebanon prices decreased from 2011 to 2014. For Madagascar prices slightly decreased from 2008 to 2015. In the case of Ecuador prices increased from 2009 to 2015.

Figure 4-16 Spinosad imports (tons)



Source. BiPRO 2016, from data from FAO, 2016b

Figure 4-17 Spinosad average real import price (2010 US$/ton)[95]



Source. BiPRO 2016, from data from FAO, 2016b

[95] Further information on calculation of pricing is given in the methodology under section 2.2

Table 4.14 Annual growth rates of Spinosad and geometric average growth rate 2008-2015[96] of import quantities of Spinosad

Years	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Annual growth rate* $_{(t\text{-}t+1)}$	-29%	59 %	30%	1%	-10%	-3%	2%
Geometric average of growth rate ** $_{(2008\text{-}2015)}$= **4 %**							

Furthermore, data on prices of Spinosad in India for the period 2005-2010 are provided in Table 4.15. Prices for the years available (2007-2010) showed a decrease.

Table 4.15 Prices of Spinosad India

Years	2005-06	2006-07	2007-08	2008-09	2009-10
Prices[91] (US$) indexed 2010	-	-	106.57US$	9.72 US$	39.63 US$

Source: http://ppqs.gov.in/PMD.htm#statewise

Other alternatives

Some of the alternatives analysed in previous sections also constitute alternatives for other substances. For Acetamipride, Diazinon, Dimethoate, Chlorpyrifos, Cypermethrin, Malathion and Bacillus thuringiensis please refer to the analysis of these alternatives in the section 3.6.

Conclusions

A total of 32 alternatives have been identified, 20 chemical (Acephate, Acetamiprid, Clothianidin, Chlorpyrifos, Cypermethrin, Deltamethrin (Pyrethroid), Diazinon, Dimethoate, D-trans Allethrin, Lambda-Cyhalothrin, Malathion, Naled , Phosmet, Pirimicarb, Pyrethrins, soap, Spinosad, and Tebufenozide) and 12 non-chemical (biological insecticide Bacillus thuringiensis and 11 cultivation practices (e.g. crop rotation, intercropping, etc.)). Uses of these alternatives have been identified in African countries and India. Most of the chemical alternatives are used in a wide number of crops and pests, with the exception of Clothianidin and Pirimicarb that are selective for corn and for alfalfa. They cover uses of Trichlorfon as insecticide, which is used in a wide number of crops (e.g. alfalfa, apple, avocado, banana, beans, broccoli, cabbage, sugar cane, cauliflower, coffee, corn, cotton, count fruit, cucumber, custard apple, etc.). Bacillus thuringiensis covers also some of the uses of triclorfon.

Numerous producers for these alternatives were also identified. Some of the producers are global producers of pesticides.

Based on available information 11 alternatives could be assessed for the period 2008-2015 (import quantities and prices). Some of them were also assessed for the period 2006 -2013, if EU export quantities were available. It seems that alternatives are available[97] in developing countries and economies in transition. For Malathion and Diazinon export quantities increased, whereas for Acephate decreased. Import quantities decreased for Malathion, Chlorpyrifos and Clothianidin whereas increased for Spinosad, Lambda-Cyhalothrin and Cypermethrin. Import quantities remained quite stable for Dimethoate. Thus, it seems that import quantities increased only for Spinosad, Lambda-Cyhalothrin and Cypermethrin. Import prices remained quite

[96] * The annual growth rate is calculated by the formula (Qt - Qt-1/Qt-1) x 100. ** The geometric average growth rate for 2008-2015 is calculated by the formula ($\prod_{t=1}^{n} annual\ growth\ rate\ t$) $^{1/n}$= (annual growth rate$_{2008}$ x annual growth rate$_{2009}$ x ….x annual growth rate$_{2015}$)$^{1/8}$.
[97] Assuming that import are not re-exported.

stable for Spinosad and Lambda-Cyhalothrin. For Malathion and Chlorpyrifos prices decreased and for Dimethoate and Cypermethrin increased.

To sum up, from 32 alternatives, 11 seem to be available in numerous developing countries and economies in transition. For these 11 alternatives trade data was assessed showing that export quantities increased in the case of Malathion and Diazinon and import quantities increased for Spinosad, Lambda-Cyhalothrin and Cypermethrin. However, import prices only increased for 2 alternatives, Dimethoate and Cypermethrin. Furthermore non-chemical alternatives as Bacillus thuringiensis is available in India and African countries and 11 cultivation practices were identified as alternatives to Trichlorfon.

4.5 Carbofuran

Overview

Carbofuran is a Carbamate and metabolite of Carbosulfan.

As reported in the notifications from Canada, EU and African countries (Cape Verde, Chad, Gambia, Mauritania, Niger, Senegal and Togo), Carbofuran is a pesticide, used as systematic insecticide, acaricide and nematicide in combination with most of the herbicides and fungicides (except propanil).

Carbofuran is used in the EU[98] and Canada[99] on a broad variety of crops against a variety of insects (sucking insects, soil insects, chewing insects), nematodes and wireworms.

In African Countries (Cape Verde, Chad, Gambia, Mauritania, Niger, Senegal and Togo) Carbofuran has been used on fruits, potato, corn, banana, coffee, sugar cane, rice, vegetable and gardening crops, as well as on soybeans against defoliator and borer insects (stem borer, yellow stem borer and leaf folder), and in forest management (Benin, Burkina Faso, Cape Verde, Ivory Coast, Guinea, Guinea Bissau, Mali, Chad, Gambia, Mauritania, Niger, Senegal and Togo)[100],[101].

Analysis on availability of alternatives

Overall 12 alternatives (10 chemicals and 2 non-chemical solutions) have been identified for Carbofuran in the course of the literature search.

Chemical alternatives include Chlorantraniliprole, Chlorpyriphos ethyl, Clothianidin, Deltamethrin, Lubendiamide, Flubendiamide, Fluopyram, Imidacloprid (see also Aldicarb), Neonicotinoid, Pyrethroid, Quinalphos.

Non-chemical alternative include Integrated Production and Pest Management and Purpureocillium lilacinum

Chemical alternatives are often applicable only for a limited number of either cops or pests. Canada reported that registered alternatives are available for some uses of Carbofuran, however, there are no registered (or viable) alternative active ingredients to Carbofuran for the control of certain pests in canola, mustard, raspberry and sugar beet (UNEP/FAO/RC/CRC.11/9). Further available information is provided in Table 32 in Appendix D.

Some producers of alternatives of Carbofuran were identified. Some of them were global producers of pesticides. There are also producers from India and from African countries. A list of all producers identified is provided in Table 33 in Appendix D.

Non-chemical alternatives identified to for Carbofuran were Integrated Production and Pest Management and Purpureocillium lilacinum.

[98] corn, sugar beets, and sunflowers, onions, ornamentals, potatoes, carrots, brassica, celery, chicory, beetroot, fodder beets, leeks, sweet corn, sunflowers, soya, tobacco, rice, garlic, cauliflower, cabbage, tomatoes, peppers, eggplant, peanuts, melons, water melons, cotton, bananas, sorghum and oilseeds
[99] canola, mustard, sunflower, corn (sweet, field and silage), sugar beets, green peppers, potatoes, raspberries, strawberries
[100] UNEP/FAO/RC/CRC.11/9
[101] UNEP/FAO/RC/CRC.11/6

Purpureocillium lilacinum was been reported to be used and commercialised in African countries as a non-chemical alternative to Carbofuran (FAO, 2016a). Integrated Production and Pest Management has been mentioned as alternative, but no additional information could be found.

Market data for alternatives to Carbofuran

For Deltamethrin and Imidacloprid there was no data on export and import, but there was data for the Indian market from 2005-2010 (see Table 65 in Appendix E for Imidacloprid and Figure 4-5 .5 in section 0 for Deltamethrin).

For Clothianidin there was data available on imports (see section 0).

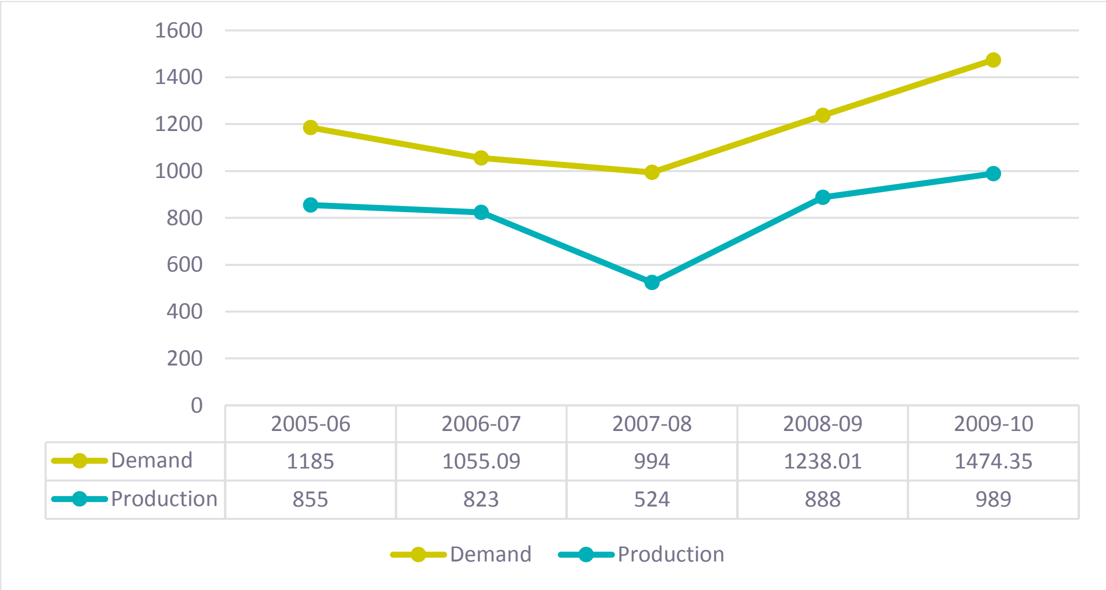
Available prices from India for Quinalphos are presented in Table 4.21. Furthermore, demand and production are represented in Figure 4-21. Demand decreased from 2005 to 2007 and increased from 2007 to 2010. Production tend to slightly increase, despite a decrease from 2005-2007. Prices for both products of Quinalphos increased from 2005-2010.

Table 4.16 Prices of Quinalphos in India

Prices[91] Quinalphos 25% EC (real prices 2010)[102]	4.27US$	4.23 US$	4.64 US$	5.38 US$	5.23 US$
Prices[91]Quinalphos 5% Gr. (real prices 2010)[111]	0.41 US$	0.96 US$	2.03US$	5.49 US$	4.15 US$

Source: http://ppqs.gov.in/PMD.htm#statewise

Figure 4-21 Market data of Quinalphos



Source: http://ppqs.gov.in/PMD.htm#statewise

[102] http://databank.worldbank.org/data/reports.aspx?source=2&series=FP.WPI.TOTL&country

Table 4.17 Market data on alternatives to Carbofuran (if available).

Alternatives	Market data
Clothianidin	Import quantities decreased Import prices slightly increased

Conclusion

Overall 12 alternatives (10 chemicals and 2 non-chemical solutions) have been identified. However, in Canada there are no registered (or viable) alternative active ingredients to Carbofuran for the control of certain pests in canola, mustard, raspberry and sugar beet. Several producers of alternatives were identified. Some of them are companies which are global producers of pesticide. Other producers identified are from India and African countries.

The most important alternatives as regards pest and crop coverage seem to be Chlorantraniliprole and Quinalphos. But there is lack of market information to assess their availability outside India. The same occurs on alternative substances such Imidacloprid and Deltamethrin. In addition market data for India and price information from the USA is rather old for an assessment. Deltamethrin and Imidacloprid seem to be rather widely available as uses are reported as alternatives to other PIC substances for India and African countries. No data on quantities of alternatives exported from the EU were identified. The application of these alternatives against pests however seems to be rather limited. However, based on information available, Clothianidin is available in Malaysia, Serbia and Thailand and registered in Malawi. Import quantities of Clothianidin decreased and import prices slightly decreased.

Purpureocillium lilacinum seems to be used as non-chemical alternative at least in African countries.

Available alternatives are on the market, but because of data availability this assessment could only conclude that alternatives are available in India and African countries. The only alternative that is available[103] in other countries is Clothianidin, which is available in 4 developing countries and economies in transition.

4.6 Carbosulfan

Overview

Carbosulfan is a Carbamate that is applied by incorporation into soil (at drilling). As reported in the notifications from EU and African countries (Burkina Faso, Cabo Verde, Chad, the Gambia, Mauritania, the Niger, Senegal and Togo), Carbosulfan is a pesticide, used as systematic insecticide / nematicide. In the EU, it was used on corn, sugar beets and citrus. It was also reported to be used in Chad, Cabo Verde, Burkina Faso, Gambia, Mauritania, Niger, Senegal and Togo[104],[105].

Analysis on alternatives

A total number of 12 alternatives (10 chemical and 2 non-chemical alternatives) have been identified for Carbosulfan.

Chemical alternatives include Abamectin, Chlorpyrifos-ethyl, Cypermethrin, Deltamethrin, Lambda-Cyhalothrin, Profenofos, Imidacloprid, Clothianidin and Fluopyram.

Non-chemical alternatives include Integrated Production and Pest Management and *Purpureocillium lilacinum*.

Numerous producers of chemical alternatives were identified. Some of them are global companies, others are Indian companies or focused on African markets. For further information see Table 34 in Appendix D.

[103] Assuming that imports will not be exported
[104] UNEP/FAO/RC/CRC.11/9
[105] UNEP/FAO/RC/CRC.11/7

In relation to chemical alternatives, detailed information on dose application, crops used and pests used against as well as countries where the alternatives are known to be used is provided below.

According to the notification of African countries the following alternatives have been authorised for the use on corn, sugar cane and vegetable crops (global list of pesticides homologate by the CSP in 2014). But according to the CSP version of May 2015 only Abamectin and Chlorpyrifos-ethyl were authorised (Sahel, 2015).

Table 4.18 Authorised alternatives in African countries

Substance	Country	Crops	Pests	Trade names	Reference
Abamectin **Chlorpyrifos-ethyl** **Lambda-Cyhalothrin** **Profenofos**	Benin, Burkina Faso, Cabo Verde, Ivory Coast, Gambia, Guinea, Guinea Bissau, Mali, Mauritania, Niger, Senegal, Chad and Togo	Sugar cane, corn and vegetable crops	Insects acarids (Mites)		UNEP/FAO/RC/CRC.11/7, Sahel, 2016a
Cypermethrin	See above	See above	n.d.	Ammo, Avicade, Barricade, CCN 52, Cymbush, Folcord, Imperator, Kafil Super, Polytrin, Ripcord and Stockade	UNEP/FAO/RC/CRC.11/7, Sahel, 2016a, Inchem website http://www.inchem.org
Deltamethrin	See above	See above	n.d. aphids (Lice)	Decamethrin, Decis, K-Othrine, NRDC 161, WHO 1998, K-Obiol, Butox Butoflin, Cislin and FMC 45498 RU 22974	UNEP/FAO/RC/CRC.11/7, Sahel, 2016a, Inchem website http://www.inchem.org (see also Trichlorfon) (FAO, 2016a).
Imidacloprid **Clothianidin**	African countries		aphid control and soli pests		SeeTable 65 and Table 66 in Appendix E and see section 0
Fluopyram	African countries		nematode control		FAO, 2016a

Purpureocillium lilacinum, which is reported to be used in African countries constitutes a non-chemical alternative to Carbofuran (FAO, 2016a).

Market comparisons between alternatives and Carbosulfan

There is information on market data for Abamectin, Cypermethrin, Deltamethrin and Lambda-Cyhalothrin. In the case of Abamectin import quantities increase and prices tend to decrease (see section 3.3). For Cypermethrin import quantities increased and prices slightly increased for the period 2008-2010. Furthermore, US prices decreased from 2002-2006 (see section 3.4). For Deltamethrin prices in India decreased form 2007-2010. There was no demand of Deltamethrin for 2005-2007, but from 2007 to 2010 demand started growing. On the other hand, production increased from 2005 to 2006 and sharply decreased from 2007-2010. There is no clear trend on consumption of imported Deltamethrin; it increased from 2005-2006, decreased to zero in 2007, increased again in 2008 and decreased in 2010 (see section 0). Consumption refers to the consumption of national produced pesticides. For Lambda-Cyhalothrin import quantities increased and prices remained quite stable from 2008-2015. Demand in India increased from 2005-2008 and decreased from 208-2010 (see section 0).

