UNEP

Effects of Trade Liberalization on Agriculture in Lebanon

With special focus on products where methyl bromide is used

UNDP

ENVIROTECH

Foreword

With the increased implementation of trade liberalization agreements throughout the world, the issue of Trade and Environment has become a growing concern for almost all countries. Developing countries in particular have to realize that trade promotion and environmental protection are both essential pillars of sustainable development. Various policies and measures to reduce the negative impact on the environment have materialized or are in the process of being developed in Lebanon. Among these policies is the implementation of a project related to the elimination of the use of methyl bromide that constitutes the umbrella under which this study lies.

In this context the agricultural sector in Lebanon is facing many challenges in light of agreements to liberalize trade. Currently, Lebanese agricultural practices, and more specifically the use of methyl bromide in crop production, impact heavily on the environment. The greatest culprit in that respect seems to be the misuse and overuse of chemicals (as pesticides). Besides the adverse impact on the environment, excess use of pesticides and continuous use of methyl bromide raises market access issues as they represent major technical barriers to Lebanese agricultural exports.

Methyl bromide is used as a soil fumigant to control a wide range of pests in high value horticultural crops. Nevertheless, this chemical is known to have a considerable damaging effect on the ozone layer as well as human and animal health. For these reasons, governments throughout the world, under the umbrella of the Montreal Protocol, have recognized the need to reduce and subsequently eliminate the use of this substance. Lebanon has until the year 2015 to completely phase out the use of methyl bromide. However, the Lebanon's Ministry of Environment has decided to achieve early the phase-out by the year 2007. Several steps have been taken to help in the phase-out.

This study analyses the inextricable links between trade and environment for products where methyl bromide is used. The report is divided into nine chapters. Chapters 1-4 present an overview of the importance of agriculture and the environmental impact of the use of methyl bromide and its alternative to determine which one will have the least impact on the environment, once trade liberalization takes place. This, in turn, should potentially lead to an increase in production and trade. Chapters 5 and 6 include an annual profitability analysis to determine which alternative is the most profitable for each crop. It also includes a cost-benefit analysis (CBA) over a 20-year projection period to determine the profitability of investing in crops, where methyl bromide is presently being used. Chapter 7 focuses on the potential impacts of trade liberalization on the environment and natural resources, the socio-economic level and market access, both with and without the use of methyl bromide. The findings and recommendations provided in chapters 8 and 9 will contribute to the improvement of the agriculture sector in terms of environmental protection and market access.

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United Nations Environment Programme

The United Nations Environment Programme (UNEP) is the overall coordinating environmental organization of the United Nations system. Its mission is to provide leadership and encourage partnerships in caring for the environment by inspiring, informing and enabling nations and people to improve their quality of life without compromising that of future generations. In accordance with its mandate, UNEP works to observe, monitor and assess the state of the global environment, improve the scientific understanding of how environmental change occurs, and in turn, how such change can be managed by action-oriented national policies and international agreements. UNEP's capacity-building work thus centres on helping countries strengthen environmental management in diverse areas that include freshwater and land resource management, the conservation and sustainable use of biodiversity, marine and coastal ecosystem management, and cleaner industrial production and eco-efficiency, among many others.

UNEP, which is headquartered in Nairobi, Kenya, marked its first 30 years of service in 2002. During this time, in partnership with a global array of collaborating organizations, UNEP has achieved major advances in the development of international environmental policy and law, environmental monitoring and assessment, and the understanding of the science of global change. This work also supports the successful development and implementation of the world's major environmental conventions. In parallel, UNEP administers several multilateral environmental agreements (MEAs) including the Vienna Convention's Montreal Protocol on Substances that Deplete the Ozone Layer, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (SBC), the Convention on Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (Rotterdam Convention, PIC) and the Cartagena Protocol on Biosafety to the Convention on Biological Diversity as well as the Stockholm Convention on Persistent Organic Pollutants (POPs).

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The Economics and Trade Branch (ETB) is one of the five branches of DTIE. Its mission is to enhance the capacities of countries, especially of developing countries and countries with economies in transition, to integrate environmental considerations into development planning and macroeconomic policies, including trade policies. ETB helps countries to develop and use integrated assessment and incentive tools for sustainable development and poverty reduction. The Branch further works to improve the understanding of environmental, social and economic impacts of trade liberalization and the trade impacts of environmental policies, and to strengthen coherence between Multilateral Environmental Agreements and the World Trade Organization. Through its finance initiative, ETB helps enhance the role of the financial sector in moving towards sustainability.

In the field of environmental economics, ETB aims to promote the internalisation of environmental costs and enhance the use of economic instruments to contribute to sustainable development and poverty reduction, including in the specific context of Multilateral Environmental Agreements.

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Executive summary

The expansion of trade liberalization throughout the world has increased concern in terms of the links between trade and the environment in almost all countries, including developing ones. Indeed, trade liberalization can have positive and negative environmental and socio-economic effects depending on the policies adopted. On the one hand trade can promote the efficient allocation of natural resources, expand production and create new employment opportunities, thus improving people's economic status and raising the standard of living. However, growth in production can also result in over-exploitation of resources and increased waste emissions, aggravating environmental degradation and resource depletion.

Trade liberalization can also lead to aggressive competition within the local market due to the influx of competitive products from other countries, although this may be limited once the high subsidies (e.g. those currently applied in European countries) are reduced or even eliminated with further trade liberalization. It is also believed that, as long as production abides by environmental regulations and international standards, Lebanese products could enjoy a comparative advantage on international markets in which they can benefit from higher prices than on the domestic market.

Succeeding in multilateral trading requires competitiveness and productivity, but these often come at the expense of the environment and sustainable development. Conversely, greater environmental awareness throughout the world has resulted in an increase in demand for environmentally friendly products that command higher prices.

This study is an integrated assessment of the effects of trade liberalization on the Lebanese agricultural sector with special focus on products where methyl bromide is used. The Lebanese Ministry of Environment (MOE) prepared the study whilst Envirotech Ltd conducted the project based on the recommendations of the "Promoting and Monitoring Synergy between Trade and Environment in Lebanon" project funded by UNEP, managed by the United Nations Development Programme (UNDP) and executed by the Lebanese MOE.

Agriculture plays a significant role in Lebanon's national economy, contributing 12 per cent of the gross domestic product (GDP) and employing 9 per cent of the total workforce. Agricultural land covers nearly one quarter of the country's total surface and agricultural products provide a considerable proportion of the raw materials for the industrial sector. As in most developing countries, rural areas depend to a large extent on agriculture. Yet, Lebanon's agricultural deficit is widening and its food dependence is increasing, thereby threatening national food security.

An integrated assessment of trade and trade liberalization policies should help develop policies to mitigate the negative environmental, social and economic impacts of trade liberalization and promote the positive ones. It is expected that increased exports will bring in more foreign currency and trigger more efficient production methods to narrow or even eliminate the agricultural deficit. Furthermore, promoting and strengthening the agricultural sector will contribute to alleviating rural-urban migration, a major socio-economic and environmental problem.

In Lebanon, several bilateral and multilateral trade agreements have been or are being implemented in the context of trade liberalization. Lebanon is on the point of joining the World Trade Organization (WTO) and has signed the Association Agreement with the European Union (EU). However, in 2004, 189 countries had acceded or ratified the Montreal Protocol on Substances that Delete the Ozone Layer. These countries will not be allowed to import products on which ozone depleting substances (ODS) such as methyl bromide have been used. It has thus become vital to recognise the implications of environmental matters on trade. To that effect, the Lebanese Government has made environmental concerns a priority and various polices have been and are still being developed. One of these policies includes eliminating the use of methyl bromide in Lebanon.

The main objective of this study is to determine the impacts of environmental measures taken in Lebanon regarding the use of methyl bromide on Lebanese trade of greenhouse agricultural products as well as the impact of these crops on the environment once the use of methyl bromide has been phased out.