In the case of Clothianidin data on imports are available (see section 0).

For Imidacloprid no data on exports and imports are available, however demand and prices in India for years 2005-2010 were available (see Table 65and Table 68 in Appendix E).

For the other alternatives mentioned above, it was not possible to identify relevant market information. No data on quantities of exports from the EU were identified for any of the alternatives.

However, a summary of market data for the alternatives to Carbosulfan is provided.

Table 4.19 Summary of market data of assessed alternatives

Alternatives	Market data (2008-2015)
Abamectin	Import quantities increased Import prices decreased
Cypermethrin	Import quantities increased Import prices increased
Lambda-Cyhalothrin	Import quantities increased Import prices remained quite stable (slightly decrease) (2008-2015)
Clothianidin	Import quantities increased Import prices slightly increased

Conclusion

A total number of 12 alternatives (10 chemical and 2 non-chemical alternatives) have been identified for Carbosulfan. Abamectin and Chlorpyrifos-ethyl were authorised in 2015 in African countries (CILSS) (Sahel, 2015). Furthermore, Purpureocillium lilacinum, Clothianidin, Deltamethrin, Fluopyram and Imidacloprid are used and commercialised in African countries. Furthermore, Imidacloprid is also available in India.

Numerous producers of alternatives were identified. Some of them were global producers of pesticides as well as Indian and African countries 'producers.

Based on the available information 4 chemical alternatives, as Abamectin, Cypermethrin, chlothianidin and Lambda-Cyhalothrin, are also available[106] in various developing countries and economies in transition. For these alternatives assessed, which information was available, import quantities increased for the period 2008-2015. For Abamectin import prices decreased whereas for Cypermethrin increased and for Clothianidin slightly increased. Import prices of Lambda-Cyhalothrin slightly decreased even they remained quite stable.

To sum up, it seems that alternatives such Abamectin, Cypermethrin, Lambda-Cyhalothrin and Clothianidin are quite accessible in developing countries and economies in transition. Regarding trade of these alternatives, import quantities increased for all the alternatives, whereas import prices increased only for Cypermethrin and Clothianidin. Furthermore, other alternatives were also available in African countries and India, but trade data was not available.

4.7 Tributyltin compounds

Overview

Tributyltin (TBT) compounds have already been included in Annex III of the Rotterdam Convention as a pesticide in 2009. The DGD from 2009 banned the use of anti-fouling paints containing TBT, whereas TBT compounds continued to be used in material and wood preservatives and as a slimicide.

In addition, there is a current proposal by CRC from November 2015 (decision CRC-11/2) to list TBT as industrial chemical in addition to listing it as a pesticide based on a notification made by Canada.

[106] Assuming that imports will not be exported.

According to this decision, TBT compounds shall include Tributyltin (TBT) compounds including: tributyltin oxide; tributyltin benzoate; tributyltin chloride; tributyltin fluoride; tributyltin linoleate; tributyltin methacrylate; tributyltin naphthenate.

Pesticide uses as already listed under PIC since 2009, according to notifications of Canada and the European Union shall cover non-agricultural biocide pest control products, namely antifouling paints for ship hulls, as well as biocides to prevent the fouling of appliances and equipment submerged in coastal and marine aquatic environments by barnacles (UNEP/FAO/RC/CRC.1/27.rev.1), and (Rotterdam Convention, 2009d).

Industrial chemical uses as discussed for listing in the notification by Canada from 2015 shall be understood as contamination/by-product in organotin stabilizers (tetrabutyltins containing more than 30 % by weight of tributyltins) used in the PVC processing industry, in glass coating and catalysts. Other industrial uses as reported by the European Union comprise use as an auxiliary agent in stereo selective intermediate synthesis in the pharmaceutical industry, use as a modifier for synthetic rubber polymers, and niche applications for some drugs (UNEP/FAO/RC/CRC.1/27.rev.1).

The Republic of Korea reported the use of TBT as industrial wood preservative and fungicide in cooling water. Japan reported industrial uses such as for preservatives, anti-mold agents, anti-fouling paints and anti-foulants for fishing nets (UNEP/FAO/RC/CRC.1/27.rev.1).

Given the listing of TBT in the pesticides category since 2009, the focus of the assessment of alternatives should be on tin-free PVC stabilizers such as lead or calcium and zinc (mixed metal) stabilisers, as well as organic stabilizers. For the use of TBT as starting material in material preservatives, no alternatives have been reported to be currently known.

The major metals contained in stabilisers are lead (Pb), barium (Ba), calcium (Ca), and tin (Sn). The stabilisers are classified into Pb stabilisers, Ba-Zn stabilisers, Ca-Zn stabilisers, and Sn stabilisers. Ba-Zn stabilisers and Ca-Zn stabilisers are used as metallic soaps such as stearates, while Sn stabilisers are used as organic tin (dialkyl tin compounds). Other than metallic soap, Pb stabilisers are used as basic sulphate, basic carbonate, or basic phosphate (UNEP/FAO/RC/CRC.11/6). Other than metallic soap, Pb stabilisers are used as basic sulphate, basic carbonate, or basic phosphate (UNEP/FAO/RC/CRC.11/6).

Lead stabilizers are currently being phased out in Europe, due to environmental and health concerns. It is being replaced by Ca/Zn or Ca/organic stabilisers (UNEP/FAO/RC/CRC.11/6). Mixed metal stabilizers are more expensive than their tin-based counterparts and are less effective in stabilization.

So far it has not been possible to identify information on alternatives for these industrial uses, because the focus of the investigation has been on antifouling agents based on information received from the Commission Services.

Assessment of Alternatives to industrial uses

Four stabilisers were identified. They have the following properties:

Lead stabiliser

- Excellent heat and light stability
- Good electrical properties
- Excellent short and long-term mechanical properties
- Low water absorption
- Wide processing range
- Good cost/performance ratio

Calcium Zinc

- High degree of clarity
- Good mechanical and electrical properties

- Excellent organoleptic properties
- Good outdoor weather ability

Barium Zinc or Potassium Zinc

- Good clarity
- Good weather ability
- Good colour hold
- Good long-term stability
- Suitability for white pigmented applications
- Low migration
- Low odour
- Low volatility
- Barium not approved for food contact, toys or medical applications

Cadmium

- Excellent heat stability
- Outstanding weather ability

Furthermore, consumption of stabilisers for 2007 for different regions is provided in the table below. Mixed metals and tin stabilisers were most consumed in North America (46% and 52%), while lead and other stabilisers were most consumed in China (50% and 22%).

Table 4.20 Consumption in 2007 of heat stabiliser in tonnes

Type	North America	Europe	China	Global
Mixed metals	36,150	97,300	72,300	309,820
Tin	41,200	18,000	17,900	110,900
Lead	1,900	101,900	159,800	414,900
Others	50	3,700	71,400	75,380
Total	79,300	220,900	321,400	911,000

Source:https://pharosproject.net/uploads/files/sources/1828/Tony%20DiMaio%20Presentation%202010.pdf

In the case of stabilisers for PVC pipes the following market trends in 2013 were identified (PVC Conf, 2014):

- Europe as well as South America presented highest levels of Ca-based stabilizer consumption with ca. 50% and 65% respectively.
- North America is clearly dominated by Sn-based stabilizer systems, and Ca-based solutions are only minimally considered as a suitable alternative system.
- In South America, a higher variety of systems is used for PVC pipe stabilization. Pb-based systems are dominating in Argentina, Uruguay and Paraguay, however, there is a clear trend towards Ca-based systems. Sn based systems dominate in Columbia, Venezuela and Ecuador. Brazil is already dominated by Ca-based stabilizers in PVC pipe applications.
- Asia in general is clearly Pb-based, although there are small amounts of Ca-based systems applied. Korea, Australia and New Zealand play here the role of trend-setters and have pushed for Pb-free solutions.

- India is dominated by Pb-based systems. Ca-based systems are only used by selected customers and there is no real pressure for Pb-free solutions.
- In the Middle East and Africa regions, ca. 90% of all stabilizers utilized are Pb-based. Sn- and Ca-based systems are seen in this region, but, are still at a relatively low level.

Assessment of Alternatives to anti-fouling paints (pesticides use)

As regards anti-fouling use of TBT there is information on alternative products (Rotterdam Convention, 2009d).

Canada reports on availability of more than 50 copper-based antifouling paints that offer antifouling properties similar to those of the TBT antifouling paints. There are two copper thiocyanate products that are suitable for application on ships with aluminium hulls, as they do not cause corrosion like other copper-containing paints.

The European Union identified copper acrylate, other copper systems with or without booster, non-stick biocide-free products. Others alternatives such natural products extracts (e.g. sponge) are reported to be still under development.

The performances of most alternatives is reported to be lower and the price to be generally higher than that of TBT-based paints.

The Republic of Korea also reported as an alternative copper thiocyanate (UNEP/FAO/RC/CRC.1/27.rev.1). Furthermore, the Republic of Korea reported alternatives such as maganeous ethylene bis dithioCarbamate, dizincdimethyldithioCarbamate (Ziram) and zinc ethylene 1,2-bis dithioCarbamate (Zineb). For these alternatives the risks to aquatic organism is lower but has less anti-fouling effect and is more weak UNEP/FAO/RC/CRC.1/27.rev.1.

Market comparisons between alternatives and TBT

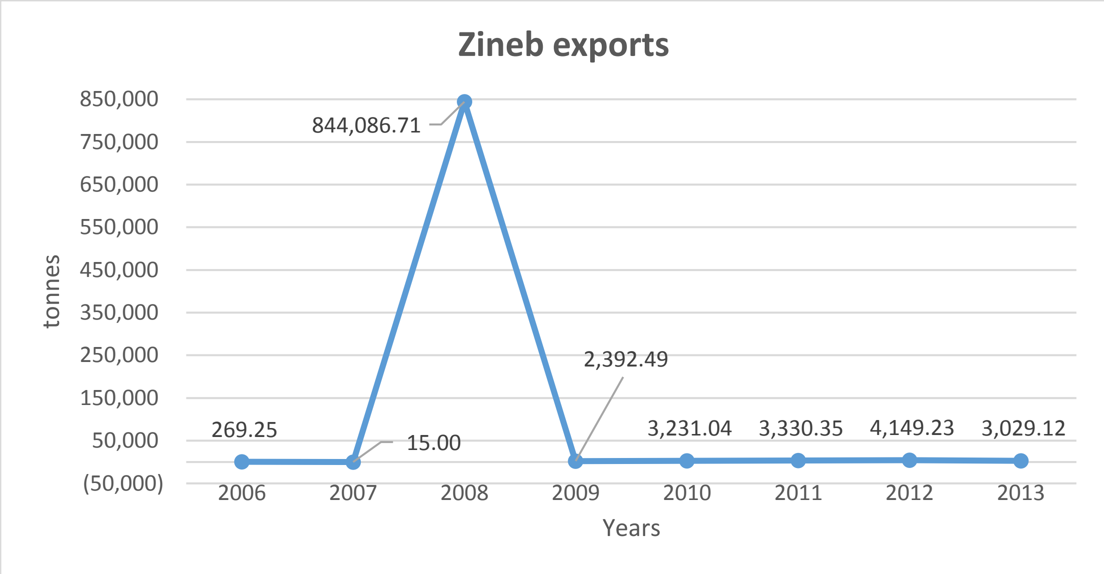
To date only market data on Zineb and Ziram could be identified.

Zineb

According to the data from European Commission Zineb has been exported from European Union countries to countries from developing countries and economies in transition from Europe, Asia, Africa[107] for the period 2006-2013 with an average of 107,562.90 tonnes (between a min. of 15 tonnes and max. of 844,086.71 tonnes) (European Commission, 2016). The Figure 4.22 shows the amounts in tonnes of these exports.

107 South Korea, China, Malaysia, Singapore, Thailand, United Arab Emirates , Indonesia, India, Turkey, Moldavia, Azerbaijan, Lebanon, Mexico, Cuba, Costa Rica, Chile, Argentina, Venezuela, Algeria, Saudi Arabia, Egypt, Vietnam, Canada, Australia , Colombia, Namibia, South Africa, Norway, Ukraine, Saudi-Arabia, Cameroon, Korea, Congo, Egypt , French Polynesia , Iceland , Madagascar , Montenegro , Nigeria , Norway ,Russia ,South Africa,Tunisia ,Turkey , Ukraine , USA , Brazil, Taiwan, Jordan,Georgia, Indonesia ,Cape Verde, Cote D'Ivoire, Ghana, Madagascar, Senegal, French Polynesia, Kazakhstan, New Caledonia, Montenegro, Falkland Islands, Guadeloupe, Iceland, Faroe Islands, Azerbaidjan, Dubai, Israel, Ecuador, Kuwait, Mauritius, Mozambic, Gibraltar, Japan, Sri Lanka, Bosnia and Herzegovina and Serbia

Figure 4.22 Zineb export amounts (tonnes)



BiPRO 2016, from data from European Commission about export quantities in tonnes

The geometric average growth of export quantities of Zineb for the period 2006-2013 is 41 % increase. The growth rates for each of the years are provided in Table 4.26.

Table 4.21 Annual growth rates of Zineb exports

2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013
-94%	5,627,145%	-100%	35%	3%	25%	-27%

Furthermore, Figure 4.23 shows demand of Zineb in metric tonnes for the period 2005-2010 in India. Consumption refers to the consumption of national produced pesticides. Consumption and demand increased sharply from 2007-2010.

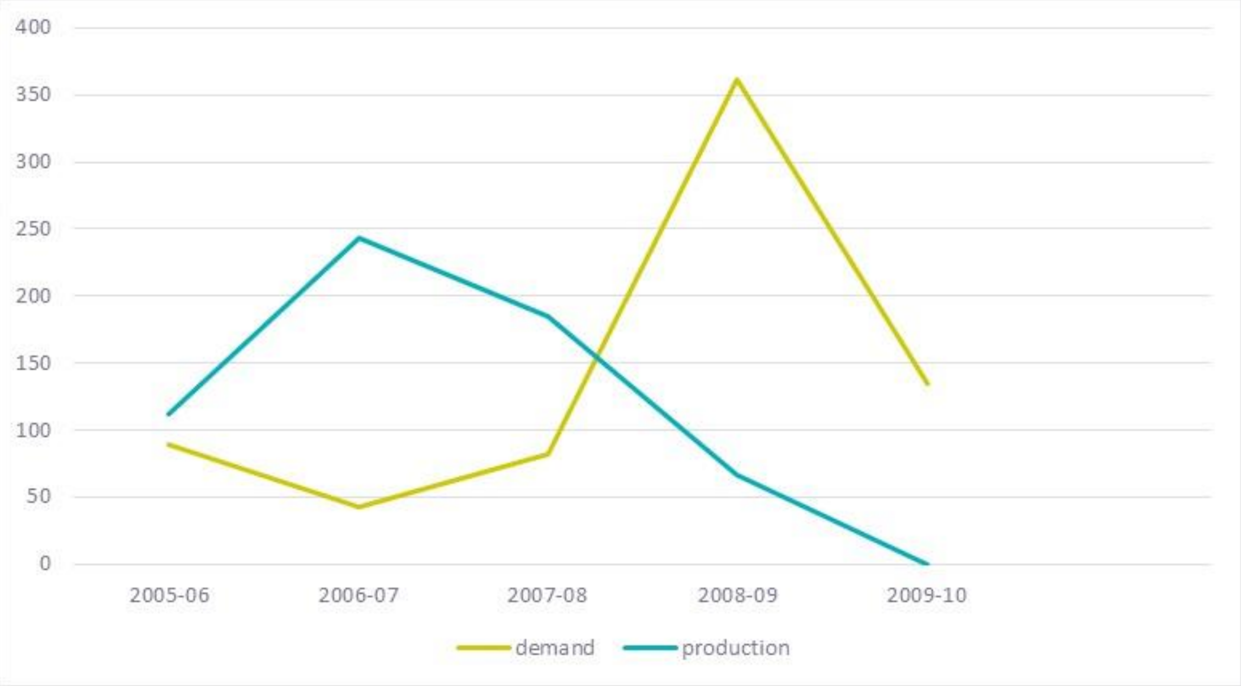
Figure 4-23 Market data of Zineb in India

BiPRO 2016. Source: http://ppqs.gov.in/PMD.htm#statewise

Ziram

The following graph shows demand and production of Ziram for India for the period 2005-2010. Consumption refers to the consumption of national produced pesticides. Production tended to decrease, however demand tended to increase

Figure 4.24 Market data of Ziram in India



BiPRO 2016. Source: http://ppqs.gov.in/PMD.htm#statewise

Conclusion

Mixed metals, calcium, lead, barium zinc or potassium zinc and cadmium were identified as a PVC stabilizer. Based on the available data calcium and zinc (mixed metal) stabilisers, as well as organic stabilizers seems to be the alternatives applied for tin-based stabilizers in PVC industry, but there does not seem to exist many viable alternatives that show similar performance levels, or do not show critical properties such as lead. For the use of TBT as starting material in material preservatives, no alternatives have been reported to be currently known. Lead and mixed metals stabilisers seems to be the stabilisers more consumed in 2007. Furthermore, based on market trends of 2013 it also seems that lead is the most dominating stabiliser in most of the regions and countries, except for Europe, South America and North America.