Methyl bromide is a fumigant used to control a wide range of pests in high value horticultural crops and commodities. In Lebanon it is used in soil fumigation, mostly in greenhouses. Yet methyl bromide is known to be one of the most dangerous chemicals in the world because of its considerable damaging effect on the ozone layer and on human and animal health. A phase-out schedule to eliminate its use has been established. Lebanon has until 2015 to completely phase out the use of methyl bromide and several projects have been initiated to test economically and environmentally feasible methyl bromide alternatives.

Both chemical and non-chemical alternatives were tested. Non-chemical alternatives include biological and physical alternatives. Chemical alternatives are categorised according to systemic, non-systemic, and acting by vapour (fumigants). Systemic and non-systemic alternatives do not have a broad-spectrum activity and thus only control specific target pests. The fumigants have a broader spectrum of soil-pest control and usually interact with soil humidity to release noxious gases that diffuse in the soil. Non-chemical alternatives are defined as either biological or physical. Biological alternatives are mainly composed of micro-organisms or plants that are applied using specific techniques (bio-fumigation, enzymes) whereas physical alternatives are related to the physical characteristics of the plants themselves (grafting) or other physical characteristics (solar energy, steam).

Decisions on the appropriate alternatives were made according to the major soil borne diseases prevailing in each site. In all cases the alternatives were selected based on their efficiency, low-cost and environment and public health friendliness. In some cases combinations of chemical and non-chemical alternatives were tested. Training sessions for local farmers were organised throughout the project to establish contact between the farmers and the project and to show farmers the proper techniques for each alternative. More than 250 principal farmers from different areas participated in the training sessions.

Other significant criteria taken into consideration are the relative use of water resources, waste generation, potential for recycling, additional employment opportunities, and the waiting period between application of the alternative and agricultural operations since this influences the length of the planting season and the period at which the farmer's produce will be brought to market (low or high season).

Results show that some alternatives seemed to be less effective than methyl bromide, whilst others were more effective. Not all alternatives were applied to all the considered crops (tomato, cucumber, strawberry and eggplant), which limits the effectiveness of the comparison among alternatives. Not surprisingly, the chemical alternatives represent the greatest potential for adverse environmental impacts. On the whole, however, the project results indicated, "as far as soil fumigation is concerned, methyl bromide can totally and successfully be replaced by a multitude of available alternatives, which in some cases provide an even better control of pests and result in higher yields".

The results of the feasibility assessment indicate that most of the alternatives are financially feasible, although several of the alternatives resulted in lower yields and lower annual net revenues than methyl bromide. The financial cost-benefit analysis (CBA) indicated that most of the alternatives tested on cucumbers, strawberries and tomatoes were financially infeasible when considered in relation to the average market prices for 2000 and 2001. However, most of these alternatives become feasible when the crops benefit from premium prices as eco-labelled products.

As a result of the success and outcomes of the project, Lebanese stakeholders and farmers expressed their readiness to completely phase out methyl bromide from the vegetable and strawberry sectors, even prior to the deadline set by the Montreal Protocol for developing countries.

To ensure the efficiency and sustainability of the phase-out, the study recommends that a national policy and action plan be put in place to organise and regulate the process and provide appropriate strategies for the phase-out reflecting the agricultural, economical and social characteristics of Lebanon. It is suggested to establish a framework for the reduction and phase-out of methyl bromide by monitoring and controlling procedures for methyl bromide imports, adopting early phase-out steps, and preventing new uses of methyl bromide. The action plan could be complemented with effective legislation and regulations to control the use of methyl bromide and its alternatives.

The phase-out is expected to last ten years, starting in 2002, and is divided into two five-year phases. The first phase will focus on training farmers and expanding the use of methyl bromide alternatives, identifying stakeholders and establishing stakeholder networks, exploring potential export markets and identifying the most desirable crops for export. During this phase farmers will benefit from funding from the Montreal Protocol Multilateral Fund (MLF) in the form of inputs and supplies. During the second phase farmers will no longer receive direct financial assistance but they will benefit from an advantage in exports to European countries. By the end of the second phase in 2012, Lebanese farmers should be ready to compete in free-trade markets.

It should be remembered, however, that methyl bromide is only one of numerous chemicals used in agricultural production in Lebanon, so although banning the use of methyl bromide will have positive health and environmental impacts, the effects will be limited if other chemicals continue to be used in an uncontrolled manner, not only in terms of the environment but also in relation to the impact on exports since chemical residues constitute a significant phytosanitary barrier to trade for agricultural products, especially those destined to the EU. Thus, in addition to recommending carrying out experiments on methyl bromide alternatives on a wider range of crops, the study recommends conducting studies on other pesticides used in crop production in Lebanon.

The study is organised as follows. Chapter 1 provides a general introduction to the project, explains the importance of the agricultural sector in Lebanon, and lists the study's objectives. Chapter 2 gives general information on methyl bromide and its effects on the environment and human health. Chapter 3 describes the environmental issues related to the use of methyl bromide and the major projects aimed at eliminating its use in Lebanon. The alternatives to methyl bromide are described in detail in Chapter 4, including application methods and effects on the environment and human health. Chapter 5 includes an environmental impact assessment (EIA) for methyl bromide and each alternative used in Lebanon. Chapter 6 analyses the feasibility of each alternative based on the annual net profit and a CBA. The environmental and socio-economic impacts of eliminating the use of methyl bromide on Lebanese imports and exports are assessed in Chapter 7. Finally, Chapter 8 suggests policies for phasing out methyl bromide and Chapter 9 summarizes the study's main conclusions and makes some recommendations, including on some future areas of study.

Abbreviations and acronyms

AVC	Average variable cost
BCR	Benefit to cost ratio
BEP	Break-even price
BEY	Break-even yield
CBA	Cost-benefit analysis
CFC	Chlorofluorocarbons
CH_3Br	Methyl bromide
dn	dunum (unit of area measurement equivalent to almost 1,000m^2)
EIA	Environmental impact assessment
EPA	Environmental Protection Agency
ERS	Economic Research Service
ETB	Economics and Trade Branch (UNEP)
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross domestic product
IDAL	Investment Development Authority of Lebanon
IPM	Integrated pest management
IRI	Industrial Research Institute
IRR	Internal rate of return
LARI	Lebanese Agricultural Research Institute
LBP	Lebanese Pound
LD	Lethal Dose
LIBNOR	Lebanese Standards Institution
MBTOC	UNEP Methyl Bromide Technical Options Committee
MITC	Methyl iso-thiocyanate
MLF	Multilateral Fund for the Implementation of the Montreal Protocol
MOA	Ministry of Agriculture
MOE	Ministry of Environment
MRL	Maximum residue limit
NGO	Non-governmental organization
NPV	Net present value
NR	Net revenue
ODP	Ozone depleting potential
ODS	Ozone depleting substance

PA	Phosphoric acid
PP	Polypropylene
ppm	Parts per million
QPS	Quarantine and pre-shipment (Montreal Protocol)
SPS	Sanitary and Phytosanitary
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
USDA	United States Department of Agriculture
UV	Ultraviolet
WTO	World Trade Organization

1. Introduction

1.1 General project context

With the increased implementation of trade liberalization agreements throughout the world, the issue of trade and the environment has become a growing concern for almost all countries including developing ones. As trade liberalization policies are adopted, rapid industrial development and growth may occur and trade in environmentally beneficial goods or methods of production may be either promoted or deterred. Moreover, trade regulations are clashing with environmental standards, and increased trade in natural resource-based sectors is placing increasing pressures on the world's ecosystems and causing serious environmental degradation. Hence, it became necessary to implement complementary environmental policies to reduce these pressures (UNEP, 2001).

In Lebanon, and within the context of trade liberalization, several bilateral and multilateral trade agreements, particularly on agriculture, have already been implemented and others are on the way. Lebanon is on the point of joining the WTO and has already signed the Association Agreement with the EU. It has thus become vital to recognize the repercussions of trade liberalization on the environment and the effects of environmental protection measures on trade. Hence, the Lebanese Government has made environmental concerns a priority and various policies to reduce the negative impact on the environment (from trade or other practices) have been developed or are in the process of being developed.

One of these policies includes a project to eliminate the use of methyl bromide in Lebanon and constitutes the umbrella under which this particular study lies. It should be noted that the ultimate requirements to succeed in the multilateral trading system are competitiveness and productivity. However, occasionally these come at the direct expense of the environment and sustainable development. An integrated assessment of trade and trade liberalization policies based on priorities and needs should help the country to identify negative environmental, social and economic impacts of trade liberalization and to develop policies to mitigate the negative effects of trade liberalization. In addition, as a result of greater environmental awareness world-wide there is a marked increase in demand for environmentally sound products.

This study was prepared by the MOE under the direct supervision and guidance of the Directorate General of the MOE. The project's executive group was composed of Dr. Naji Chamieh, General Manager, Envirotech; Dr. Ragy Darwish, Senior Agricultural Economist; Dr. John Davey, Senior Environmentalist; Mr. Edgard Chehab, Environment Specialist; Ms. Carla Moukarzel, Agricultural Economist; Mr. Nabil Chemaly, Agricultural Economist; Mr. Garo Haroutunian, Project Manager UNDP-Methyl Bromide Alternatives Project; Mrs. Ariane Saade, Project Manager Trade and Environment Project; and Ms. Rola Sheikh, MOE Environmental Management Specialist, Trade and Environment Focal Point.

The project was conducted by Envirotech Ltd based on the recommendations of the "Promoting and Monitoring Synergy between Trade and Environment in Lebanon" project funded by UNEP. Accordingly this study constitutes a main part of the "Trade and Environment" theme developed by the Lebanese MOE.

1.2 Importance of the agricultural sector in Lebanon

1.2.1 Economic importance

Agriculture plays a significant role in Lebanon's national economy, since agricultural products provide a good deal of the raw materials for the industrial sector. Agricultural land covers nearly a quarter of the total surface area of Lebanon. Agriculture contributes about 12 per cent of the GDP and employs 9 per cent of the total workforce. Hence, developing the agricultural sector will not only benefit the rural population, it will also promote Lebanon's overall economic status

Despite the importance of the agricultural sector, Lebanon has a widening agricultural deficit and growing food dependence. Increased exports should bring in foreign currency and may also trigger more efficient production methods, thus narrowing the agricultural deficit or even eliminating it.

1.2.2 Food security

In addition to its economic importance, agriculture plays a considerable role in the food security of any country. According to the agro-biodiversity study carried out by the Lebanese Ministry of Agriculture (MOA), Lebanon is self-sufficient in poultry production, but only produces about 15 per cent of its wheat consumption, 45 per cent of its legumes and 10 per cent of its sugar needs. Moreover, Lebanon imports 78 per cent of its dairy and meat products. Alternatively, it exports fruits and vegetables including apples, potatoes, citrus fruits, tomatoes and other fruits and vegetables.

"Per capita cereal production" statistics can provide a rough indication of whether a country is able to feed its population. Lebanon has a low rate of average per capita cereal production with only 24 metric tons per 1,000 people (1986-1988) and 30 (1996-1998), compared to 310 and 349 metric tons per 1,000 people in Syria (1986-1988 and 1996-1998 respectively). In addition, the net cereal imports and food aid represent 90 per cent of the total cereal consumption in Lebanon (1995-1997). These figures indicate that the country is far from being self-sufficient in grain production and has to depend on imports.

1.2.3 Regional rural development

As in most developing countries, rural areas in Lebanon depend to a large extent on agriculture. In Lebanon, the Bekaa region has the largest area allocated for agriculture in terms of hectares. In reference to the national Human Development Report of Lebanon, human development differs substantially between Beirut and Mount Lebanon on the one hand and North Lebanon, Nabatieh, the Bekaa and South Lebanon on the other. The Bekaa, the North and the South are the regions most involved in agriculture production.

The Mapping of Living Conditions study, conducted by the Ministry of Social Affairs and the UNDP in 1998 ranked the mohafaza in terms of percentage of households living below the threshold of basic need satisfaction. The mohafaza of Nabatieh demonstrated the highest percentage of households below this threshold, followed by the north with 44 per cent, the Bekaa with 41 per cent and south Lebanon with 37 per cent, while the national average was 32 per cent. Accordingly, in relation to income inequality, the Gini index rates 0.437 in 1997, which is rather high (UNDP, 2002).

In terms of sustainable development, by helping attenuate the problems faced by the agricultural sector, the Government would be directly and indirectly contributing to improving the living conditions of rural citizens and reducing the imbalances that exist between cities and rural areas. This support should include

Table 1.1: Lebanon regional human development index, 1996-1997

Indicator	Beirut	Mount Lebanon	North Lebanon	South Lebanon	Nabatieh	Bekaa	Lebanon
Life Expectancy Index	0.825	0.808	0.725	0.802	0.760	0.742	0.772
Education Index	0.847	0.822	0.712	0.767	0.734	0.750	0.801
GDP Index	0.609	0.595	0.482	0.483	0.498	0.502	0.502
Regional Index	**0.706**	**0.742**	**0.640**	**0.684**	**0.664**	**0.665**	**0.705**

Source: UNDP, 2002

Table 1.2: Lebanon regional human poverty index, 1996

Beirut	Mount Lebanon	North Lebanon	South Lebanon	Nabatieh	Bekaa	Lebanon
6.3	7.0	14.3	10.4	12.8	11.6	9.7

Source: UNDP, 2002

improving marketing and distribution schemes, intensifying promotion, finding new markets, enhancing research, imposing pest and disease control, improving training and extension services, providing inspection services and boosting infrastructure services related mainly to electricity and water supply.

In turn, promoting and strengthening the agricultural sector in Lebanon will contribute to alleviating a major socio-economic and environmental problem, namely rural migration that results in heavy concentrations in Beirut and its suburbs, which is unsustainable in terms of development and the environment.

1.3 Methyl bromide in the Lebanese agricultural sector

Methyl bromide is a fumigant that controls a wide range of pests in high value horticultural crops and commodities (Methyl Bromide Alternatives Project – Lebanon, 2001). In Lebanon, methyl bromide is only used in soil fumigation, mostly in greenhouses. However, this chemical is known to be one of the most dangerous chemicals in the world because of its considerable damaging effect on the ozone layer as well as on human and animal health.

Governments throughout the world recognized the need to reduce or even eliminate the use of methyl bromide mainly because it is an ODS. Hence, a phase-out schedule of methyl bromide was developed. Lebanon has until 2015 to completely phase out methyl bromide. To achieve this, a series of projects were initiated to replace methyl bromide with economically and environmentally feasible alternatives. These projects, which will be described in more detail later on in this report, are the "Methyl Bromide Alternatives Demonstration Project of Lebanon", the "Methyl Bromide Phase-out Project" (Investment Project), and the United Nations Industrial Development Organization (UNIDO) Project on Strawberries.

The demonstration project was on the vegetable and strawberry sectors and was managed by UNDP. It was followed by two parallel investment projects, one managed by UNDP and relating to the vegetable, cut flower and tobacco sectors, and another managed by UNIDO relating to the strawberry sector. Both projects will completely phase out the use of methyl bromide in all sectors in Lebanon by 2007.

1.4 Study objectives

1.4.1 General objective

The main objective of this study is to determine the impact of environmental measures taken in Lebanon regarding the use of methyl bromide on Lebanese trade of greenhouse agricultural products as well as the impact of Lebanese trade of these crops on the environment once the use of methyl bromide has been phased out.

1.4.2 Specific objectives

This study will specifically:

1. Provide information on environmental issues related to methyl bromide use in the country.
2. Provide information on the country's endogenous capacity to respond to environmental challenges.
3. Assess the positive and negative environmental impacts of trade liberalization policies and multilateral trade rules, taking into account social and economic impacts of the products where methyl bromide is used.
4. Provide an EIA for methyl bromide and the suggested alternatives.
5. Assess the impact of the elimination of methyl bromide use on exports and production.
6. Elaborate country and sector specific methodologies to assess these impacts.
7. Perform a CBA of the alternatives to methyl bromide.
8. Formulate policies and policy packages to succeed with phasing out methyl bromide, maximizing the positive effects and minimizing the negative ones.
9. Perform a CBA of the study's recommended policy package including an estimate of the market access competitiveness costs and estimate of the costs of implementing the policy package.
10. Draw up an action plan for implementation.