Five alternatives were identified (copper anti-fouling paints, Zineb, Ziram, maganeous ethylene bis dithioCarbamate and non-stick biocide-free product) for TBT as pesticide use. Ten anti-fouling paints containing copper (as cuprous thiocyanate) are authorised and available in Canada. In addition, a pesticide producer informed that chemical alternatives as propineb and non-chemical alternatives as Bacillus subtilis are commercialised and used in African countries as an alternative to tributyltin compounds. Based on the available information Zineb and ZIRAM are available in India. Furthermore Ziram is produced in India. Additionally, Zineb was exported from EU to a wide number of developing countries and economies in transition. These exports tended to increase from 2006-2013. Prices were not available.

5. Conclusion and summary

5.1 Summary of key findings

Assessment of chemicals added to the Convention

The Rotterdam Convention was created in order to address concerns with the safe use and management of specific named chemicals which could pose a risk to human health and the environment. Core to the overall objectives of the Convention is the shared responsibility for the safe management of those substances named within the Convention's Annexes. This is to be achieved by promotion of information exchange on risks and on safe management and use of the named chemicals, with a particular emphasis on providing developing countries with information on how to store, transport, use and dispose of hazardous chemicals safely. Additionally the Convention also puts in place a mechanism for national decision making on the import of chemicals named within the Annexes, which is the prior informed consent procedure. This enables developing countries to protect health and the environment in their countries by denying consent for import of these chemicals.

Since the creation of the Convention there have been mounting concerns over the effectiveness of the Convention in adding new chemicals to Annex III of the Convention. A number of substances have been discussed multiple times over successive Conference of the Parties (COP) meetings without resolution. The core objections to listing are mainly socio-economic, with concerns raised that listing of a chemical within the Annexes of the Convention may lead to increased prices and a delay in the supply of goods to end users. Many of the named chemicals are pesticides, with end users will be within the agricultural sector, and those countries in economic development or transition have been considered particularly vulnerable to such effects.

The current study has aimed to assess whether these arguments are valid by reviewing the market effects for named chemicals listed within the Annexes of the Convention, both before listing and after listing. In conducting this review it is important to discuss the limitations of the study early on. The use of a given pesticide on a global basis will be affected by a large number of variables, which can affect the demand and use for that pesticide on a regional basis in different ways. Furthermore for those pesticides where many alternative products exist, it can prove difficult to definitively identify the effects of one variable (listing in the Convention) against all other variables affecting use (such as efficacy, price, preference of farmers towards a given product, seasonal variation, variation in crops, variation in pests).

To help provide clear and transparent results within the current study, the scope has aimed to focus on core elements i.e. trade of named pesticides into named countries, and development of a set of hypotheses to be tested i.e. after the year of listing the price of the named pesticide increases or does not increase. The aim of the study has been to use this approach to test what the effects of listing might be and to help identify whether the objections raised at multiple COP meetings are valid.

Four case studies have been used to explore these aspects, with the following outcomes:

- **Alachlor**: For this case study, the evidence reviewed suggested that, after listing, the price of Alachlor increased in a number of countries where data was available, but decreased in sum for all countries for which data was available. Data reviewed suggests a potential trade decrease observed in one country. There was also an increase in the trade of the main alternative to Alachlor (Metolachlor). The main point of interest for the first case study is that there was only one main alternative to Alachlor, which had poorer efficacy. In this context, a lack of competition within the market place (fewer number of chemicals available) could mean that the market is more likely to increase costs, which would mean negative outcomes for end-users upon listing in the Convention, but as stated above this has not been widely observed.
- **Aldicarb**: For this case study, the evidence suggested that, after listing, there was no effect on either price or trade, with both continuing broadly in a similar fashion before and after listing. Additionally nine viable alternatives (chemical and non-chemical) were identified. For Aldicarb and its chemical alternatives, price and trade fluctuate without any clear trends. However the key point of interest in this case was that, because there was a broad array of alternatives, it meant

the need for the market to remain competitive, and this perhaps suggests that manufacturers or distributors have not been able to increase prices for Aldicarb.

- **Monocrotophos**: The available data for this case study was scarce, meaning it is less well defined that the others. Based on the data that is available, trade and price of Monocrotophos do not appear to have been affected by listing within the Rotterdam Convention. As with Aldicarb, there is a large number of alternatives, both chemical and non-chemical; however not all of these alternatives are viable in all climatic regions, with fewer options in some areas such as parts of Africa. Due to the data gaps that exist it is difficult to draw hard conclusions for this case study.
- **Parathion**: The available data for this case study was also scarce, particularly price data. However, based on review of the data available, the listing of Parathion does not appear to have had a significant impact on trade after listing. Again a number of alternatives exist (both chemical and non-chemical), and evidence exists that the trade for both Parathion and its main alternatives increased after listing, while for at least one country (India) there was a minor decline in trade.

The case studies developed as part of this study have highlighted some important messages, particularly around flexibility of the market and competitiveness of competing pesticides. The core aims of the Rotterdam Convention aim to maintain the safe use and control of hazardous substances, and promotion of information exchange to that effect, allowing the safe trade of substances between nations. The Convention does not intend to promote the phase-out of named chemicals in favour of alternatives. This objective is more suited to the related Stockholm Convention. This means available information on alternatives has been more limited to help further the discussions during COP meetings.

However based on the findings of the case studies developed it could be useful to gather more information on economic aspects to understand any possible market sensitivities and effects of listing. This would in particular include information on the number of alternatives available for a given chemical. Furthermore for Monocrotophos where some of the alternatives are not applicable under specific climatic regions or conditions, this can create less flexible markets where the demand for a given pesticide means that market is more sensitive to any reductions in production in turn affecting prices.

The case study for Aldicarb and to a lesser degree that for Parathion suggested that, where multiple alternatives exist, there is a need to remain competitive within the market place, meaning that manufacturers and distributors are less willing to increase prices after listing in the Rotterdam Convention. For both of these chemicals, the evidence reviewed suggested that the price of the named chemical remained broadly similar after listing, with trade also continuing at a similar rate.

In conducting this analysis care is also needed when assessing effects on a more localised/national basis. The data reviewed covered price and trade across a range of countries where named pesticides were used. General trends and potential effects on price and availability were analysed and included within this report. It is however important to recognise that the use of pesticides can vary seasonally; so for example if a particular pest is more prevalent one year than another in a specific nation, it is likely more pesticide will be needed. If the flexibility (number of alternatives, supply and demand of goods) of the market is constrained across a particular region, in this period of increased demand any impacts of listing in the Rotterdam Convention would in turn be increased also.

Therefore to assess whether listing of a given chemical on the Rotterdam Convention has an impact on end-users (in the current study the agricultural sector), it is necessary to review information on alternatives and the flexibility of the market.

Assessment of chemicals nominated for addition to the Convention

The current study has also involved a review of the chemicals nominated for addition to the Convention, which will be discussed at the next COP in May, 2017. These are chrysotile asbestos, SHPF of Paraquat, SHPF of Fenthion and Trichlorfon. The study has also assessed alternatives for Carbofuran, Carbosulfan and TBT. Table 5.1 provides an overview of the chemical and non-chemical alternatives identified for each in turn. In the majority of cases a wide number of alternatives have been found, including both chemical and non-chemical alternatives. This should suggest that there is a good degree of market flexibility and competitiveness which would limit the impacts of any listing on the Rotterdam Convention.

For chemicals such as chrysotile asbestos and TBT, there has already been widespread action to ban or severely restrict the use of these substances by many nations, which has acted as a positive driver to seek alternatives, and as such alternatives are now often widely available. For other chemicals the situation is more mixed. In particular for SHPFs of Paraquat few chemical alternatives exist, with Glyphosate being the main alternative. This may not be a viable solution for all regional climatic areas, and could reflect the more restricted kind of market flexibility witnessed in the Alachlor case study. However it is important to highlight that a high number of effective non-chemical alternatives do exist. In assessing the potential impacts of listing a given chemical on the Rotterdam Convention, it is necessary to also consider choice and preference of the end-user group. For pesticides, which have particular seasonal use, the agricultural sector typically has strong preference towards a given pesticide based either on past performance or advice from distributors and agricultural advisors. Any switch towards non-chemical alternatives would require support through exchange of information.

The review of alternatives for Carbofuran also highlighted that, while ten chemical alternatives exist, suggesting a good range of choice for end-users, in practice their application can be more selective with a number of alternatives not being a viable option depending on climatic region, type of pest and type of crop. This means that the market flexibility and competitiveness within specific geographical regions could be more variable, with the possibility that in a number of cases the number of options is more limited, and the market more sensitive to any additional costs which listing might add.

Table 5.1: Overview of alternatives for nominated chemicals

Chemical	No. of Chemical Alternatives	No. of Non-chemical Alternatives	Notes
Chrysotile Asbestos	11	0	In many parts of the world chrysotile asbestos has already been banned or heavily restricted. The available alternatives mean a good degree of market flexibility to ensure that the listing of chrysotile asbestos does not result in significant impacts for end-users in terms of price.
SHPF Paraquat	3	10	More limited options for chemical alternatives exist, with the main alternative Glyphosate not a direct replacement. There may also be regional/national sensitivities depending on climate and types of pest. However a wide number of non-chemical alternatives exist and these are likely to provide an effective alternative
SHPF Fenthion	4	8	A number of chemical alternatives exist with global producers able to satisfy markets in Africa and Asia. Multiple non-chemical alternatives also exist, suggesting a good number of viable options and flexibility within the market place
Trichlorfon	20	12	A large number of alternatives (both chemical and non-chemical) exist for Trichlorfon, with a high level of flexibility within the market suggesting that sales would be highly competitive, with potential options to allow the listing of Trichlorfon successfully without significant impacts.
Carbofuran	10	2	While a broad number of chemical alternatives do exist, their specific applicability for treating against particular pests and particular crops are more limited. This means that the flexibility of the market is more limited than first appears, with fewer alternatives covering all uses of Carbofuran.
Carbosulfan	10	2	A broad number of chemical alternatives exist, with a number available in African and Asian countries (full trade data was not available), meaning that a good level of market flexibility can be expected. This should mean that listing would be unlikely to cause significant effects on prices to end users.
TBT	50	-	A number of alternative mixed metal compounds exist as for use in application as stabilisers, while Canada identified 50 viable alternatives to TBT for anti-fouling paints. The two quoted within the current study (Zineb and Ziram), both have global application, suggesting that there are many alternative options to TBT available.

5.2 Recommendations

The current study has aimed to assess what potential impacts might occur when a given chemical is listed in the Rotterdam Convention. Particular focus has been given to the potential impacts on end-user groups, in this case the agricultural sector. Based on a case study approach and review of market trends and assessment of alternatives, the case studies developed have highlighted that under certain specific conditions negative impacts can occur. The authors also highlight the limited number of case studies and uncertainty in the results, which should be taken into account..

For those regional / national markets where the level of market flexibility (number of alternatives, buyer's choice, and market competition) is more limited, it is possible that any reductions in supply in reaction to listing on the Rotterdam Convention can result in increased prices. The Alachlor case study in particular reflected an increase in price, decrease in trade for Alachlor and an increase in trade for the main alternative. While these impacts are correlated with listing on the Convention, it should be noted that this does not imply a definitive causal link.

A few Parties to the Rotterdam Convention have raised objections in successive COPs due to the concerns around such impacts for their respective nations. However the information to fully understand whether these arguments are justified are not typically available, as information on alternatives is not a requirement of the decision guidance document.

However care is needed in how this issue is managed, given that the Convention is not intended to focus on phase-out or transition to alternatives. The addition of such data requirements within the DGD could set a precedent that suggests phase-out and transition to alternatives should be considered.

Improved information exchange would also be important for the success of the Convention. For Paraquat in particular the chemical alternatives are more limited, suggesting that some impacts on how the plant protection needs of end users are met could be expected. However a wide range of non-chemical alternatives do exist, and could be used to help address issues with price and availability of chemical alternatives. However the switch from chemical to non-chemical approaches can prove difficult, particularly depending on the preference of the end-users to proven chemical products. Therefore a second recommendation would be to consider improved support and information exchange to help explore non-chemical alternatives. This could possibly involve the use of regional centres to look at aspects of farming and use of chemical products, further discussion on the development of new alternatives is provided in section 5.1 covering the case study on Paraquat.

6. References

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Canada	2007	Re-evaluation Note. Preliminary Risk Assessment of Trichlorfon, Pest Management Regulatory Agency. http://publications.gc.ca/collections/collection_2007/pmra-arla/H113-5-2007-5E.pdf
Canada	2016	Spinosad reduces the population of flea beetle (Altica sylvia Malloch) larvae in lowbush blueberry, Agriculture and Agri-Food Canada
European Commission	2016	Export notifications for the period 2006 - 2013
FAO	2016 a	Data from African manufacturers on alternatives
FAO	2016 b	Import and export data 2008 -2015
FERA	2016	Pesticide usage survey of the UK, produce by FERA, https://secure.fera.defra.gov.uk/pusstats/myindex.cfm
Gonçalves da Silva et al	2010	The Economic Impact of the Banning of the Use of Asbestos in Brazil.
India	1968	Insecticides Registered under/section 9 (3) of the Insecticide Act, 1968, Directorate of Plant Protection, Quarantine & Storage of India
India	2016 a	Trade of major chemicals product-wise (import and export, value and quantity, 2006-2016). Collated from Open Government Data Platform India. Data provided by DGCI & S, Kolkata, Ministry of Commerce & Industry. https://data.gov.in/catalog/import-major-chemicals-product-wise-group-wise and https://data.gov.in/catalog/export-major-chemicals-product-wise-group-wise
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PANAP	2016	Glyphosate monograph and factsheet, http://www.panap.net/sites/default/files/monograph_glyphosate.pdf http://www.panap.net/sites/default/files/pesticides-factsheet-specialrelease-glyphosate.pdf
PMFA	2016	Pesticides capacity and production in India (1999-2003). Pesticides Manufacturers & Formulators Association of India. http://www.pmfai.org/images/183/%20Production%20of%20pesticides.pdf
PVC Conf	2014	Proceedings of the 17th Plastic Pipes Conference; - http://www.plasticpipesconference.com/content/chichago/september_23/Session_7B/Udo%20ANDERS_Highlight%20on%C2%A0%20PVC%20Stabiliser%20for%20Pipes%20-%20Comparison%20and%20Trends_7B.pdf
Rotterdam Convention	2005	Decision Guidance Document for Monocrotophos
Rotterdam Convention	2009 a	Decision Guidance Document for Alachlor
Rotterdam Convention	2009 b	Decision Guidance Document for Aldicarb
Rotterdam Convention	2009 c	Decision Guidance Document for Parathion
Rotterdam Convention	2009 d	Decision Guidance Document for Tributyltin
Sahel	2015	Global list of authorised pesticides by the CSP, Sahel Committee of pesticides, http://www.reca-niger.org/IMG/pdf/liste_globale_pesticides_autorises_CSP_mai_2015.pdf
Sahel	2016 a	Comité Sahélien des Pesticides. Annexe à la décision d'interdiction du carbosulfan, Permanent Interstate Committee for Drought Control in the Sahel
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Appendix A
Summary of Data for Screening of Named Chemicals

Data identified for chemicals listed before entry into force

For these substances, FAO data only cover the time period after the listing enabling the assessment of whether the substances are still traded despite the listing but without the comparison with the status before listing.