1.4.3 Activities and deliverables

This comprehensive report consists of nine chapters including this one. Chapter 2 provides information on methyl bromide in general, and its effects on the environment and on human health. It also describes the regulation on the consumption of methyl bromide under the Montreal Protocol, and includes a brief description on the major alternatives to methyl bromide. Chapter 3 includes a description of the environmental issues related to the use of methyl bromide in Lebanon and the major projects that are being conducted with the aim of eliminating its use. This chapter specifically describes the "UNDP Methyl Bromide Project (Demonstration and Investment Phases) and the UNIDO Project on Strawberries. Chapter 4 includes a detailed description of each methyl bromide alternative used in Lebanon in terms of the application method and effects on the environment and human health. Chapter 5 presents an EIA for methyl bromide and each of its alternatives used in Lebanon. Chapter 6 then goes on to analyse the feasibility of methyl bromide and its alternatives in Lebanon. The chapter is divided into two main parts: feasibility based on the annual net profit and a CBA. Chapter 7 assesses the impact of methyl bromide elimination and trade liberalization on the environmental and socio-economic levels as well as on the import and export of Lebanese products. Finally, Chapter 8 provides a two-phase policy for a successful phasing out of methyl bromide in Lebanon, while Chapter 9 summarizes the main study conclusions and provides some recommendations for future areas of study.

2. Information on issues related to methyl bromide

2.1 Description of methyl bromide

Methyl bromide (CH_3Br) is a fumigant used to control arthropods, nematodes, pathogens and weed seeds in several high value crops, such as tomatoes, peppers, eggplants, tobacco, strawberries, ornamentals, etc. Methyl bromide also has a variety of other applications; it is used in the treatment of durable commodities (such as grains and wood products), perishable commodities (such as quarantine shipments of fresh fruits and vegetables), and in the fumigation of structures and buildings (Lebanese Ministry of Environment and UNDP, 2001).

At normal temperatures and pressures, methyl bromide is a colourless and odourless gas, but it can be handled as a liquid under moderate pressure. It is a powerful chemical that depletes the Earth's ozone layer. Its ozone depleting potential (ODP) is 0.4, i.e. higher than the admissible threshold of 0.2 (FAO and UNEP, 2001). According to the U.S. Environmental Protection Agency (EPA), about 50 to 95 per cent of the methyl bromide injected in the soil can eventually enter the atmosphere (U.S. Environmental Protection Agency, 2001).

When used as a soil fumigant, methyl bromide gas is usually injected into the soil at a depth of 30 to 60 centimetres before crop planting or transplanting. This will effectively sterilize the soil, killing a vast majority of soil organisms. Immediately after methyl bromide is injected, the soil is covered with plastic sheets that slow the movement of methyl bromide from the soil to the atmosphere. However, methyl bromide is emitted into the atmosphere at the end of the fumigation when the sheets are removed. The duration for which the sheets are kept on varies with cultural practices from one area to another. In strawberry production in California for example, the sheets are removed 24 to 72 hours after fumigation of the field. However, in tomato production in Florida, the sheets are sometimes left on for the entire growing season (the case of row fumigation).

In the United States, strawberries (18 per cent of the country's total agricultural production) and tomatoes (23 per cent of the country's total agricultural production) are the crops for which most methyl bromide is used, i.e. about 7,000 tons annually (U.S. Environmental Protection Agency, 2001).

2.2 Effects of methyl bromide on human health

Methyl bromide is considered an extremely toxic substance (Extension Toxicology Network, 1993a). It will not only affect the target pests against which it is used, but non-target organisms as well. Because methyl bromide dissipates rapidly into the atmosphere, it is most dangerous at the actual fumigation site. The lowest inhalation level found to cause toxicity in humans is 35 parts per million (ppm) in the air (Extension Toxicology Network, 1993a). Human exposure to high concentrations of methyl bromide can result in central nervous system and respiratory system failure, as well as specific and severe deleterious actions on the lungs, eyes and skin. Common initial symptoms include weakness, despondency, headache, visual disturbances, nausea and vomiting. Later, problems relating to the central nervous system emerge, including numbness, defective muscular coordination, tremors, muscle spasms, lack of balance, extreme agitation, coma and convulsions. Inhaling large doses of methyl bromide may result in serious permanent disabilities or even death (U.S. Environmental Protection Agency, 2001). A dose of 1,600 ppm for 10 to 20 hours, or 7,900 ppm for 1.5 hours is lethal to humans (Extension Toxicology Network, 1993a). In 1993, about 1,000 human poisoning incidents caused by methyl bromide exposure were documented in the United States, with effects ranging from skin and eye irritation to death. Most fatalities and injuries occurred when methyl bromide was used as a fumigant.

2.3 Methyl bromide residues in food

Agricultural crops that are consumed usually do not contain any detectable residues of methyl bromide since these residues (inorganic bromides) are known to accumulate primarily in leaves and stalks, rather than roots or fruits. Bromine uptake by plants mainly depends on soil texture, soil organic matter content, temperature, the amount of leaching that has occurred, and plant species. Food tolerances for methyl bromide residues have been established in a wide variety of agricultural commodities, ranging from 25 to 300 ppm, with the majority at 60 ppm or less. Dietary consumption of bromine residues is not well understood so a maximum average daily intake (ADI) of 1 mg bromine per kg of body weight for humans has been established.

2.4 Effects of methyl bromide on the environment

The main environmental impact of methyl bromide is on the ozone layer. The ozone layer forms a thin shield in the upper atmosphere, protecting life on earth from harmful ultraviolet (UV) radiation emitted by the sun. Depletion of the ozone layer results in increased UV radiations reaching the earth's surface. Over exposure to these radiations causes health problems such as skin cancer, eye cataracts and suppression of the immune system (U.S. Environmental Protection Agency, 1999).

Methyl bromide was added to the official list of ODSs in 1992 (UNEP, 2000). According to UNEP, methyl bromide's environmental impact can be explained by the following mechanism: "the bromine atom from methyl bromide acts quickly in the stratosphere to break down 60 times as much ozone as a chlorine atom from chlorofluorocarbon (CFC) emissions. Methyl bromide released from human activities is responsible for 5-10 per cent of the total ozone depletion in the earth's stratosphere".

Despite universal agreement on methyl bromide's ozone depleting effect, some contradicting or controversial views do exist. Dr. Fred Singer, an atmospheric physicist and emeritus professor of environmental sciences at the University of Virginia, claims that about two-thirds of the methyl bromide present in the atmosphere is of natural origin and no increasing trend of the bromine ion in the stratosphere had been observed so far, indicating that methyl bromide in the atmosphere is not influenced by human activities (Singer, 1997).

Other than being an ODS, methyl bromide is moderately toxic to aquatic organisms. Acute toxicity may occur at concentrations of 11 ppm for some freshwater fish and about 12 ppm for brackish water fish. However, when applied properly, methyl bromide is not expected to enter surface waters via run-off or erosion, and thus poses little risk to aquatic species. It is not highly toxic to most plants.

The amount of bromide ion (the metabolite of methyl bromide) in residues is proportional to the protein content of the crop. Higher levels of bromide ion will most likely be found in high-protein plants. When used as a soil fumigant, only a small amount of methyl bromide is transformed into the bromide ion while much of the gas enters the atmosphere. Transformation of methyl bromide into bromide ions increases as the amount of organic matter in the soil increases. The rate of degradation in fumigated soil is 6-14 per cent per day at 20° C. More leaching occurs in sandy than in loamy soil.

Methyl bromide run-off from fields into water surfaces is rare due to the way this chemical is normally applied. Calculations have shown the average half-life for methyl bromide under field conditions to be 6.6 hours at 11° C when it comes into contact with water. Another study showed the half-life in water to be 20 days at 25° C in a neutral solution.

Finally, some methyl bromide is vaporized during chemical manufacturing and processing operations. It can also originate from car exhaust fumes when used as gas additive (Extension Toxicology Network, 1993a).

2.5 The Montreal Protocol

The Montreal Protocol on Substances that Deplete the Ozone Layer is an international agreement designed to protect the Earth's stratospheric ozone layer by controlling the production and consumption of ODSs, including chlorofluorocarbons (CFCs), halons and other human-made chemicals. The Protocol was adopted on 16 September 1987 and came into force on 1 January 1989. As of July 2004, 189 countries have acceded or ratified the treaty (UNEP Ozone Secretariat).

The Protocol provides separate phase-out schedules for developed and developing countries. Developing countries with an annual calculated level of consumption of Annex A CFCs of less than 0.3 kg per capita (countries operating under Article 5 of the Protocol) are permitted a ten-year grace period compared to the phase-out schedule for developed countries (countries that do not operate under Article 5). Lebanon operates under Article 5 of the Protocol.

The Protocol was designed so that the phase-out schedules could be revised on the basis of periodic scientific and technological assessments. Following such assessments, the Protocol was adjusted to accelerate the phase-out schedules. It has also been amended to introduce other kinds of control measures and to add new controlled substances to the list. The Copenhagen Amendment adopted in 1992 at the Fourth Meeting of the Parties introduced control measures for both production and consumption of methyl bromide (Annex E, Group I). The Copenhagen Amendment entered into force on 14 June 1994.

The Multilateral Fund for the Implementation of the Montreal Protocol (MLF) provides funds to help developing countries (Article 5 countries) comply with their obligations under the Protocol to phase out their production and consumption of ODSs, including methyl bromide, at an agreed schedule. Financial

Table 2.1: Montreal Protocol control schedule for methyl bromide

Applicable to production and consumption. Amounts for quarantine and pre-shipment (QPS) applications exempted.

Developed countries	Developing countries
Baseline level: 1991	Baseline level: Average of 1995-1998
25 per cent reduction by 1 January 1999	Freeze of consumption by 21 January 2002
50 per cent reduction by 1 January 2001	
70 per cent reduction by 1 January 2003	20 per cent reduction by 1 January 2005
Complete phase-out by 1 January 2005 (with possible critical use exemptions)	Complete phase-out by 1 January 2015 (with possible critical use exemptions)

Source: UNEP DTIE OzonAction Programme.

and technical assistance is provided in the form of grants or concession loans and is delivered primarily through four implementing agencies: UNEP, UNDP, UNIDO, and the World Bank.

Under the MLF, ratification of the Copenhagen Amendment is a pre-requisite for eligibility for developing country Parties to the Montreal Protocol for methyl bromide investment projects. Lebanon has ratified this Amendment.

As of July 2004, the Fund has approved more than 264 methyl bromide projects for developing countries at a total value of about US$ 79 million. One hundred of these projects are phase-out projects and the others are for technical assistance, demonstration projects, preparing projects, training and awareness-raising. Once completed, these current phase-out projects and technical assistance projects will result in the elimination of 3,889 ODP tons of methyl bromide consumption. Once implemented, the existing and anticipated projects under the MLF will phase out about 10,000 tons of methyl bromide before 2007, eliminating more than 50 per cent of the peak consumption in developing country regions (UNEP, 2002). The MLF has approved seven phase-out projects and three preparation projects for Lebanon as of July 2004.

2.6 World consumption of methyl bromide

The UNEP Methyl Bromide Technical Options Committee (MBTOC) estimates that global consumption of methyl bromide for controlled uses was about 64,550 tons in 1991 and remained above 60-63,000 tons until 1998. On the basis of available national (Article 7) data available in October 2002, global consumption was estimated to have been at least 60,200 tons in 1998, 49,170 tons in 1999 and 45,360 tons in 2000 (UNEP, 2002a).

Controlled methyl bromide consumption in developing countries rose from about 8,460 tons in 1991 to about 17,600 tons in 1998, representing an increase of about 15 per cent per year on average. However, based on data available to date, developing country consumption was reduced to about 16,440 tons in 2000, indicating an annual average reduction of about 3 per cent per year between 1998 and 2000 (UNEP, 2002a). The 15 largest consumers of methyl bromide are indicated in Table 2.2.

While certain developing countries continue to increase consumption, national consumption was reduced by more than 20 per cent in some developing countries in the period 1998-2000 (UNEP, 2002a).

Table 2.2: Largest consumers of methyl bromide

	1991 (ODP tons)	**1998** (ODP tons)	**2002** (ODP tons)	**Base** (ODP tons)
China	76.2	1960.2	1087.8	1102.1
Mexico	237.9	1207.5	1067.5	1130.8
Guatemala	0.0	579.5	709.4	400.7
South Africa	759.0	604.0	593.8	602.7
Thailand	424.8	52.9	470.5	164.9
Honduras	0.0	269.1	412.5	259.4
Morocco	132.6	960.0	387.0	697.2
Turkey	296.4	415.2	280.8	479.7
Costa Rica	276.0	436.7	280.0	342.5
Egypt	55.2	240.0	270.0	238.1
Brazil	564.3	578.3	238.5	711.6
Zimbabwe	390.0	819.0	202.3	557.0
Lebanon	0.0	110.9	197.3	236.4
Argentina	14.8	504.6	168.6	411.3
Chile	153.8	298.1	165.2	212.5

15 Largest Consumers (Article 5 countries) in 2002 – Methyl Bromide (Article 7 data, Ozone Secretariat, August 2004)
ODP ton: For methyl bromide the ODP is 0.6.

Table 2.3: Maximum level of methyl bromide consumption by crop (ODP tons)

Year	Vegetables/tobacco/cut flowers	Strawberries	Total phase-out	Consumption level
2001				236.5
Dec-2002	25.8	6	31.8	204.7
Dec-2003	36	10.1	46.1	158.6
Dec-2004	54	14.2	68.2	90.4
Dec-2005	36	11.1	47.1	43.3
Dec-2006	34.3	9	43.3	43.3
2007 (Totals)	186.1	50.4	236.5	0

A MBTOC survey of ozone offices and national experts in 2001-2002 provided information on the breakdown of methyl bromide uses in major consuming countries in 2000, a sample covering about 70 per cent of global methyl bromide use. The results of this sample indicated that approximately 74 per cent of methyl bromide use was for soil and approximately 26 per cent for commodities/structures, including QPS. The estimated proportions for major sectors were: soil 74 per cent, durable commodities 15 per cent, perishable commodities 8.5 per cent, and structures 2.5 per cent. With almost all methyl bromide use on perishables and an estimated 80 per cent on durables falling into the uncontrolled QPS category, it can be seen that soil treatments account for about 93 per cent of controlled uses (UNEP, 2002a).

Lebanon's baseline of methyl bromide (1995-1998 average) is 236.5 ODP tons. Table 2.3 shows the commitment of the Government of Lebanon towards the Montreal Protocol in achieving yearly phase-outs of the mentioned quantities. Actually, the targets set for years 2003 and 2004 have been met and exceeded.

2.7 Alternatives to methyl bromide

The MBTOC has found existing alternatives for more than 93 per cent of current methyl bromide consumption, excluding QPS. Significant efforts must now be made to transfer, register and implement these alternatives and to optimise their use (UNEP, 2002a).

The reduction in consumption of methyl bromide for soil fumigation has been the major contributor to the overall reduction in global consumption of methyl bromide as most developed countries have met or exceeded the 50 per cent reduction schedules for soil use agreed under the Montreal Protocol. The most common replacement options for methyl bromide as a pre-planting soil fumigant include alternatives that either provide a broad spectrum control of pests, diseases and weeds (e.g. chemicals and their combinations, steam and solarization) or cultural practices which avoid the need for methyl bromide (UNEP, 2002a).

Phasing out the use of methyl bromide required seeking alternatives, particularly for agriculture. Hence, during the last five years, several projects and activities have been carried out in various countries to study the effect of suggested soil fumigant alternatives. Both chemical and non-chemical alternatives were proposed as a replacement for methyl bromide. These required an initial investment in training, technical advice and materials, or capital equipment. The work conducted was mainly in the form of applied field research for the development of new alternatives and the demonstration of highly effective alternatives in different areas.