Monocrotophos (on draft list from 2002, listed in 2004)

Key data available:

- Capacity and production in India before listing, additional information on manufacturers globally covering before the listing time period.
- Usage data for India for several crops, covering before and after listing.
- US price data covering before and after listing.
- FAO trade data after listing covering countries in Latin America, Sub-Sahara Africa, European transition economies, Turkey and Malaysia.
- Alternatives: crops, pests and dose applications for alternatives are available as well as for countries where alternatives are used (Burkina Faso, Capo Verde, Gambia, Guinea-Bissau, Mali, Mauritania, Niger, Senegal and Australia). Furthermore, annual export quantities (tonnes) from EU for several years as well as FAO data on annual imports (tons and US$) for 2008-2015 for some alternative are available. For some alternatives prices in India and US are available.

Parathion (listed 2004)

Key data available:

- No production data, some information on manufacturers from before listing.
- Usage data for US for several crops, covering before and after listing.
- FAO trade data after listing for countries in Latin America, Sub-Sahara Africa, European transition economies, Eurasia and South-East Asia. A single data point of marginally small values for quantities of exports from European countries after listing.
- Alternatives: developing countries; where alternatives are used; were identified. Crops, pests and dose applications are available for some alternatives. Annual export quantities (tonnes) from the EU for several years and FAO data on annual imports (tons and US$) for 2008-2015 for some alternatives are available. Furthermore, for some alternatives prices in India and US are available.

Data identified for chemicals listed after entry into force

Methamidophos has been listed very recently (2015) and no data from after the listing is available yet.

Tributylin compounds (TBT) has been listed at the very beginning of the range of years covered by FAO data (2008). Hence, the data only allows conclusions regarding whether the substance is still traded despite listing, but no comparison with the levels of trade before the listing.

Endosulfan is not covered by FAO data at all but some Indian production and trade data for Endosulfan are available.

The remaining three substances in this category (Alachlor, Aldicarb Azinphos-methyl) have been listed well within the range of years covered by FAO data. These three substances are all suitable for analysis, although for Azinphos-methyl (listed in 2013) only two years of FAO data after listing are available, whereas for Alachlor and Aldicarb (listed in 2011) four years of data are available, potentially revealing more long-term impacts.

Alachlor (listed in 2011)

Key data available:

- No production data, some information on manufacturers from before listing.
- Usage data for US for several crops, covering before and after listing and for several EU countries only before listing.
- US price data covering before and after listing.
- FAO trade data covering before and after listing and countries in Latin America, Sub-Sahara Africa, European transition economies, Turkey and South-East Asia. Export quantities (in tonnes) from EU countries only before listing.
- Alternatives: crops, pests and dose applications for alternatives are available. Developing countries, where alternatives are used, are identified as well as prices for alternatives in US. FAO data on annual imports (tons and US$) for 2008-2015 for alternatives are available for some alternatives.

Aldicarb (listed in 2011)

Key data available:

- No production data, but information on manufacturers from multiple points in time until listing.
- Usage data for US and UK covering several crops, ending around time of listing.
- US price data covering before and after listing.
- FAO trade data covering before and after listing and countries in Latin America, Sub-Sahara Africa, European transition economies and Turkey. Export quantities (in tonnes) from EU countries only before listing.
- Alternatives: some countries where alternatives are used (Jamaica and Canada) were identified as well as crops, pests and dose application. However, for some alternatives country is not identified. Annual export quantities (tonnes) from EU for several years as well as FAO data on annual imports (tons and US$) for 2008-2015 for some alternatives are available. For some alternatives prices in India and US are available.

Azinphos-methyl (listed 2013)

Key data available:

- No production data, some information on manufacturers from about time of listing.
- Usage data for US for several crops, from before listing.
- US price data covering before and after listing.
- FAO trade data covering before and after listing and countries in Latin America, Sub-Sahara Africa, European transition economies, Turkey and South-East Asia. Export quantities (in tonnes) from EU countries only before listing.
- Alternatives: 12 chemical alternatives and 3 non-chemical alternatives were identified. From these alternatives, countries where alternatives are used are not identified; whereas crops, pests and dose applications as well as export and import data for some alternatives are available. Alternatives identified are provided in Annex B on table Table B.2 .

Methamidophos (listed 2015)

Key data available:

- No production data, some information on manufacturers from before and about time of listing.
- Usage data for US, three crops, from before listing.

- FAO trade data covering years until the year of listing and some countries in Latin America, Sub-Sahara Africa, European transition economies and Malaysia. Export quantities from EU countries only before listing.
- Alternatives: crops, pests and dose applications as well as countries where alternatives are used (El Salvador, Burkina Faso, Capo Verde, Gambia, Guinea-Bissau, Mali, Mauritania, Niger, Senegal, Australia and Thailand) are identified. Furthermore, export and import data were available. A total number of 30 alternatives have been identified, which are provided in Annex B on table Table B.2 . From these 26 chemical alternatives and 4 non-chemical alternatives. Alternatives are available in El Salvador where there are registered pesticides for the same uses as Methamidophos with lower toxicological category and exposition risk (28). In CILSS countries in 2014 there was already at least 10 insecticides/acaricides authorised in the global list of pesticides approved by the Comité Sahélien des Pesticides (CSP) for cotton and vegetable crops containing Abamectin, Cypermethrin, Deltamethrin, ethopropphos, Lambda-Cyhalothrin and Profenofos. Furthermore, according to PANAP there are cultural, mechanical and biological alternatives to Methamidophos as well as natural sprays (always depending on the pest and the situation)[108].

Tributyltin (TBT) (listed 2008)

Key data available:

- No production data, some information on manufacturers from about time of listing.
- FAO trade data beginning the year of listing covering Georgia, Mexico, Russia, South Africa, Turkey and Philippines.
- Alternatives: only developed countries were identified as using alternatives (Republic of Korea, Canada and EU). Furthermore, export and import data[4] were available as well as prices for some alternatives in India. Alternatives identified are provided in Annex B on table Table B.2 .

Endosulfan (listed 2011)

Key data available:

- Capacity and production in India before the time of listing, some info on manufacturers globally from before and about time of listing.
- Usage data for US and UK, several crops, before and after time of listing and for China only before listing.[109]
- US price data covering before and after listing.
- India trade data covering before and after listing. Export quantities from EU countries before and after listing.
- Alternatives: 41 chemical alternatives and 154 non-chemical alternatives were identified. Countries where alternatives are used were identified (Burkina Faso, Capo Verde, Gambia, Guinea-Bissau, Mali, Mauritania, Niger, Senegal, Paraguay, India, Chili, Costa Rica, Benin, Cuba, Mexico, Brazil, Germany and Bolivia) and crops, pest and dose application as well as export and import data[4] were available.

Chemicals already considered by COP but no decision taken so far

As these substances have not been listed yet, they are not suitable for ex-post analysis regarding the impact of listing.

[108] Inchem website http://www.inchem.org
[109] Usage 2004-2005. Hongliang Jia, Liyan Liu, Yeqing Sun and Yi-Fan Li: Endosulfan in China: Usage, Emissions, and Residues. In: Margarita Stoytcheva (editor) (2011): Pesticides - Formulations, Effects, Fate. http://www.intechopen.com/books/pesticides-formulations-effects-fate/endosulfan-in-china-usage-emissions-and-residues

Trichlorfon

Key data available:

- Some information on manufacturers from multiple points in time.
- Usage data for UK, several crops (1998-2006).
- FAO trade data covering countries in Latin America, Sub-Sahara Africa, European transition economies, Turkey and South-East Asia. Export quantities from EU countries.
- Alternatives: crops, pests, dose application for alternatives as well as export and import data[4] are available as well as prices in India and US.

Fenthion

Key data available:

- Production in India (1999-2003), some information on manufacturers from multiple points in time.
- India trade data (2006-2014).
- FAO trade data covering some countries in Latin America, Sub-Sahara Africa, European transition economies and Malaysia. Export quantities from EU countries.
- Alternatives: crops, pests, dose application are available for some alternatives and countries where alternatives are used (Georgia, Niger, Bulgaria, Chad, Madagascar and Mauritania) are available. Furthermore, export and import data are available as well as prices in India and US.

Paraquat

Key data available:

- Capacity and production in India (1999-2003), additional information on manufacturers globally from multiple points in time.
- Usage data for US and UK (1990-2015).
- US price data (2001-2008).
- FAO trade data covering countries in Latin America, Sub-Sahara Africa, European transition economies, South-East Asia, Turkey and Bangladesh. Export quantities from EU countries.
- Alternatives: crops, pests and dose applications as well as countries where alternatives are used (Burkina Faso, Cape Verde, Chad, Gambia, Guinea-Bissau, Mali, Mauritania, Niger, Senegal, Costa Rica, Ethiopia, Indonesia, Brazil, Papua New Guinea, Ecuador, Guatemala, Colombia and Philippines) are available. No data about import/export quantities. Prices of some alternatives are available for US.

Chrysotile asbestos

Key data available:

- Production 1999 by country.[110]
- Usage 2003 by world region.[111]
- Note: More data may be available for asbestos in general, most of which is chrysotile nowadays according to the draft DGD 2005: "Chrysotile is by far the predominant asbestos fibre consumed today [1998] (94% of the world's production)".

[110] http://www.chrysotile.com/en/chrysotile/overview/production.aspx
[111] http://www.chrysotile.com/en/chrysotile/overview/production.aspx

- E.g.: 1900-2003 production, trade and consumption by region/selected countries.[112]
- Alternatives: industrial uses are identified (cement and roof sheeting and tiles) as well as countries where alternatives are used (Thailand, japan, Korea, Brazil, Chili, EU, Australia, Vietnam and South Africa). Furthermore, for some alternatives, prices and market share and are available. Additionally, some producers for some alternatives are identified.

Data identified for chemicals recommended by CRC for listing

Similarly to the category above, these substances are not listed on Annex III to the Rotterdam Convention, so are not suitable for ex-post analysis regarding the impact of listing.

Carbofuran

- No production data, but some information on manufacturers.
- Usage data for US (1990-2015) and UK (1990-2002).
- US price data (2001-2015).
- FAO trade data covering countries in Latin America, Sub-Sahara Africa, European transition economies, South-East Asia, Turkey and Bangladesh. Export quantities from EU countries.
- Alternatives: export and import data for alternatives is available for some alternatives. Countries where alternatives are used (Canada, India, USA, Burkina Faso, Capo Verde, Gambia, Guinea-Bissau, Mali, Mauritania, Niger and Senegal) and crops, pests, dose application are available as well as prices in India and US.

Carbosulfan

- Usage data for UK (1990-2015).
- US price data (2001-2008).
- FAO trade data covering countries in Latin America, Sub-Sahara Africa, European transition economies, South-East Asia, Turkey and Bangladesh. Export quantities from EU countries.
- Alternatives: crops, pests, dose application are available for some alternatives and countries where alternatives are used (Benin, Burkina Faso, Cabo Verde, Ivory Coast, Gambia, Guinea, Guinea Bissau, Mali, Mauritania, Niger, Senegal, Chad and Togo) are available. Furthermore, export and import data4 are available as well as prices in India and US.

[112] http://pubs.usgs.gov/circ/2006/1298/c1298.pdf

Appendix B
Summary of Alternatives

Alternatives to substances listed in Annex II

Note – page numbers in the header should be prefixed with the Appendix letter and must be manually edited for each Appendix section.

Alternatives to substances listed in Annex III

Table B.1 Summary of alternatives for case study substances already added in Annex III of the Rotterdam Convention

Substances	Chemical alternatives	Non-chemical alternatives
Alachlor	Metolachlor, Isoxaflutole	Not identified
Aldicarb	Abamectin, Bromopropylate, Dimethoate, Fenbutine Oxide, Fluopyram, Imidacloprid and shell white oil along with Diazinon	Integrated Pest Management Programmes, Purpureocillium lilacinum
Monocrotophos	Acetamiprid, Alphamethrin, Alpha-Fenvalerate, Carbamates, Chlorpyrifos, Cypermethrin, Dimethoate, Dicofol , Fenitrothion, Indoxacarb, Imidacloprid, Malathion, Pyrethroid, Profenofos, Spirotetramat, Thiacloprid	Bacillus thuringiensis, azadirachtine (from neem)
Parathion	Dimethoate, Fenoxycarb, Imidacloprid, Malathion, Spirotetramat, Thiacloprid	Terpenoid mix

Table B.2 Summary of alternatives for further substances not selected for case studies already added in Annex III of the Rotterdam Convention

Substances	Chemical alternatives	Non-chemical alternatives
Azinphos-methyl	Alpha-Cypermethrin, DiflubenzuronDiflubenzuron, Dimethoate, Esfenvalerate, Fenpropathrin, Imidacloprid, Indoxacarb, Flupyradifurone, Lambda-Cyhalothrin, Phosalone, Spinosad, Thiacloprid	Heterorhabditis megidis, pheromone-based mating disruption, Terpenoid mix
Endosulfan	Acephate and Acetamiprid, Abamectin, Acetamiprid, Azoxystrobin, Betacyfluthrine and Imidapride, Beta-cyfluthrin & Imidacloprid, Bifentrin, Buprofezine, Cheer, Chlorfluazuron, Cromafenozide, Cypermethrin, Cypermethrin and Acetamipride, Cypermethrin and Chlorpyriphos, Cypermethrin high-cis and Profenofos, Cypermethrin and Profenofos, Cyromazine, Deltamethrin (Pyrethroid), Diafenthiuron, Emamectine Benzoate, Lubendiamide FLubendiamide , Lubendiamide FLubendiamide & Spirotetramat, Flupyradifurone, Hexythiayox, Imidacloprid, Indoxacarb, Iprodine, , Lambda-Cyhalothrin, Lambda-Cyhalothrin and Acetamipride, Lambda-Cyhalothrin and Profenofos, Lubendiamide /Spirotetramat, Lufenuron, Malathion, Myclobutanil, Profenofos, Pyrethroid, soap, Spinosad, Spiromesifen , sulphur, Thiamethoxam, Tralomethrine, Zeta-Cypermethrine and Profenofos	Wide range of natural extracts, emulsions and sprays from plants, from organic materials from animal and vegetables and minerals (e.g. basil leaf extract, garlic bulb extract, neem leaf extract, etc.) Bacillus thuringiensis, Bacillus thuringiensis Berliner, Boscia senegalensis, Tephrosia kinds, Neem (Azadiracta indica) products, Terpenoid mix, biological control (e.g. beuveria bassiana, cotesia wasp, ect.), Ecological management of soil, pests and diseases, traps, plant ash and powders, aloe moth attractant, soil baits used against white grub, wireworm and Bagging of fruits
Methamidophos	Acephate, Abamectin, Bifenthrin, Chlorpyrifos, Chlorpyrifos-ethyl, Clothianidin, Cyfluthrin, Cypermethrin, Deltamethrin (Pyrethroid), Diflubenzuron, Dimethoate, Fipronil, Flupyradifurone, flufenoxurom, Imidacloprid, Indoxacarb, Lambda-Cyhalothrin, Lufenuron, Maldison, Novalurom, Profenofos, Pyrethrins, Spinosad, Spirotetramat, Thiamethoxam, Triflumuron	Bacillus thuringiensis and its varieties, biological control with alternate crops of neem, control of breeding sites, Integrated Pest Management and vectors

Alterntaives to substances proposed for listing in Annex III

Table B.3 Summary of alternatives for substances proposed to be added in Annex III of the Rotterdam Convention

Substances	Chemical alternatives	Non-chemical alternatives
Carbofuran	Chlorantraniliprole, Chlorpyriphos ethyl, Clothianidin, Deltamethrin, Lubendiamide FLubendiamide , Fluopyram, Imidacloprid, Neonicotinoid, Pyrethroid, Quinalphos	Purpureocillium lilacinum
Carbosulfan	Abamectin, Chlorpyrifos-ethyl, Chlorpyrifos-5 ethyl, Clothianidin, Cypermethrin, Deltamethrin, Lubendiamide FLubendiamide , Fluopyram, Imidacloprid, Lambda-Cyhalothrin, Profenofos	Purpureocillium lilacinum
Fenthion	Imidacloprid, Cyanophos Thiamethoxam, Thiacloprid, Deltamethrin (trap)	Traditional / Japanese trapping nets, nest removal campaign, protection of crops with nets, guarding of crops and/or scaring of birds from crops, sound and detonators, date of seeding, alternate crops, variable choice (some varieties are morphologically disturbing for birds), ecological struggle, typha control (by carbonisation, bio-methanisation, basket-making, livestock feed)
Chrysotile asbestos	Baked tiles, aluminium, plastic, aramid, Polyvinyl Alcohol (PVA), polyamides, polyacrylonitrile, corrugated Polyvinyl Chloride (PVC), corrugated iron & coloured IBR sheeting, steel sheeting, concrete roof tiles, (coated) pressed metal tiles, gypsum board and vermiculite board, corrugated metal roofs (galvanised and coated), para-amid fibres, cellulose fibres, polypropylene, attapulgite, polyethylene fibres, ceramic fibres (ceramic textile fibres and refractory ceramic fibres), Glass fibre (i.e. glass wool or fibreglass, continuous glass filaments and special purpose glass fibres), Kevlar, mineral wool (rock wool and slag wool) and silicon carbide fibres	Plant fibres and natural organic fibres, natural minerals (aluminium oxide, Carbon/graphite fibres, Fibrous clays, Steel wool, and Wollastonite)
Paraquat	Glyphosate, Glufosinate, Indaziflam	Field sanitation (e.g. maintain cleanliness on the irrigation canals), alternative weed management (e.g. manual /mechanical land preparation before sowing), pine oil/ coconut oil extracts, crop rotation, cover crops, primary tillage, seed bed preparation, soil solarisation, irrigation and drainage system, crop residue management, crop genotype choice, intercropping, fertilization, mechanical weeding, mechanical cultivation, thermal weed control, biological weed control curative method
Trichlorfon	Acephate, Acetamiprid, Chlorpyrifos, Clothianidin , Cyfluthrin, Cypermethrin, Deltamethrin (trap) (Pyrethroid), Diazinon, Dimethoate, d-trans allethrin, Lambda-Cyhalothrin, Malathion, Naled, Phosmet, Pirimicarb, Pyrethrins, Spinosad, soap, Tebufenozide, Thiacloprid, (z)-9-tricosene	Bacillus thuringiensis and its varieties, wide range of cultivation practices (e.g. crop rotation, natural enemies, soil cultivation, etc.)
Tributyltin compounds	Copper anti-fouling paints (e.g. copper thiocyanate or copper acrylate), maganeous ethylene bis dithioCarbamate, dizincdimethyldithioCarbamate (Ziram), zinc ethylene 1,2-bis dithioCarbamate (Zineb), non-stick biocide-free products, other copper systems with or without booster, propineb	Natural products extracts (e.g. sponge), Bacillus subtilis

Appendix C
Specific Information on Chemical and Non-chemical Alternatives for Some Case Studies

Chemical alternatives to Aldicarb

Table C.1 Chemical alternatives to Aldicarb

Chemical alternative	Crop	Pest	Dose application	Trade name	User countries
Abamectin	n/a Pear, Apple, Strawberry, Celery, Potato, Grapes, Bulb Onion Sub-Group of 3-07-A, Caneberry Sub-Group of 13-07A	red spider mites Spotted Tentiform, Onion Thrips, Spider mite, Potato psyllid, Pea Leafminer, McDaniel spider mite, Cyclamen mite, Two-spotted spider mite, Yellow mite, Pear Psylla, Pear rust mite, European red mite, Leafminer	n/a Depending on the crop**	Agri-Mek (by Syngenta)	Jamaica Canada
Bromopropylate	n/a	Red spider mites (acaricide)	n/a	Neoron	Jamaica, PIC website
Dimethoate* **	Cotton Fruits (apples, citrus, bananas, mangoes), vegetables (beans, broccoli, cabbage, cauliflower, pepper, potatoes, spinach, tomatoes), wheat, alfalfa, cotton, tobacco, ornamentals, olives, sunflower, and others	Seeding pests Insects and mites	Systematic against a broad range of insects and mites and is applied at 0.3-0.7 kg active ingredient/ha on numerous For residual treatment, 10-25 g/litre formulations are used (0.046-0.5 g active ingredient/m2).	Bi 58, Cygon, Dimethoate, Fosfamid, Fostion MM, Rogor, Perfekthion and Roxion.	n/a
	Bajra, corn, Sorghum, Castor, Mustard, Safflower, Bhindi, Brinjal, Cabbage & Cauliflower, Chillies, Onion , Potato, Tomato, Apple , Apricot, Banana, Citrus, Fig , Mango, Rose	Milky weed bug, Stem borer, Shoot fly, Midge, Jassids, Mites, Semi looper, Leaf minor, Aphid , Sawfly, Leaf hopper, Shoot borer, Painted bug, Mustard aphid, White fly, Lace wing bug, Black citrus aphid , Fig jassid, Mealy bug, Hopper, Scale, Thrips	Formulatios include emulsifiable concentrates, wettable powders, and granules. There is also a formulation for ultra-low volume application Ranging between 500-200 l/ha	DIMETHOATE 30% EC	India
Imidacloprid****	Cotton,rice, okra, cucumber, sunflower, sorghum, pearl millet, soybean, chillies, sugarcane, mustard, paddy, mango, citrus, groundnut, tomato and grapes	seeding pests, Jassids, Aphids, Thrips, White Backed Plant Hoppers, Whitefly, Shoot fly, termites, Mustard sawfly & painted bug, Brown plant hopper, White backed plant Hopper, Green Leaf Hopper, Leaf miner, psylla	IMIDACLOPRID 0.3% GR, IMIDACLOPRID 17.8% SL, IMIDACLOPRID 30.5% M/M SC, IMIDACLOPRID 70% WS, IMIDACLOPRID 48% FS, IMIDACLOPRIDE 70% WG	Ranging from 10 to 1875 l/ha 125 -1200 formulation (gm/l) ha	India
Fenbutine Oxide	n/a	acaricide for red spider mites	n/a	Vendex	Jamaica
Shell white oil along with Diazinon *****		scales			Jamaica

* It has been identified also as a chemical alternative for Endosulfan, Methamidophos and Carbosulfan. ** Dilute spray: 4.5 - 9 mL/100L water with 0.25-1% v/v spray oil registered for use on pears. Concentrated spray*: 170 – 340 mL/ha (69 – 138 mL/ac) with 10-20 L/ha (4

– 8 L/ac) of spray oil registered for use on pears. Dilute spray: 4.5 mL/100L water with 0.25-1% v/v spray oil registered for use on apples Concentrated spray: 170 mL/ha (69 mL/ac) with 10-20 L/ha (4-8 L/ac) spray oil registered for use on apples. Strawberry Pre-harvest: 225 mL/ha (91 mL/ac) with 0.1-0.5% v/v non-ionic surfactant (NIS). Strawberry Post-harvest: 225 mL/ha (91 mL/ac) with 0.1-0.5% v/v non-ionic surfactant (NIS). Celery: 135-250 mL/ha (55 -101 mL/ac) with 0.1-0.5% v/v non-ionic surfactant (NIS). Potato: 225 mL/ha (91 mL/ac) with 0.1-0.5% v/v non-ionic surfactant (NIS). Grapes: 130-265 mL/ha (53 – 107 mL/ac) with 0.1-0.5% v/v non-ionic surfactant (NIS). Bulb Onion Sub-Group of 3-07-A: 135-270 mL/ha (55 –109 mL/ac) with 0.25-0.5% v/v non-ionic surfactant (NIS). Caneberry Sub-Group of 13-07A: 225 mL/ha (91 mL/ac) with 0.1-0.5% v/v non-ionic surfactant (NIS). *** It has been identified also as a chemical alternative for Azinphos-methyl, Methamidophos, Monocrotophos, Parathion and Trichlorfon. ****There are quite a number of soil applied systemic alternatives for control of early pests in cotton but none of these include the same range of pests as Aldicarb. It has been also identified as a chemical alternative for Endosulfan, Methamidophos and Fenthion (see the sections for these substances for further information). ***** This alternative can be considered as a second priority alternative due to being on the list of banned or not approved substances in the EU 28.

Table C.2 Identified producers of alternatives to Aldicarb

Alternative	Use countries	Producer (presence)
Abamectin	Registered in many countries worldwide including the US and Europe., Brazil	Syngenta (global), Savana France (African market), Rotam (global)
Bromopropylate	Turkey	Syngenta
Dimethoate	n/a	BASF (global), FMC Agricultural Solutions (Cheminova) (global)
Imidacloprid	India, Chile, Sudan, Brazil, Burkina Faso, Capo Verde, Gambia, Guinea-Bissau, Mali, Mauritania, Niger and Senegal, New Zeadland	Nagarjuna Agrichem Limited (local in India/ exports), Bayer Crop Science (Global), Savana (African market), Rotam (Global), Helm, Chemet Chemicals PVT.LTD., PI Industries Ltd (local),, Nufarm (local / export)
Fenbutine Oxide	Mexico	BASF
Diazinon	New Zeadland	Syngenta, Nufarm
Fluopyram	African countries	Bayer CropScience

Source: Information publicaly available on producer´s websites.

Chemical and non-chemical alternatives for Monocrotophos

Table C.3 Chemical alternatives to Monocrotophos

Chemical alternative	Crop	Pest	Dose application	Trade names	User countries
Acetamiprid	Cotton Cotton Cabbage Okra Chilli Rice	Cotton pests Aphids, Jassids, Whiteflies Aphids Aphids Thrips BPH	n/a 500-600 l/ha	Acetamiprid 20% SP and used at	Benin, Burkina Faso, Capo Verde, Ivory Coast, Gambia, Guinea, Guinea Bissau, Mali, Mauritania, Niger, Senegal, Chad and Togo India
Alpha-Fenvalerate	tobacco	budworm	n/a		n/a

Chemical alternative	Crop	Pest	Dose application	Trade names	User countries
Alphamethrin	n/a	boll worm	n/a		Australia
Carbamate	n/a	boll worm (lerp insects)	n/a		Australia
Chlorpyrifos.	bananas, fruits and vegetables and potatoes and tomatoes Cotton Rice Paddy Beans Gram Sugarcane Cotton Ground nut Mustard Brinjal Cabbage Onion Apple Ber Citrus Tobacco Bengal gram	spurthroated locusts cotton pests Stem borer, Leaf, Roller, Gall midge, Bollworms Hispa Leaf roller,Gall midge, Stem borer and Whorl maggot, Green leaf hopper, Brown plant hopper, Leaf folder, Gall midge , Grass hopper Pod borer and Black bug, Cut worm , Black bug, Early shoot & stalk borer Pyrilla" Aphid and Bollworm , White fly, Cut worm Aphid Root grub Aphid Shoot & fruit borer Diamond back moth Root grub Aphid Leaf hopper Black citrus, Aphid Ground beetle Helicoverpa armigera	n/a n/a Ranging 500-1000 l/ha depending on the crop. Except for rice, paddy and Bengal gram 10000 Formulation (gm/l)/ha (rice) and 25000 Formulation (gm/l)/ha (bengal gram and paddy)	 Chlorpyrifos 10% G, Chlorpyrifos 20% EC, Chlorpyrifos 50% EC and Chlorpyrifos 1.5% DP	Australia Sahel India
Cypermethrin (insecticide)	Cotton Cotton Brinjal Cabbage Okra Brinjal Wheat Sunflower Bhindi	cotton pests Bollworms, Jassids, Thrips, Spotted bollworm, American bollworm , Pink bollworm Fruit & shoot borer, Diamond backmoth Fruit borer Fruit & shoot borer Shoot fly Bihar hairy caterpillar Shoot & fruit borer, Jassids	n/a 20000-24000 Formulation (gm/l) /ha 150-1000 l/ha 100-400 l/ha 150-400 l/ha 150-400 l/ha 500-800 l/ha 500-700 l/ha 400-800 l/ha 200-300 l/ha " 150-200 l/ha 150-200 l/ha	Ammo, Avicade, Barricade, CCN 52, Cymbush, Folcord, Imperator, Kafil Super, Polytrin, Ripcord, and Stockade. In India under trade names Cypermethrin 0.25% DP, Cypermethrin 10% EC and Cypermethrin 25% EC (India, 2016b)	Sahel India

Chemical alternative	Crop	Pest	Dose application	Trade names	User countries
Dimethoate	beans, cotton and tomatoes fruits (apples, citrus, bananas, mangoes), vegetables (beans, broccoli, cabbage, cauliflower, pepper, potatoes, spinach, tomatoes), wheat, alfalfa, cotton, tobacco, ornamentals, olives, sunflower, and others	psyllid (lerp insects) indoor and outdoor control of flies cattle grubs and for residual treatment	n/a doses between 0.3-0.7 kg active ingredient/ha n/a 10-25 g/litre formulations are used (0.046-0.5 g active ingredient/m2)		Australia n/a n/a n/a
Dicofol	cotton crops tea okra citrus litchi cotton Brinjal Bottle & Bitter gourd	n/a Red spider mite, Scarlet mite , Pink mite, Purple mite, Yellow mite Red Spider mite Red Spider mite Red Spider mite Red Spider mite Yellow mite Red Spider mite	n/a 500-1000 l/ha except for tea (250 l/ha)	Dicofol 18.5% EC	India
Fenitrothion	n/a	spurthroated locusts	n/a		n/a
Indoxacarb	Cotton Cotton Cabbage Chillies Tomato Pigeonpea Rice Soybean	cotton pests Bollworm Diamond back moth Fruit borer Fruit borer Pod borer complex Leaf folder, Piller, Green semilooper, stem fly Tobacco caterpillar, Green semilooper, stem fly	n/a	Indoxacarb 14.5% SC and Indoxacarb 15.8% EC	Sahel India
Malathion	Cotton Paddy Sorghum Pea Soybean Castor Sunflower Bhindi Brinjal Cabbage Cauliflower Radish Turnip Tomato Apple Mango Grape	cotton pests Rice Hispa Earhead midge Pod borer Leaf weevil Jassids, Semi looper White fly Aphid, Jassids, Spotted Boll Worm Mites Mustard aphid Head borer Stem borer Tobacco caterpillar White fly Sanjose scale,, Wooly aphid Mealy scale, Mango hooper Beetle	n/ 500-2000l/ha´depending on the crop	Malathion 50% EC	Sahel India
Profenofos	Cotton cotton	cotton pests Bollworm, Jassids, Aphids, Thrips, Whiteflies	n/a	Profenofos 50%	Sahel India

Chemical alternative	Crop	Pest	Dose application	Trade names	User countries
	soybean	Semi looper & Girdle beetle			
Pyrethroids	to tomatoes	n/a	n/a		n/a

Table C.4 Non-chemical alternatives to Monocrotophos

Non-chemical alternative	Crop	Pest	Dose application	Trade names	User countries
Azadirachtine (biological insecticide)	Cotton Cotton Rice Tea Tomato Brinjal Bengal Gram Red gram Okra Cabbage Jute Tobacco Cauliflower Bhindi	Cotton pests White fly, Bollworm, American bollworm, Aphids, Aphids, Jassids, White Flies, Bollworms, White Fly, Leaf Hoppers, H.armigera, Aphids Thrips, Stem borer, Brown Plant hopper, Leaf folder, Leaf roller, Stem borer, BPH, Brown Plant Hopper, Leaf Folder, Stem Borer Thrips, Red Spider mites, Caterpillar, Pink mite, Red Spider mites, Thrips Fruit borer (Helicoverpa armigera), Aphids, Whitefly, Fruit borer Fruit and Shoot borer (Leucinodes orbonalis), Shoot & Fruit borer, beetles Pod Borer (Helicoverpa armigera) Pod Borer (Melangromyze) Fruit borer, White flies Leaf Hopper Aphids, DBM, Cabbage worm, Cabbage looper Semi looper, Hairy caterpillar Tobacco caterpillar, Aphids Spodoptera, Diamond back moth, Aphids Leafhopper, whitefly, Aphid, Pod Borer	Ranging from 400 to 1000 l/ha depending on the crop and pest.	Azadirachtin 0.15% W/W MIN. Neem Seed Kernel based E.C., Azadirachtin 0.3% (3000 PPM) Min. Neem Seed Kernel based E.C., Azadirachtin 1% MIN. E.C. Neem based., Azadirachtin 1% (10000 PPM) Min. Neem based E.C. containing, Azadirachtin 0.03% Min. Neem oil based E.C. containing, Azadirachtin 0.03% (300 PPM) Neem oil based WSP containing, Azadirachtin 5% W/W MIN. Neem extract concentrates in India (UNEP-FAO-RC-CRC.8-9-Rev.1)	Benin, Burkina Faso, Capo Verde, Ivory Coast, Gambia, Guinea, Guinea Bissau, Mali, Mautitania, Niger, Senegal, Chad and Togo India
Bacillus thuringiensis *and varieties:* **BACILLUS THURINGIENSIS VAR. KURSTAKI SEROTYPE H-39, 3B, STRAIN Z-52 BIO-TECH. INTERNATIONAL** **BACILLUS THURINGIENSIS-K** **BACILLUS THURINGIENSIS VAR. GALLERIAE**	n/a Cotton Rice Gram Pigeon Pea Soybean Tobacco Castor Teak Cotton Cabbage & Cauliflower Tomato Bhindi	boll worm Bollworms, Spodoptera Stem borer & Leaf folder Heliothis Heliothis Spodoptera, Heliothis, Spilosoma, Semilooper, Leaf miner Spodoptera, Heliothis Hairy caterpillar, Ahea Janata Defoliator (Hyblaea pured), Skeletonizer (Eutectona machaeralis) Bollworm Diamond back moth (Plutella xylostella)	500-750 Formulation (gm/ml) /ha for all crops except for Teak (as required) 750-1000 l/ha 500l/ha 500l/ha 500l/ha 1000l/ha	Rijin, Bitayon, Delfin, Thuricide by Scientific & Technological Development, Jewin-Joffe Industry Ltd, SDS Biotech KK (Inchem website http://www.inchem.org)	Australia India