Results concerning these alternatives are in some cases inconclusive. Some alternatives seemed to be less effective than methyl bromide, whilst others were more effective. Researchers from the U.S. Economic Research Service (ERS) expect currently available alternatives to be less effective than methyl bromide, such as lower yields for tomatoes, strawberries, eggplants, peppers and cucumbers. Over time, increasing infestations of pests currently controlled by methyl bromide could lead to larger yield losses. Hence, according to the ERS and based on current knowledge on methyl bromide alternatives, the planned phase-out will cause substantial short-term losses. It is estimated that the net annual loss from banning methyl bromide for pre-plant fumigation on selected crops would be about US$ 200-400 million per year (Economic Research Service/USDA, 1999). However, according to UNEP, many alternatives provide the necessary level of pest control, and some provide more effective control than methyl bromide. Most of these alternatives have the advantage of providing continuous and on-going management of pests, thus preventing them from building up to damaging levels (UNEP, 2000).

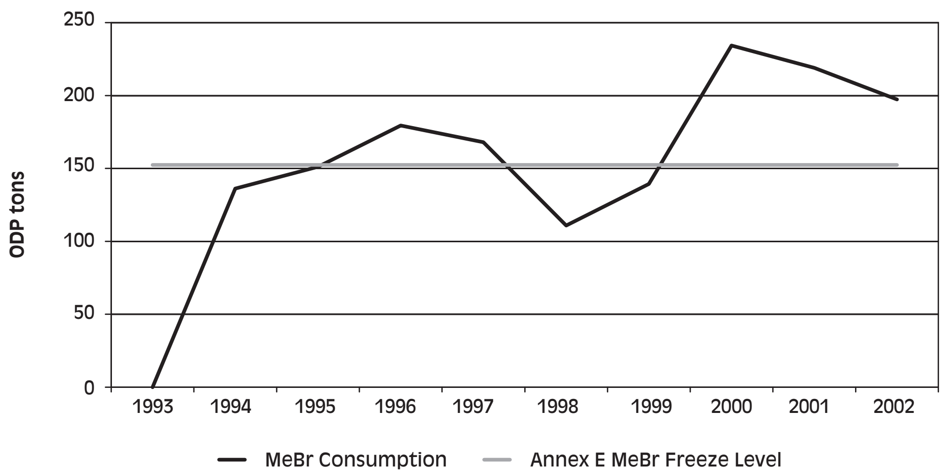
2.8 Environmental issues related to methyl bromide in Lebanon

2.8.1 Methyl bromide consumption in Lebanon

In Lebanon, methyl bromide is strictly used in soil fumigation inside greenhouses to protect crops from soil-born pathogens such as nematodes, fungi (Fusarium sp., Verticillium sp., Phytophtora sp., etc.), and bacteria (Pseudomonas sp.)

Figure 2.1 shows the trend in methyl bromide consumption in Lebanon from 1995 until 2002.

Figure 2.1: Methyl bromide consumption trends in Lebanon



Source: UNEP DTIE OzonAction Programme

2.8.2 Methyl bromide imports in Lebanon

Only four agricultural companies in Lebanon are involved in the import of methyl bromide: Debbaneh, Robinson, the Agricultural Materials Company, and Agri-Italia Services.

Lebanese methyl bromide imports are subject to prior approval of the Lebanese Ministry of Agriculture (MOA). The Ministry issues licenses to the previously mentioned companies depending on the quantity of chemical needed. The General Directorate of the Lebanese Customs supervises methyl bromide imports. Generally, methyl bromide is imported in Lebanon from France (Mebrom, Sobrom) and other European countries. Only few companies import it from American sources.

3. Methyl bromide phase-out projects in Lebanon

3.1 Introduction

In view of the growing environmental challenges that Lebanon is currently facing, concerns have emerged regarding environmental protection methods. Following the requirements of the Montreal Protocol on phasing out methyl bromide, the Lebanese Government has initiated a series of projects to face these environmental challenges, namely the "Methyl Bromide Demonstration Project (Phase I)", the "UNDP-Methyl Bromide Project for the Phase-out of MeBr in the Sectors of Vegetables, Cut Flowers and Tobacco", and the UNIDO Project on phasing out methyl bromide in strawberries (Investment Projects). UNDP has managed the demonstration project and is currently managing the first of the two investment projects, whilst UNIDO is managing the second one.

3.2 Demonstration Project on Methyl Bromide Alternatives in Soil Fumigation – Phase I

3.2.1 General description of the project

Funded by the MLF of the Montreal Protocol, and managed by UNDP, The Methyl Bromide Alternatives Demonstration Project was initiated by the Ozone Office of Lebanon in May 1999, and was executed by the MOE with the objective of phasing out methyl bromide in Lebanon by 2015. The project aimed to demonstrate the effectiveness of various chemical and non-chemical methods as technical and economical alternatives to methyl bromide, training local farmers on the correct use of the alternatives, as well as designing a national strategy for the replacement of methyl bromide.

3.2.2 Project implementation

3.2.2.1 Site selection

The study was conducted mainly on the coastal area where greenhouse production is concentrated as well as in the Bekaa where some greenhouses are also present. Fifty-two greenhouses, distributed over 19 sites and covering an area of 20,500 m^2 were chosen:

• Jbeil, Rmeily, Damour and Shweifat	Mount Lebanon
• Tripoli and Akkar	North Lebanon
• Aakbiyye and Sarafand	South Lebanon
• Btedii, Zahle, Bar Elias and Kherbet Anafer	The Bekaa

Results from this study were taken throughout four consecutive seasons from three main regions. The crops were cucumber, eggplant, strawberry and tomato.

In the process of site selection, the following three criteria were taken into consideration:

- presence of at least one soil-born problem (nematodes, fungi or weeds) necessitating the use of methyl bromide
- systematic use of methyl bromide as part of cultural practices in that specific site
- willingness of the site-owning farmer to fully cooperate with the project.

The project also provided the laboratory of the MOE with the necessary equipment for the detection and identification of nematodes in the soil. Before the start of each growing season, preliminary extraction and identification of nematodes was carried out at the MOE laboratory. Soil samples were regularly sent to the laboratory of the state of Idaho, USA for further analysis throughout the growing season.

3.2.2.2 Selection of alternatives

Several chemical and non-chemical alternatives were tested during the demonstration project. The chemical ones were 1-3 Dichloropropene, Cadusafos, Dazomet and Oxamyl and the non-chemical ones were soil solarization, bio-fumigation (oil radish and Sudan grass) and grafted plants.

Decisions on the appropriate alternative in each case were made according to the major soil borne diseases prevailing in each site. In all cases, the alternatives were selected based on the following characteristics:

- efficiency
- low-cost
- environment and public health friendliness.

In addition to the previously mentioned alternatives, some combinations of chemical and non-chemical alternatives were tested together on one site, for example solarization in combination with 1.3-Dichloropropene (Condor + plastic cover) and solarization in combination with Oxamyl.

Descriptions on each of the alternatives are presented in detail in Chapter 4 of this report and include the mode of action of the alternatives, their method of application, as well as the major advantages and disadvantages of each.

Training sessions for local farmers were also organised throughout the project to establish a direct contact between the project and the farmers of different regions. The training sessions served primarily to show the farmers the proper techniques for introducing the available alternatives. More than 250 principal farmers from different areas participated in the training sessions that were organised over the project's life span.

3.2.2.3 Project experimental design

Table 3.1 represents the design or distribution that was followed by the demonstration project in applying the alternatives in the different sites. The value inside each cell indicates the number of replicates carried out on each crop for each of the considered alternatives as well as for methyl bromide.

As can be seen from the table, no clear experimental design was followed throughout the project regarding the distribution of the alternatives under consideration. In other words, not all alternatives were applied to all the considered crops (tomato, cucumber, strawberry, and eggplant). This restriction in the experimental design limits the effectiveness of the comparison among alternatives, as not all alternatives can be compared regarding each crop.

It should be noted that the CBA conducted in the present study is based on the results obtained in the Methyl Bromide Demonstration Project. In other words, the alternatives for each of the crops are only the ones that were tested in the demonstration project.