Non-chemical alternative	Crop	Pest	Dose application	Trade names	User countries
BACILLUS THURINGIENSIS SEROVAR KURSTAKI (3A, 3B, 3C) 5% WP.	Chillies cotton rice cotton red gram cabbage	Fruit borer (H. armigera) Fruit borer (Earias spp.) Fruit borer (spodoptera litura) Bollworm (Heliothis armigera) Leaf folder (Cnaphalocrocis medinalis) American Bollworm, Spotted BollwormPod Borer Diamond back moth	1000l/ha 1000l/ha 500-1000 l/ha 500-1000 l/ha 500-1000 l/ha		

Table C.5 Identified producers of alternative substances to Monocrotophos

Alternatives	Producers
Acetamiprid	BASF, FMC Agricultural Solutions, Chemet Savana France (African market), Sumitomo Corporation
Chlorpyrifos	Dow AgroSciences (global), India Gharda Chemicals Ltd, Aimco Pesticides Ltd (India),, Syngenta (global), Arysta LifeScience (Agriphar), Excel Crop Care LTD (India), Senchim(Senegal), ALM International, Nufarm (local India / export)
Cypermethrin	BASF, PI Industries Ltd (India local), Savana France (African market)
Dimethoate	BASF (global), FMC Agricultural Solutions (Cheminova) (global)
Dicofol,	Hindustan Insecticides Ltd (India)
Fenitrothion	Sumitomo chemical, Nufarm (local New Zeadland / export)
Indoxacarb	Arysta LifeScience, Savana France (African market)
Malathion	Savana France (African market), ALM International, Zhechem (China)
Profenofos	Savana France (African market), Senchim (Burkina Faso, Capo Verde, Gambia, Guinea-Bissau, Mali, Mauritania, Niger and Senegal), Nagarjuna Agrichem Limited (India local/ exports), PI Industries Ltd (local), Syngenta (global)
Bacillus thuringiensis	Valent Biosciences corporation, Sumitomo Chemical (Philagro subsidary), Savana France (African market)

Source: Information publicaly available on producer´s websites.

Table C.6 Information on Azadirachtin products from an Indian producer[113].

Trade name		Crop	Pest	Dose application	Annual production
Ozoneem Trishul	0.03%	Rice cotton	leaf roller, stem borer, BPH Helicoverpa armigera) and (bollworm) aphids	1000l/ha 500l/ha	400 tonnes
	0.15%	Rice cotton	thrips, stem borer, brown plant hopper and leaf bore against white fly and bollworm	500l/ha 500-1000l/ha	

113 http://ozonebiotech.com/neem-pesticides.html

Trade name		Crop	Pest	Dose application	Annual production
	0.3%	cotton	American bollworm	1000 l/ha	
	0.5%	n/a	n/a	n/a	
	1%	Tea Tomato brinjal	thrips and red spider mites fruit borer (Helicoverpa armigera) fruit and shoot borer (Leucinodes orbonalis)	450 l/ha and 600 l/ha 500 l/ha 500 l/ha	
	3%	n/a	n/a	n/a	
	5%	Tea Tobacco Rice Cotton Cauliflower bhindi	caterpillar, pink mite and red spider mites tobacco caterpillar and aphids brown plant, hopper, leaf folder white fly, leaf hoppers, heliothis and aphids aphids, diamond back moth, Spodoptera leafhopper, whitefly, aphid, pod borer, fruit borer	400 l/ha 400 l/ha 400 l/ha 750 l/ha 400 l/ha 400 l/ha	
Ozoneem Aza Technical		broad spectrum biopesticide controlling a large number of insect including caterpillars, beetles, whiteflies, leafhoppers, aphids, mites, thrips, borer, mealy bug, leaf folders and many more.			20-25 tonnes

Chemical alternatives to Parathion

Table C.7 Chemical alternatives to Parathion

Alternative	Crop	Pest	Trade name	User countries
Dimethoate	Ornamentals, olives, sunflower, tobacco, cotton, alfalfa, wheat, beans, broccoli, cabbage, cauliflower, pepper, potatoes, spinach, tomatoes, apples, citrus, bananas and mangoes	control of cattle grubs	0.3-0.7 kg active ingredient/ha (for fruits) Bi 58; Cygon; Dimethoate; Fosfamid; Fostion MM, Rogor, Perfekthion; Roxion systematic For residual treatment, 10-25 g/litre formulations are used (0.046-0.5 g active ingredient/m2) (WHO, 1984) emulsifiable concentrates, wettable powders, granules and ultra low volume application systematic For residual treatment, 10-25 g/litre formulations are used (0.046-0.5 g active ingredient/m2) (WHO, 1984) emulsifiable concentrates, wettable powders, granules and ultra low volume application	USA
Fenoxycarb	n/a	n/a	n/a	n/a

Alternative	Crop	Pest	Trade name	User countries
Imidacloprid	n/a	n/a	n/a	African countries, FAO 2016b
Malathion	Paddy, Sorghum, Pea, Soybean, Castor, Sunflower, Bhindi, Brinjal, Cabbage, Cauliflower, Radish, Turnip, Tomato, Apple, Mango and Grape	Rice Hispa, Earhead midge, Pod borer, Leaf weevil, Jassids, Semi looper, White fly, Aphid, Spotted Boll Worm, Mites, Mustard aphid, Head borer, Stem borer, Tobacco caterpillar, White fly, Sanjose scale, Wooly aphid, Mealy scale, Mango hooper, Beetle	MALATHION 50% EC 500-2000 l/ha depending on the crop	India
Spirotetramat	n/a	n/a	n/a	Afican countries, FAO, 2016b
Thiacloprid	n/a	n/a	n/a	Afican countries, FAO, 2016b

Table C.8 Identified producers of alternative substances to Parathion

Alternatives	Producers
Dimethoate	BASF (global), FMC Agricultural Solutions (Cheminova) (global)
Fenoxycarb	Syngenta (global)
Imidacloprid	Bayer Crop Science, Nagarjuna Agrichem Limited (India local/ exports), Chemet Chemicals PVT.LTD. (India), PI Industries Ltd (local) (India), Helm (Brazil), Rotam (Global), Savana France (African market), Nufarm (local New Zeadland / export)
Malathion	Savana France (African market), ALM International, Zhechem (China)
Spirotetramat	Bayer Crop Science
Thiacloprid	Bayer Crop Science

Source: Information publicaly available on producer´s websites.

Appendix D
Specific Information on Chemical and Non-chemical Alternatives for Substances Proposed for Listing

Chrysotile asbestos

Table 2: Suppliers of Chrysotile asbestos

Region	Number	Names and countries
Global	16	**Everite Group, South Africa** – fiber-cement flat sheet and roofing. **Etex Group, Belgium** – fiber-cement roofing, boards, siding; affiliates worldwide. **Parry Associates, UK** – microconcrete roofing; design and engineering firm (with local and international clients in 80 countries). **Worldroof, Belgium** – recycled polypropylene and high-density polyethylene and crushed stone. **Kuraray, Japan** – manufacturer of PVA fiber used to make fiber-cement by companies in countries including Ukraine, Nigeria, Turkey, Vietnam, Thailand, Malaysia, Mexico, Colombia, and Brazil. Unitika, **Japan** – manufacturer of PVA fiber used in fiber-cement. **Domtar Paper Co., US** – wood products company developing fiber-cement markets using wood pulp. **Fiber Cement Forum, Norway** – expanding markets for use of waste materials silica fume, flyash, and rice husk ash in fiber-cement products. **Saint-Gobain, France** – developing fiber-cement products using polypropylene and cellulose for use in Brazil, India, etc. **FCM Bell, Switerland** – supplies machines for making flat and corrugated fiber-cement sheets. **Wehrhahn, Germany** – supplies machinery and plants for making fiber-cement roofing and sheets. Sichuan, **China vinylon plant (SVW)** **Anhui, China chaohu PVA plant (Wanwei)** **Fujian, China PVA plant (Fuwei)** **Lan Zhou, China PVA plant (Lanwei)**
Europe	5	**Cembrit Group, Denmark** – fiber-cement flat sheets and corrugated roofing made in Czech Republic, Poland, Finland, Italy, Hungary. **Eternit, Switzerland** – fiber-cement sheet and other products. **Società Italiana Lastra, Italy** – fiber-cement sheet. **Landidi, Italy** – fiber-cement roofing and ducts. **Atermit, Turkey** – fiber-cement sheets. http://www.atermit.com
Latin America and the Caribbean	5	**Brazil– Brazilit**- polypropylene and cellulose fiber-cement roofing. **Brazil-Infibra** – fiber-cement roofing. **Brazil-Engeplas + Ecotop** – recycling dental tubes plastics + aluminum. **Brazil-Onduline** (vegetable fiber + asphalt/betume). **Brazil-Tecolita** (vegetable fiber + asphalt).
Asia	28	**Malaysia- UAC Berhad** – Siding, interior boards, ceiling panels. **Malaysia- Hume Cemboard** – Siding, interior boards, ceiling panels. **Taiwan - Taisyou International Business Col, Ltd** (ceiling and interior boards, siding) **Taiwan - Wellpool Co., Ltd**. (ceiling and interior boards, siding) **Taiwan.-.L.H. Fortune Co., Ltd**. (ceiling and interior boards, siding) **Korea - Byucksan Korea** - Kumgang Korea Chemical Co., Ltd. **Indonesia** – Nusantara **Philippines- James Hardie** (fiber-cement manufacturers) **Philippines - Aptech Manufacturing Corp**., Angeles and Pampanga, plantation wood/rattan wastes(fiber-cement manufacturers) **Philippines - Fabricemtech**, Lucena and Quezon, plantation wood and bagasse(fiber-cement manufacturers) **Philippines - GC Enterprises**, Zamboanga, yemane and palo verde(fiber-cement manufacturers) **Philippines - San Nicolas Multipurpose Coop**., Candon and Ilocos Sur, giant ipil-ipil and tobacco stalks(fiber-cement manufacturers) **Philippines - R-II Builders**, National Capital Region, plantation wood(fiber-cement manufacturers) **Philippines - Cemboard Systems Inc**., Lipa and Batangas, yemane(fiber-cement manufacturers) **Philippines - Phela Resources**, Genaral Samtos City, yemane(fiber-cement manufacturers)

Region	Number	Names and countries
		Philippines - Boalan Agri-Resources, Zamboanga del Sur, yemane and palo verde(fiber-cement manufacturers) **Philippines - Cruzayco Corp**., Kambankalan, Negros Occ., yemane(fiber-cement manufacturers) **Philippines - Cagayan Wood Works Manufacturing Corp**., Solana and Cagayan, yemane(fiber-cement manufacturers) **Philippines - Caraga Women's Cooperative**, Butuan City, yemane and rattan waste(fiber-cement manufacturers) **Philippines - Earn Corporation**, Bay and Laguna, yemane(fiber-cement manufacturers) **Philippines - Villarica Forest Products**, Samal Island and Daval, yemane(fiber-cement manufacturers) **Philippines - Zementboard Cooperative**, Korondal and South Cotabato, yemane(fiber-cement manufacturers) **Philippines - Versaboard Enterprises**, Angeles and Pampanga, bagasse(fiber-cement manufacturers) **Philippines - Alenter Cane Corp., Cebu**, rattan wastes(fiber-cement manufacturers) **Philippines - Lemon Products Int'l./Victorians Marketing**, Imus and Cavite, rattan wastes(fiber-cement manufacturers) **Thailand - Mahaphant** – fiber-cement roofing and sheet. **Thailand - Diamond Roofing Tiles**. **Thailand - Siam-Fibre Cement** – fiber-cement roofing and sheets **Thailand - Conwood**

Table 24: Alternatives to Chrysotile asbestos

Function	Alternatives	Sources
Roofing	Synthetic fibers (polyvinyl alcohol, polypropylene) and vegetable/cellulose fibers (softwood kraft pulp, bamboo, sisal, coir, rattan shavings and tobacco stalks, etc.); with optional silica fume, flyash, or rice husk ash, Microconcrete (Parry) tiles, Galvanized metal sheets, Clay tiles, Vegetable fibers in asphalt, Slate, Coated metal tiles (Harveytile), Aluminum roof tiles (Dekra Tile), Extruded uPVC roofing sheets,Recycled polypropylene and high-density polyethylene and crushed stone (Worldroof), Plastic coated aluminium, Plastic coated galvanized steel	International Ban Asbestos Secretariat[114]
Flat sheet (ceilings, facades, partitions)	vegetable/cellulose fibers (see above), wastepaper, optionally synthetic fibers, Gypsum ceiling boards (BHP Gypsum), Polystyrene ceilings, cornices, and partitions, Façade applications in polystyrene structural walls (coated with plaster) , Aluminum cladding (Alucabond) , Brick, Galvanized frame with plaster-board or calcium silicate board facing, Softwood frame with plasterboard or calcium silicate board facing.	International Ban Asbestos Secretariat[115]
	In order to prioritization :Aramid and para-amid fibres (human hazard medium), fibrous glass (glass fibre, glass wool), carbon/graphite (low/undetermined hazards), ceramic fibres, wollastonite (low hazard), cellulose fibres (low hazard, but indeterminate to the respirable fibres), mineral wool (rock wool, slag wool), Polyvinyl alcohol (PVA) fibres (undetermined hazard), polypropylene (indeterminate hazard), polyvinyl chloride (PVC) (undetermined hazard), attapulgite (high hazard) and polyethylene fibres. Second less important group: Aluminium silicates, basic magnesium sulphate whisker, erionite, ductile iron, mica, phosphate, polyacryl nitryl, polytetrafluoroethylene, potassium titanate whisker, semi-metallics, silicon carbide whisker, and steel fibres, as a second less important group (UNEP/FAO/RC/CRC.2/INF/5) Not considered further by WHO: Magnesium sulphate, polyethylene, potassium octatitanate fibres, synthetic vitreous fibres (including glass wool/fibrous glass, mineral wool, special purpose vitreous silicates, and refractory ceramic fibres), and xonotlite,	(WHO)

[114] http://www.ibasecretariat.org/
[115] http://www.ibasecretariat.org/

Non-chemical alternatives to Parathion

Table 4: Examples of weed control depending on the weed

Crop	Country	Weed	Control method
Rice, corn, vegetables, orchards, and other agricultural crops	Worldwide	Barnyard grass (Echinochloa spp. B)	Proper selection of seeds, thorough seedbed preparation to prevent weed growth, thorough land preparation by plowing and at least harrowing twice, not to practice direct seeding (only rice), closer planting to prevent sunlight to weed's seeds, regular plant monitoring, hand weeding (early days of growth), removing weeds (before blooming), deep flooding (submerging the whole plant) and crop rotation.
Most agricultural crops	Asia, Africa, Europe, South America, USA	Bermuda grass (Cynodon dactylon)	Proper selection of seeds, thorough land preparation, cultivation, regular plant monitoring, and hand weeding and mowing
Most agricultural crops	Asia, Australia, tropical Africa, Europe, South America, and USA	Cogongrass (Imperata cylindrical)	Regular field monitoring, breaking up the rhizomes, frequent cultivation (hand tools and other farm implements), cutting or slashing every two weeks to kill the rhizomes, and bending the stems at ground level followed by plowing to place soil
Most agricultural crops	Africa, Asia, Europe, South America, USA	Crabgrass (Digitaria spp)	Proper selection of seeds, thorough land preparation by plowing and harrowing twice, closer spacing, hand weeding or hoeing and regular field monitoring
Most agricultural crops	Asia, Australia, Africa, South America, USA	Crowfoot grass (Dactyloctenium aegyptium)	Proper seed selection, thorough land preparation, regular field monitoring, hand weeding/hand pulling when the weeds are young, cultivation using farm or mechanical implements, removing weeds (before blooming), mulching, closer planting and intercropping
Corn, upland rice, sweet potato, cassava, sugarcane, cotton, vegetables, soybean and other legumes, and other crops	Worldwide	Goosegrass (Eleusine indica)	Proper seed selection, cutting the weeds (using sharp-bladed farm implements) before flowering, hand weeding of seedlings (at early growing), mulching (2-3 inches layer mulch), proper plowing and harrowing before planting and regular field monitoring
Rice, sugarcane, citrus, and vegetables	Worldwide	Torpedo grass (Panicum repens)	Use clean seeds, make sure that the seedbed is free of weeds, proper land preparation, keep surroundings (bunds, levees, irrigation canals) free of weeds, hand weeding or hoeing and regular field monitoring
Rice	Worldwide	Globe fringerush (Fimbristylis miliacea, F. littoralis)	Proper seed selection, deep plowing and proper field level, repeated tillage or soil disturbance and hand weeding
Most agricultural crops	Worldwide	Nutsedge (Cyperus spp)	Deep plowing and proper field level, cut the weeds before blooming (seed bearing species), repeated tillage or soil disturbance, flooding, proper seed selection 6. Mulching 7. Crop rotation with pigeon pea. Pigeon pea has the ability to control the emergence and growth of nutsedge.
Mostly irrigated rice	Worldwide	Arrowleafed monochoria (Monochoria vaginalis)	Proper seed selection, regular field monitoring, thorough land preparation by plowing and harrowing, keeping seedbeds free of weeds, hand weeding, and crop rotation
Crops that belong to the nightshade family (tomato, eggplant, pepper, potato), beans, corn,	Worldwide	Black nightshade (Solanum nigrum)	Thorough land preparation by plowing and harrowing, regular field monitoring, corn gluten meal (ca. 10 kg of corn gluten meal per 1,000 sq. ft.), hand weeding at the early stage of growth, and practice crop rotation

Crop	Country	Weed	Control method
and other agricultural crops			
Rice, corn, cotton, crucifers, potato, tomato, and many other agricultural crops	Worldwide	Common purslane (Portulaca oleracea)	Proper soil tillage or thorough land preparation by plowing and harrowing at least two times, hand weeding, regular plant monitoring, corn gluten meal (ca. 10 kg of corn gluten meal per 1,000 sq. ft,crop rotation with sorghum (ability to reduce the emergence or growth of pigweeds), mulching at least 3 inches thick (prevents seeds germination)
Mostly irrigated rice		Gooseweed (Sphenoclea zeylanica)	Proper seed selection, thorough land preparation by plowing and harrowing, rice seedbeds should be free of weeds, regular plant monitoring, proper water and fertilizer management, closer plant spacing to prevent sunlight exposure to germinating seeds, hand weeding, crop rotation
Almost all agricultural crops	Worldwide	Horseweed (Conyza canadensis, Erigeron Canadensis)	Proper seed selection and proper choice of cultivars, thorough land preparation, regular field monitoring, hand weeding, cutting the weeds before blooming
Corn, sorghum, cotton, legumes, potato, banana, and other summer crops		Jimsonweed (Datura stramonium)	Proper seed selection, proper soil tillage or thorough land preparation by plowing and harrowing, regular plant monitoring, field surrounding should be free of weeds, hand weeding before the weeds start to set seeds.
Corn, soybean, potato, and other agricultural crops	Worldwide	Lambsquarter (Chenopodium album)	Proper seed selection, through land preparation, proper weed management, regular plant monitoring, corn gluten meal (ca. 10 kg of corn gluten meal per 1,000 sq. ft., and vinegar at 10, 15, or 20% concentrations control smooth pigweed up to 6 inches tall (to avoid contact with the main crop).
Almost all agricultural crops	Worldwide	Pigweeds (Amaranthus spp.)	Proper selection of seeds, thorough land preparation by plowing and harrowing at least two times, regular plant monitoring, proper weed management, vinegar at 10, 15, or 20% concentrations control smooth pigweed up to 6 inches tall (to avoid contact with the main crop), corn gluten meal (ca. 10 kg of corn gluten meal per 1,000 sq. ft.), and crop rotation with sorghum
Corn, millets, rice, sorghum, and sugarcane are the hosts for the first 4 Striga species, while S. gesnerioides is a parasitic weed of cowpea and wild legumes	Mostly in Africa but also found in Asia and the USA	Striga weed (Striga hermonthica, S. asiatica, S. aspera, S. forbesii, S. gesnerioides)	Proper seed selection, use seeds that are Striga seeds-free, regular plant monitoring, intercropping sorghum with cowpea, intercropping corn with silver leaf desmodium (Desmodium uncinatum) or green leaf desmodium (D. intortum) (desmodium is a leguminous plant that is a good source of fodder for the farm animals, it covers the surface in between the rows of the main crop (corn, sorghum, or millet) and emits chemical into the soil that is unfavourable for Striga's growth. 2.5 kg of seeds per 1 ha.), hoeing and hand weeding before blooming, off-barring and hilling-up the rows, apply (organic and inorganic) fertilizers, and crop rotation with legumes (e.g. soybean, mungbean).
Mostly irrigated rice	Worldwide	Water hyacinth (Eichhornia crassipes)	Proper soil tillage and/or thorough land preparation, hand weeding, regular plant monitoring, rotate rice with legumes, biological control with the use of weevils (neochitina eichhorniae and N. bruchi)

Chemical and non-chemical alternatives to Fenthion

Table 5: Chemical alternatives to Fenthion

Chemical alternative	Crop	Pest	Trade names	User countries
Deltamethrin (traps)	n/a	fruit flies	n/a	African countries

Chemical alternative	Crop	Pest	Trade names	User countries
Cyanophos	n/a	birds	n/a	Tanzania
Imidacloprid*	n/a	beet weevil, gray maize weevil and black beet weevil	Gaucho FC 600	Bulgaria
Thiacloprid.	n/a	fruit flies	n/a	African countries
Thiamethoxam	n/a n/a wide range of crops(cotton, sorghum, wheat, soybeans, chili, okra, corn, sunflower, tomato, rice, mango, tea, potato,etc)	beet weevil, gray maize weevil and black beet weevil Quelea control Wide range of pests (aphid, whiteflies, thrips, jassids, shoot fly, termites, stern fly, Stem borer, Gall midge, Leaf folder, White backed plant hopper, Brown Plant Hopper, Green Leaf Hopper, hoppers, mosquito bug, and psylla)	Cruiser 350 FS Thiamethoxam 30% FS. Thiamethoxam 70% WS and Thiamethoxam 25% WG	Bulgaria African countries India

Table 6: Non chemical alternatives to Fenthion

Non-chemical alternative	Use	Advantage	Disadvantage
Traditional /Japanese trapping nets	Well implemented in Madagascar	good results	nets are fragile, its installation and collection of the birds need to be done carefully, availability is limited and the costs for the small farmers is not affordable
Guarding of crops and/or scaring of birds from crops (sound and detonators), gardening (alarms, noise, slingshot...)	locally implemented in Mauritania and Chad	it does not damage the environment	are that this type of materials is not available for the small farmers, it has short time effectiveness and it does not act on the pest populations
Nest removal /destruction campaign	Implemented locally in Chad and Mauritania in grain crops (e.g. cereals) with good results	n/a	is carried out in limited time (some days), limited coverage, lack of motivation of the locals to perform it, and coordination needs
Protection of crops with nets	n/a	n/a	n/a
Date of seeding (crops maturation does not occur with the bird pressure)	Implemented locally in Mauritania	any damage is caused to the birds	difficulties such as not limiting pest seasonal populations, that fluctuations for irrigated crops (water stress) can happen, plus difficulties to collectively respect the dates
Alternate crops	The method is not is not commonly observed or implemented in Mauritania	costs for fighting birds are avoided; it can	the alternate crops cannot be productive enough to motivate the farmer to implement this method or

Non-chemical alternative	Use	Advantage	Disadvantage
		have the same interests as the crops rotation	that the new crops can need special facilities
Variable choice (some varieties are morphologically disturbing for birds)	The method is not commonly observed or implemented in Mauritania	this method limits the damage caused by the birds	The problems are due to the availability of varieties, the commercial value and the output and taste can also be a problem, and the methods do not act on pest populations
Ecological struggle	The method is not is not commonly observed or implemented in Mauritania It consists in changing the ecological conditions in the close areas to make an unfavourable habitat for the pest (e.g. weeding and cleaning the channels at the rice levels, fight against Typha australis which is an ecological niche for the granivorous birds by carbonisation, bio-methanisation, basket-making, and livestock feed)	it can be accounted as a hygienic measure	the method should be carried out in general and involve all farmers (which is difficult), if the grain grasses do not exist in the rice crops there is more pressure on the rice crops, and it can be damaging for the environment.

Table 28: Producers of alternatives to Fenthion

Alternative	Producers
Thiamethoxam	Syngenta (global) and Nagarjuna Agrichem Limited (local India/ exports)
Deltamethrin	Rivale (Global), Bayer Crop Science (Global) Savana France (African market)
Imidacloprid	Bayer Crop Science, Nagarjuna Agrichem Limited (India local/ exports), Chemet Chemicals PVT.LTD. (India), PI Industries Ltd (local) (India), Helm (Brazil), Rotam (Global), Savana France (African market)
Thiacloprid	Bayer Crop Science

Chemical alternatives and non-chemical alternatives to Trichlorfon

Table 29 Chemical alternatives to Trichlorfon

Chemical alternatives	Crop	Pest	Trade names	User countries
Acephate	deciduous tree Forest trees and shade trees Spruce forest plantations or young regeneration situations tobacco Brussels sprouts cabbage and cauliflower Corn (sweet) Ornamental flowers/ shrubs /trees	against Forest tent caterpillar Gypsy moth larvae (instars 1st to 2nd only) Yellowheaded spruce sawfly Armyworms and leafminers Hornworms, imported cabbageworm, diamondback moth European corn borer (Quebec only), Pepper (Pepper maggot and arksided cutworm) Bagworms, leafminers, and webworms	Orthene, Asataf, Pillarthene, Kitron, Aimthane, Ortran, Ortho 12420, Ortril, Chevron RE 12420, and Orthene 755, by Valent USA names Acephate 75% SP and Acephate 95% SG	Canada India

Chemical alternatives	Crop	Pest	Trade names	User countries
Acetamipride (28)	lettuce, kale, spinach and in ornamental flowers, ornamental shrubs and ornamental trees	dipterous leafminers and leafminers		Canada India
Clothianidin (28)	corn (field), corn (sweet), corn (popcorn)	cutworms		Canada
Chlorpyrifos(28).	Deciduous tree canola (rapeseed) flax barley, oats, wheat (durum), wheat (spring), wheat (winter) corn (field), corn (sweet), corn (popcorn)	Forest tent caterpillar Diamondback moth Forest tent caterpillar Diamondback moth armyworm, western yellowstriped armyworm, variegated cutworm and bertha armyworm true armyworm, western yellowstriped armyworm and Bertha armyworm darksided cutworm and redbacked cutworm		Canada India
Cypermethrin (28)	Brussels sprouts, Cabbage, Cauliflower Collards, Kale Corn (field) Corn (popcorn, sweet) Tobacco	Imported cabbageworm, Diamondback moth); Thrips cutworms Cutworms, European corn borer (Quebec only) Red backed cutworm ,Darksided cutworm	Avicade, Barricade, CCN 52, Cymbush, Folcord, Imperator, Kafil Super, Polytrin, Ripcord, Stockade (Inchem website http://www.inchem.org).	Canada
Deltamethrin (Pyrethroid)(28)	Canola (rapeseed) Flax Alfalfa Brussels sprouts, Cabbage, Cauliflower) Corn (sweet) Oats, Sugar beet, Table beet, Barley and Wheat (spring), Wheat (winter) Tobacco	Beet webworm, Diamondback moth, Lygus bugs Beet webworm, Variegated Cutworm Lygus bugs, Tarnished plant Bug Variegated cutworm Imported cabbageworm, Diamondback moth); European corn borer (Quebec only)) Variegated cutworm) Darksided cutworm, Redbacked cutworm	Decamethrin, Decis, K-Othrine, NRDC 161, WHO 1998, K-Obiol, Butox Butoflin, Cislin and FMC 45498 RU 22974 (Inchem website http://www.inchem.org)	Canada
Diazinon (28).	spruce in Christmas tree plantations, in spruce trees in municipal parks, in deciduous tree (against); in beans (dry) and beans (lima), in beans (snap) Brussels sprouts, cabbage, and cauliflower; in carrot, rutabaga and salsify; in lettuce, kale and spinach ; in pepper (against); in sugar beet, table beet (); Tomato (against dipterous leafminers); in turnip (against dipterous	spruce budworm larvae, forest tent caterpillar, against armyworms, imported cabbage worm, dipterous leafminers, Mexican bean beetle and variegated cutworm), armyworms, imported cabbage worm, dipterous leafminers, Mexican bean beetle), imported cabbageworm, variegated cutworm, and diamondback moth, dipterous leafminers, imported		Canada

Chemical alternatives	Crop	Pest	Trade names	User countries
	leafminers, variegated cutworm, diamondback moth, beet armyworm, and salt-marsh caterpillar); in ornamental flowers and ornamental shrubs (against armyworms, bagworms, cutworms, leafminers and webworms) and in ornamental trees (against armyworms, bagworms, leafminers and webworms)	cabbageworm, variegated cutworm, diamondback moth, beet armyworm and salt-marsh caterpillar, beet webworm, dipterous leafminers, variegated cutworm, armyworms, and salt-marsh caterpillar, dipterous leafminers, Beet webworm, Dipterous Leafminers, Variegated Cutworm, Alfalfa webworm, Beet armyworm		
Dimethoate (28)	apples, citrus, bananas, mangoes), vegetables (beans, broccoli, cabbage, cauliflower, pepper, potatoes, spinach, tomatoes), wheat, alfalfa, cotton, tobacco, ornamentals, olives, sunflower and others Balsam fir and spruce in Christmas tree plantations, in farm woodlots, alfalfa, in beans (dry), beans (lima), and beans (snap), in pepper, in ornamental flowers, ornamental shrubs and ornamental trees	control of cattle grubs, spruce budworm larvae; lygus bugs and tarnished plant bug) dipterous leafminers, lygus bugs, Mexican bean beetle; (against pepper maggot); (against leafminers; and bagworms and leafminers	0.3-0.7 kg active ingredient/ha Bi 58; Cygon; Dimethoate; Fosfamid; Fostion MM, Rogor; Perfekthion and Roxion (Inchem website http://www.inchem.org)	Canada
D-trans allethrin (28).	deciduous tree ornamental flowers and ornamental shrubs and ornamental trees	forest tent caterpillar; armyworms and cutworms; and armyworms		Canada
Lambda-Cyhalothrin (28).	Canola (rapeseed), alfalfa, Brussels sprouts, cabbage and cauliflower, in corn (field and popcorn), in corn (sweet), tobacco	lygus bugs; tarnished plant bug); imported cabbageworm and diamondback moth); armyworms and cutworms; armyworms, cutworms and European corn borer (Quebec only); and darksided cutworm		Canada
Malathion ((28).	balsam fir and spruce, Christmas tree plantations, in in deciduous tree; in tobacco; in canola (rapeseed); alfalfa barley, beans (dry); beans (lima) and beans (snap) ; Brussels sprouts, cabbage, cauliflower, carrot, rutabaga and turnip oats; pepper; in sugar beet, table beet and tomato; wheat (durum), wheat (spring) and wheat (winter),	(against forest tent caterpillar); in fir forest plantations (against yellowheaded spruce sawfly), (against hornworms), (against diamondback moth), against beet armyworm, lygus bugs, tarnished plant bug), against true armyworm, western yellowstriped armyworm and bertha armyworm), (against imported cabbageworm and Mexican bean beetle), (against		Canada