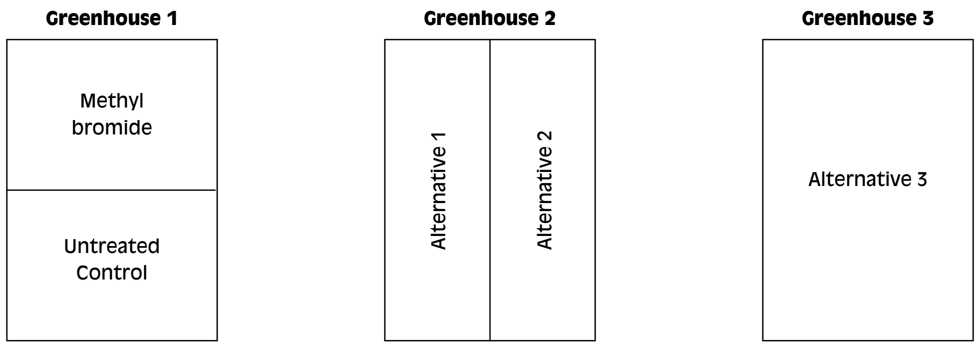
A specific experimental design was applied for the experiment carried out at each site. There were three greenhouses at each site, one of which was divided into a control area (untreated) and a methyl bromide treated area, whilst the other two were treated with two other alternatives (sometimes each greenhouse was divided into two areas with two different alternatives) (Figure 3.1).

Table 3.1: Distribution of alternatives among crops and number of replicates per alternative*

FUMIGATION TECHNIQUE															
		Non-chemical alternatives					Chemical alternatives							Mixed alternatives	
Crop	Methyl Bromide	Solarization	Bio-fumigation			Grafted plants	Dazomet			Oxamyl	Cadusafos	1,3-D		Solarization + 1,3-D	Solarization + Oxamyl
			OR	OR + Ch	SG		40 g/m²	60 g/m²	80 g/m²			Cov	Uncov		
Cucumber	7	–	1	–	–	–	–	2	–	1	2	2	2	–	–
Eggplant	1	–	1	1	1	–	–	–	–	–	–	–	–	–	–
Strawberry	2	1	–	–	–	–	1	1	1	–	–	–	–	–	–
Tomato	5	5	–	–	2	1	–	–	–	–	–	–	–	1	1

** MBr: methyl bromide; OR: oil radish; Ch: Chitinase; SG: Sudan grass; 1,3-D: 1,3-Dichloropropene; Cov: covered; Uncov: uncovered*

Figure 3.1: Scheme representing a sample design for the experiment sites



3.2.2.4 Project activities

First National Workshop on Alternatives to Methyl Bromide in Lebanon

The Methyl Bromide Alternatives Demonstration Project organised a first National Workshop on Alternatives to Methyl Bromide in Lebanon in the Riviera Beirut on 1 February 2001. Representatives of various offices of the United Nations in Lebanon, Ministries of Environment and Agriculture, private sector, universities, and research stations attended this workshop during which data resulting from the applications of all alternatives were presented and discussed.

First National Survey on Methyl Bromide Consumption in Lebanon

The Methyl Bromide Alternatives Demonstration Project conducted a survey on the totality of the agricultural lands in Lebanon to identify the producers of vegetables, cut flowers, tobacco and strawberries. The survey specifically determined the number of producers across the country, the total production area and the quantity of methyl bromide consumed annually from 1995 to 2000. The first survey was initiated on 1 March 2001 and completed by 30 June 2001. Information on both events is available from the UNDP-Methyl Bromide Alternatives Project.

Booklet on "Alternatives to Methyl Bromide – Lebanon"

A booklet was prepared in Arabic and English to disseminate information on the risks and hazards resulting from methyl bromide fumigation, the existing alternatives and the rules and regulations of the methyl bromide phase-out in different countries. The booklet is distributed to farmers, universities, research stations, agricultural syndicates and cooperatives.

3.2.3 Project conclusion

The project results indicated that, "as far as soil fumigation is concerned, methyl bromide can totally and successfully be replaced by a multitude of available alternatives, which in some cases provide an even better control of pests and result in higher yields".

As a result of the success and outcomes of the project, Lebanese stakeholders and farmers expressed their readiness to completely phase out methyl bromide from the vegetable and strawberry sectors, even prior to the deadline set by the Montreal Protocol for developing countries.

It is worth mentioning that the Methyl Bromide Demonstration Project in Lebanon is still referred to as one of the most successful Methyl Bromide Alternatives Projects in the world.

3.2.4 Project sustainability

Throughout the two-year demonstration project implementation period, new technologies for environment-safe soil disinfections were transferred to the Lebanese farmers. The long-term objective of the project was the adoption of these technologies by all Lebanese farmers and a complete shift from methyl bromide use. This was the main motive behind the support of the MOA, the MOE, the private sector, NGOs and the farmers themselves. The necessary documents are being prepared to achieve a complete phase-out of methyl bromide in Lebanon over the next five years and a phasing-out project is currently ongoing to complement and complete the work carried out during the first project.

3.3 Methyl Bromide Phase-out Project – Phase II

Following the implementation of the demonstration phase of the Methyl Bromide Alternatives Project, the MOE launched the investment projects in 2002, with the main objective of achieving the complete phase-out of methyl bromide in Lebanon over the next five years. Hence, the MOE has developed two parallel projects, one in coordination with UNDP to phase out the use of methyl bromide in the vegetables, cut flowers and tobacco sectors, and another one, in coordination with the UNIDO, to phase out the use of methyl bromide in strawberry production in Lebanon. These projects started in February 2002 and alternatives for each of the sectors have been defined in line with the regulations of the MBTOC of the Montreal Protocol.

The International Consultant, Dr. Saad Hafez, trained the staff of both projects on the application of the alternative techniques (as some of these were newly introduced technologies), so that the information could be disseminated to Lebanese farmers.

3.3.1 UNDP-Methyl Bromide Alternatives Project for the sectors of Vegetables, Cut Flowers and Tobacco

Since the consumption of 43 metric tons of methyl bromide had to be phased out during the first year of the UNDP-Methyl Bromide Alternatives Project, and in consideration of the remaining time, activities of the first growing season were concentrated on the vegetable sector only. Based on previous surveys, engineers visited the farmers and provided technical assistance to help each farmer make the appropriate decision on the alternative to adopt for the coming season. Training sessions were also organised during which site engineers explained the correct and safe application of the alternative in question. In some cases, experts from local agricultural companies were also involved in the application of the alternatives. The total number of farmers trained during the first season of the project was 1,023, corresponding to a total phase-out area of 965 dunums.* The target of phasing out 43 tons of methyl bromide during the first year of the project has thus been met.

The alternatives that will be implemented in this project vary from one sector to another as follows:

The vegetable sector:
- Soil solarization + low dose of Oxamyl
- Bio-fumigation + low dose of Oxamyl
- Grafted plants
- 1,3-Dichloropropene
- Dazomet

The cut flowers sector:
- Steam fumigation

The tobacco sector:
- Floating tray technique

The chemical and technical names including formulae for these alternatives are the following:

DAZOMET

3,5-Dimethyl-1,3,5-thiadiazine-2-thione
Tetrahydro-3,5-dimethyl-1,3,5-thiadiazine-2-thione
Dimethylformocarbothialdine
C5H10N2S2
Molecular mass: 162.3

CAS # 533-74-4
RTECS #XI2800000
ICSC # 0786
UN # 2588
EC # 613-008-00-X

Also known as DMTT, this nematicide has American (Union Carbide and others) and German (BASF) origins. It decomposes in the soil as thiocyanates and acts as vapour on a wide range of parasitic nematodes and soil-borne fungi such as Pythium, Fusarium, Verticillium, and Rhizoctonia. It also acts on weed seeds, as it kills germinating seeds upon application, as well as on soil insects.

OXAMYL (PDS)

Common name:	Oxamyl (BSI, ISO, ANSI, JMAF)
IUPAC:	N, N-dimethyl-2-methyl-carbamoyloximino-2-(dimethylthio) acetamide
CAS#1:	methyl N’, N’-dimethyl-N-((methylcarbamoyl)oxy)-1-thiooxamimidate
CAS Reg. No.:	23135-22-O
Mol. Form.:	C7H13N3O3S
Mol Wt.:	219. 29
Synonyms:	D-1410; DPX-1410; Thioxamyl; VydateR

* A unit of area measurement: 1,000 m^2 = 1/4 acre.