Chemical alternatives	Crop	Pest	Trade names	User countries
	ornamental flowers and ornamental trees and ornamental shrubs	imported cabbageworm), (against true armyworm, western yellowstriped armyworm and Bertha armyworm, gainst dipterous leafminers, (against true armyworm, western yellowstriped armyworm and bertha armyworm, bagworms, leafminers, lygus bugs, tarnished plant bugs, against bagworms, lygus bugs and tarnished plant bugs		
Naled (28)	Alfalfa, Brussels sprouts, cabbage and cauliflower, tomato, Ornamental flowers /trees	lygus bugs; imported cabbageworm and diamondback moth); dipterous leafminers; leafminer		Canada
Phosmet (28).	Blueberry ornamental trees deciduous tree	blueberry spanworm Leafminers forest tent caterpillar		
Pirimicarb (28).	alfalfa	lygus bugs		Canada
Pyrethrins (28)	ornamental flowers and ornamental shrubs	armyworms, bagworms, cutworms, leafminers, stink bugs, webworms; and in ornamental trees against armyworms, bagworms, leafminers, stink bugs, and webworms		Canada
Soap (28)	ornamental flowers, ornamental shrubs and ornamental trees	leafminers		Canada
Spinosad (28)	forest trees and shade trees Brussels sprouts, cabbage, cauliflower, rutabaga and turnip corn (sweet)	gypsy moth larvae (instars 1st to 2nd only) imported cabbageworm and diamondback moth European corn borer		Canada, (2016)
Tebufenozide (28).	Balsam fir and spruce in farm woodlots, in rights-of-way, in Christmas tree plantations, in spruce trees in municipal parks	against Spruce budworm larvae		Canada

Table 30: Non-chemical alternatives to Trichlorfon

Alternative	Crop	Pest	Trade name	User countries
Bacillus thuringiensis (28)	spruce trees , Christmas tree plantations, deciduous tree, forest trees, shade trees, tobacco, blueberry, Brussels sprouts, cabbage, cauliflower, and turnip, corn (sweet), rutabaga, ornamental shrubs and ornamental trees	against forest tent caterpillar; gypsy moth larvae (instars 1st to 2nd only); Hornworm; white marked tussock moth; imported cabbageworm and diamondback moth; European corn borer (Quebec only); (against imported cabbageworm; bagworms, bagworms and webworms	Rijin, Bitayon, Delfin, Thuricide by Scientific & Technological Development, Jewin-Joffe Industry Ltd, SDS Biotech KK (Inchem website http://www.inchem.org)	Canada African countries. India
Cultivation practices				
crop rotation		European corn borer populations		
intercropping corn and soybean				
appropriate soil cultivation and use of natural enemies				
harvesting alfalfa early		alfalfa webworm, alfalfa caterpillar and other pests		
planting beans away from alfalfa		decrease logos bug populations		
providing float row covers	small cabbage and cauliflower fields	prevent diamondback moths from laying eggs		
pruning out caterpillar tents	lueberries	caterpillar		
physical barriers or ditches filled with water	in lettuce and kale fields	stop migrating caterpillars		
removing horse nettle	pepper	pepper maggot		
Use of resistant varieties;				
Using sprinkler irrigation	Brussels sprouts, cabbage, cauliflower, rutabaga and turnip	diamondback larvae		

Table 31: Identified producers of Trichlorfon

Alternatives	Producers
Acephate	AMVAC Chemical Corporation, Osho chemical industries LTD (local Kenya), Beijing Lingbao Tech LTD (China), Aike Reagent (China), Chengdu Best reagent (China), Shanghai Industrial Co., Ltd. (China), Nagarjuna Agrichem Limited (local India / exports), PI Industries Ltd (India local)
Naled	AMVAC Chemical Corporation

Alternatives	Producers
Phosmet	BASF
Acetamiprid	BASF, FMC Agricultural Solutions, Chemet, Savana France (African market), Sumitomo Corporation
Dimethoate	BASF (global), FMC Agricultural Solutions (Cheminova) (global)
Diazinon	Syngenta, Nufarm
Deltamethrin (Pyrethroid)	Rivale (Global), Bayer Crop Science (Global), Savana France (African market)
Cypermethrin	BASF, PI Industries Ltd (India local), Savana France (African market)
Chlorpyrifos	Dow AgroSciences (global), India Gharda Chemicals Ltd, Aimco Pesticides Ltd (India),, Syngenta (global), Arysta LifeScience (Agriphar), Excel Crop Care LTD (India), Senchim(Senegal), ALM International, Nufarm (local India / export)
Clothianidin	Bayer Crop Science (Global)
Lambda-Cyhalothrin	Savana France (African market), Rotam (Global), Senchim (African market) and Syngenta (global)
Malathion	Savana France (African market), ALM International, Zhechem (China)
Pirimicarb	FMC Agricultural Solutions (Cheminova)
Spinosad	Bayer Crop Science (Global), Nagarjuna Agrichem Limited (local india / exports), Dow AgroSciences (global)
Tebufenozide	SinoHarvest (local China), Dow AgroSciences (global)
Bacillus thuringiensis	Valent Biosciences corporation, Sumitomo Chemical (Philagro subsidary), Savana France (African market)

Source: Information publicaly available on producer´s websites.

Chemical alternatives to Carbofuran

Table 32 : Summary information on products, use countries, crops and pest application for chemical alternatives to Carbofuran

Substance	country	crops	pest	dose	Ref
Chlorantraniliprole	India	paddy rice, cabbage, Cotton, sugar, cane, tomato, chili, brinjal, pigeon pea, soybean, bengal gram, bitter gourd black gram, okra	Stem/shoot/top/pod borer, leaf folder, Diamond back moth, bollworm, caterpillar, termite, green semi looper, stem fly and girdle	18.5% SC; 30 a.i (gm)/ha 0.4% GR.; 40 a.i (gm)/ha	PVC Conf, 2014
Chlorpyriphos ethyl	USA and Sahelian countries			Lorsban™ 4E and Dursban	PVC Conf, 2014
Clothianidin	African countries		soil pests		FAO, 2016a
Deltamethrin			aphid		FAO, 2016a
Lubendiamide FLubendiamide	India	paddy rice, cotton, tomato, cabbage, pigeon pea, black gram, chili,	Stem/ leaf/fruit/pod borer, American/spotted bollworm, diamond back moth	Lubendiamide FLubendiamide 20% WG and Lubendiamide FLubendiamide 39.35% M/M SC 125 Formulation: 25 a.i (gm)/ha	PVC Conf, 2014, India, 2016b

Substance	country	crops	pest	dose	Ref
				50 Formulation: 24 a.i (gm)/ha	
Fluopyram	African countries		nematode control		FAO, 2016a
Imidacloprid	African countries		aphid control and soil pests		FAO, 2016a
Neonicotinoid	USA	grapes		Poncho™	PVC Conf, 2014
Pyrethroid	n.d.	n.d.	n.d.	Capture™ 2EC	
Quinalphos	India	paddy rice chili, sorghum, okra, cotton, tomato, okra, tea, tur, groundnut, wheat, begal/red/ black gram, French bean, soybean, jute, mustard, sesam, bhindi, cauliflower, apple, banana, citrus, pomegranate, cardamom, safflower	Brown plant Hopper, Leaf roller, Stem borer, Hispa, Gall midge, Green leaf hopper/webber/folder/miner, bune beetle aphid, stem borer, earhead bug, earhead midge, shoot/stem/saw/pod fly, aphid, jassids, thrips, bollworms, caterpillars spodoptera, mite, leaf weevil, Tingid bug, Scale and Citrus butterfly,	250 a.i (gm)/ha, Quinalphos 25% Gel 250 a.i (gm)/ha Quinalphos 5% Granule 250-300 a.i (gm)/ha, Quinalphos 20% AF 325-500 a.i (gm)/ha, Quinalphos 25% EC 300 a.i (gm)/ha, Quinalphos 1.5% DP	PVC Conf, 2014, India, 2016b

Table 33: Identified producers for Carbofuran

Alternatives	Producers
Chlorantraniliprole	DuPont Crop Protection
Chlorpyriphos ethyl	ALM International, Arysta LifeScience, Rivale (Global), Savana France (African market), Dow AgroSciences (global)
Clothianidin,	Bayer Crop Science (Global)
Deltamethrin	Rivale (Global), Bayer Crop Science (Global), Savana France (African market)
Lubendiamide FLubendiamide	Bayer Crop Science (Global)
Fluopyram.	Bayer CropScience
Imidacloprid	Nagarjuna Agrichem Limited (local in India/ exports), Bayer Crop Science (Global), Savana (African market), Rotam (Global), Helm, Chemet Chemicals PVT.LTD., PI Industries Ltd (local),, Nufarm (local / export)
Quinalphos.	Chemet Chemicals PVT. LTD., Crop Chemicals India Limited

Source: Information publicaly available on producer´s websites

Chemical alternatives to Carbosulfan

Table 34: identified producers of alternatives to Carbosulfan.

Alternatives	Producers
Abamectin	Syngenta (global), Savana France (African market), Rotam (global)

Alternatives	Producers
Chlorpyrifos-ethyl	ALM International, Arysta LifeScience, Rivale (Global), Savana France (African market), Dow AgroSciences (global)
Cypermethrin	BASF, PI Industries Ltd (India local), Savana France (African market)
Deltamethrin	Rivale (Global), Bayer Crop Science (Global), Savana France (African market)
Lambda-Cyhalothrin	Savana France (African market), Rotam (Global), Senchim (African market) and Syngenta (global)
Profenofos	Savana France (African market), Senchim (Burkina Faso, Capo Verde, Gambia, Guinea-Bissau, Mali, Mauritania, Niger and Senegal), Nagarjuna Agrichem Limited (India local/ exports), PI Industries Ltd (local), Syngenta (global)
Imidacloprid	Nagarjuna Agrichem Limited (local in India/ exports), Bayer Crop Science (Global), Savana (African market), Rotam (Global), Helm, Chemet Chemicals PVT.LTD., PI Industries Ltd (local),, Nufarm (local / export)
Clothianidin	Bayer Crop Science (Global)
Fluopyram	Bayer CropScience (Global)
Purpureocillium lilacinum.	Bayer CropScience (global)

Appendix E
Indian Market and US price Information for Alternatives to Case Study Substances and on Alternatives to Substances Proposed for Listing in Annex III

Source Indian Market: http://ppqs.gov.in/PMD.htm#statewise

Source US prices: https://www.nass.usda.gov/Quick_Stats/

Dimethoate

Table 63: Market data of Dimethoate in India

Years	2005-06	2006-07	2007-08	2008-09	2009-10
Demand (metric tonnes)	536	605.05	579	744	784
Consumption (metric tonnes)	785	798	530.43	820	636
Imports (metric tonnes)	101	100	12	344.1	133
Prices[116] of Dimethoate 30% US$, real prices 2010[117]	3.39 US$	3.94 US$	3.75 US$	4.61 US$	4.53 US$

Table 64: Prices of Dimethoate in US from 2002-2008.

Years	2002	2003	2004	2005	2006	2007	2008
Prices US$, real prices 2010[122]	51.54	49.33	46.72	44.48	42.71	40.2	39.86

Imidacloprid

Table 65: *Market data of Imidacloprid in India*

Years	2005-06	2006-07	2007-08	2008-09	2009-10
Demand (metric tonnes)	72.306	79	32.0	129.07	250.43
Prices (US$), real prices 2010	-	-	17.29 US$	19.11 US$	13.38 US$

Table 66: Prices of Imidacloprid in US from 2002-2006.

Years	2002	2003	2004	2005	2006
Prices, real prices 2010	80.98	76.60	72.79	67.72	60.65

[116] This values has been converted from Rate Rs. per kg/litres to US$ per per kg/litres. Formula applied Price x (0.015). Due to 1Rs= 0.015 US$. 66.77 RS= 1US$Source: https://www.federalreserve.gov/releases/h10/current/
[117] http://databank.worldbank.org/data/reports.aspx?source=2&series=FP.WPI.TOTL&country

Diazinon

Table 18: Prices of Diazinon in US from 2002-2008.

Years	2002	2003	2004	2005	2006	2007	2008
Prices, real prices 2010	50.84	50.80	46.22	45.53	46.52	46.95	42.88

Acetamiprid

Table 69: Demand of Acetamiprid in India period 2005-2010.

Years	2005-06	2006-07	2007-08	2008-09	2009-10
Demand (metric tonnes)	46	34	49.007	65	33.07

Alphamethrin

Table 70: Production of Alphamethrin in India period 2005-2010

Years	2005-06	2006-07	2007-08	2008-09	2009-10
Production (metric tonnes)	249	172	211	16	0

Chlropyriphos

Table 70: Market data of chlropyriphos in India

Years	2005-06	2006-07	2007-08	2008-09	2009-10
Demand (metric tonnes)	1,916.05	1,810	1,289	1,941.33	1,872
Production (metric tonnes)	4,942	4,654	4,539	3,887	2,897
Consumption of imported substance (metric tonnes)	0	4,375	1,410.072	28	1,540.9
Prices Chlorpyriphos 20% EC US$, real prices 2010	3.66 US$	2.77 US$	3.24 US$	3.84 US$	2.89 US$

Cypermethrin

Table 71: Market data of Cypermethrin in India

Years	2005-06	2006-07	2007-08	2008-09	2009-10
Demand (metric tonnes)	1,545.225	484.16	897	843.17	0
Production (metric tonnes)	4,942	4,654	4,539	3,887	2,897
Consumption (metric tonnes)	2154	856	919	907.051	2,473
Consumption of imported substance (metric tonnes)	0	4,375	1,410.072	28	1,540.9
Imports (metric tonnes)	0	0	147	32	29
Prices Cypermethrin 10% EC US$, real prices 2010	3.20 US$	3.21 US$	3.77 US$	4.48 US$	4.33 US$
Prices Cypermethrin 25% EC US$, real prices 2010	0.79 US$	4.47US$	5.35US$	5.90 US$	5.53 US$

Dicofol

Table 72: Market data on Dicofol in India

Years	2005-06	2006-07	2007-08	2008-09	2009-10
Demand (metric tonnes)	132	47.02	74.04	0	0
Production (metric tonnes)	37	51	88	88	20
Consumption of imported substance (metric tonnes)	4	53.11	41.14	0	69

Fenitrothion

Table 73: Market data on Fenitrothion in India

Years	2005-06	2006-07	2007-08	2008-09	2009-10
Demand (metric tonnes)	154	13.026	54.02	139.16	128.01
Production (metric tonnes)	n/a	n/a	n/a	n/a	n/a
Consumption (metric tonnes)	133	129.16	119.11	121.01	132

Indoxacarb

Table 74: Market data on Indoxacarb in India

Years	2005-06	2006-07	2007-08	2008-09	2009-10
Demand (metric tonnes)	50	1.15	44.11	49.09	6.1
Prices Indoxacarb US$, real prices 2010	n/a	n/a	41.52 US$	59.30 US$	32.89 US$

Malathion

Table 75: Market data on Malathion in India

Years	2005-06	2006-07	2007-08	2008-09	2009-10
Demand (metric tonnes)	2,740	4,040	3,968	2,000	619
Consumption (metric tonnes)	1,340	1,520	1,246.1	1,258.096	1,739.39
Imports (metric tonnes)	113	114	0	n/a	40
Pricesof Malathion 5% Dust US$, real prices 2010	10.08	45.98	82.84	64.10	299
Prices of Malathion 50% EC US$, real prices 2010	2.76 US$	3.28 US$	3.36 US $	4.04 US$	10.75 US$

Bacillus thuringiensis

Table 76: Market data on Bacillus thuringiensis in India

Years	2005-06	2006-07	2007-08	2008-09	2009-10
Demand (metric tonnes)	145.11	149	227.292	228.041	136.17
Production (metric tonnes)	8,475	8,333	10,059	9,652	10,833
Consumption (metric tonnes)	0	0	0	157.06	131
Consumption of imported substance (metric tonnes)	110	169	310.09	67.2	77
Prices US$, real prices 2010	14.13 US$	13.74 US$	12.22 US$	17.25 US$	10.39 US$

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