Oxamyl is a broad spectrum, carbamate pesticide; a fast-acting anti-cholinesterase agent with effective direct contact and stomach action. Highly toxic to mammals, it is rapidly metabolised and non-cumulative in animal tissues. Oxamyl is an effective plant systemic with excellent knockdown properties but poor residual action.

3.4 Alternative fumigants to methyl bromide in tobacco and cut flowers production

No fumigant alternatives to methyl bromide have yet been tested on tobacco or cut flowers (carnation, gypsofil, roses) in Lebanon, although these are important crops in the Lebanese agricultural sector. Therefore, the most common alternatives that are used in various areas outside Lebanon are described hereafter. These descriptions may give an idea of what alternatives should be considered for future use in Lebanon.

3.4.1 Tobacco

Among the alternatives that are being studied in relation to tobacco production by the United States Department of Agriculture (USDA) and the Agricultural Research Service (ARS) are chloropicrin, Telone C-17 and Metam Sodium, as well as combinations of the previously mentioned alternatives. Results indicated that the combination of Metam Sodium plus Chloropicrin, Telone C-17 and Telone C-35 tended to be most efficient in reducing populations of fungi in the soil (Csinos, 1996b).

Other results indicated that a combination of Metam Sodium, Dichloropropene, and Chloropicrin covered with a polyethylene film controlled most of the pests, allowing optimum tobacco production and seedling vigour (Csinos, 1996b).

A study conducted in China shows that the floating seed tray is a suitable alternative to methyl bromide for tobacco. This fumigation technique has the following advantages:

1. It can produce uniform high quality tobacco seedlings.
2. The seedlings raised can be transplanted directly and do not need a recovery period, whilst in the routine way they need to be transplanted twice.
3. There were no weeds or soil insects in the floating seed tray.
4. The tobacco seedlings are able to resist drought in early spring and stay sufficiently moist to grow.
5. More plants can be produced per unit area than using methyl bromide, thus saving land. Up to 1,250 plants/m^2 can be produced, compared to 156 plants/m^2 with methyl bromide.
6. A great deal of labour is saved in terms of irrigation and transplanting.
7. The application of insecticides and herbicides is not necessary and therefore the environmental impact is low.

Despite these advantages, significant barriers to this technique do exist. For example, the substrate used in floating seed trays is imported from Europe and is expensive for the local farmers (in China). It also requires setting up greenhouses with water analysis and treating systems to prevent poor growth as a result of low temperatures and drought in early spring.

In Cuba and Argentina, the substrate gave better seedlings than traditional planting using methyl bromide in several ways: more seeds germinated successfully; more seedlings were suitable for planting in the fields; and seedlings survived better after they had been planted in the fields. For example, some results indicated that 14 per cent of methyl bromide seedlings died after being planted, compared to only 1 per cent of substrate seedlings. The final crop was much more uniform, and produced higher grades of tobacco leaves, which means better prices for farmers. Farmers who tried the substrate system in Africa and Latin America were also pleased with the results.

The same results were obtained from the demonstration project on the alternatives to the use of methyl bromide in Brazil. Seedbed solarization proved to be a technically feasible and cost-effective non-chemical alternative to methyl bromide. The high temperature reached during the process controlled both weeds and pathogens in the upper soil layers of the treated seedbed. Since tobacco seedlings present a shallow root system, this technique can be used with satisfactory results. This system has advantages compared to chemical fumigation in that it is safer, less expensive and has less effect on the biological equilibrium of the soil. However, special care must be taken in relation to climatic conditions since solarization is effective only in sites with high temperature and radiation during the summer months.

Metam Sodium is safer and easier to use than methyl bromide and can be considered a potential alternative since costs are similar. Metam Sodium demonstrated good weed control and, contrary to Dazomet, had no effect on seed germination.

Bio-fumigation presented different results related to weed control. Despite its low cost, this alternative is limited in view of the high volume of fresh manure required to implement the system efficiently.

This is why, considering all aspects, namely management, cost and plant performance in the field, the floating in low tunnel systems is recommended for tobacco seedling production. For growers using seedbeds, solarization can be used and is a safe alternative (UNIDO, 2000).

3.4.2 Cut flowers

In Argentina, a project was conducted to study the alternatives to methyl bromide cut flowers. The main conclusions of the project were that Metam Sodium was the most technically and economically feasible alternative to methyl bromide. However, steam was also recommended for special soil problems, such as some types of weeds and nematodes, as a very effective methyl bromide alternative, although it is more expensive and more complicated to use (Sangiacomo et al., 1997)

Another study showed that combining IPM technologies for the control of pests and diseases in horticulture is a proven technology package that is widely used. For example, Columbian cut flower growers using an IPM approach report annual losses of only 1-2 per cent due to bacterial and fungal diseases, compared with much higher losses when relying on methyl bromide. The IPM approach is not only environment-friendly it is also economically feasible.

One pest management tool that can be used as part of an IPM programme is pasteurisation of the soil using steam. This treatment involves heating the soil to inactivate nematodes, fungi and weeds. Steam pasteurisation can be an effective pest control method for many nursery crops, including ornamental bedding plants, fresh cut flowers and greens, garden seeds and sod. As a replacement to methyl bromide, steam is mostly applicable for nursery soils and containers, and might prove to be cost effective in the case of seedbeds, as has been demonstrated by the extensive use of this technique by several firms in the cut flower sector in Colombia, the United States, the Netherlands and the Dominican Republic.

Since the initiation of both investment projects, Lebanon has successfully met all its obligations in terms of timely phase-out of the agreed quantities of methyl bromide. Targets set for 2002 and 2003 were exceeded. More than 6,000 Lebanese farmers were trained on the different alternatives suggested by the projects in different agricultural areas of the country. Most often, farmers encouraged by the results of the alternatives, are phasing out additional areas through personal initiatives, and eliminating methyl bromide in greater quantities than required and expected. Therefore, agricultural import companies have recently started to reduce imports of methyl bromide. It is also worth noting that most of the phase-out is being achieved with the use of 100 per cent environmentally friendly non-chemical alternatives (97 per cent for 2003).

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3.5 UNIDO Methyl Bromide Phase-out Project for the Strawberry Sector

The project is executed by the MOE and managed by UNIDO. It is a five-year project that started in 2002 and responds to Lebanon's ratification of the Montreal Protocol that set schedules to phase out the use of ODSs in both industrialized and developing countries.

The project aims to progressively phase out methyl bromide from the strawberry sector in Lebanon and replace it by soil steaming. The ultimate goal is to reach complete phase-out by 2007. Depending on the soil type, two soil-steaming techniques would be applied: sheet steaming for clayey soils and negative pressure steaming for most types of soil especially sandy ones. The boilers and their accessory pipes will be imported, and farmers will be trained in their use.

Soil steaming will be applied along with an integrated pest management (IPM) programme, which constitutes a complete and integrated approach to plant protection. IPM measures, such as field monitoring, disease identification, selection of seeds and transplants and proper cultural practices play an important role in preventing soil re-infestation, improving the efficacy of soil steaming and preventing soil re-infestation after steam application.

As part of the IPM programme, efforts will be made to adopt environmentally sound measures that tend towards sustainable or organic agriculture as no sustainable crop protection and production management can be achieved in a polluted or non-equilibrated environment. Also these measures would encourage strawberry marketing both inside and outside Lebanon.

The UNIDO staff will transfer the soil steaming and IPM expertise to the farmers via training sessions and awareness campaigns. At the end of the project, Lebanon must be able to continue the project on its own and should commit to permanently stopping the use of methyl bromide by adopting import restrictions and other policies that it deems necessary.

4. Alternatives to methyl bromide in Lebanon

4.1 Introduction

As previously mentioned, the Methyl Bromide Alternatives Demonstration Project of Lebanon has already shown the efficacy of various alternatives of methyl bromide used for soil fumigation in Lebanon. These alternatives were divided into two major categories: chemical and non-chemical alternatives. Their selection was based on three main criteria: efficiency in terms of pest control, low cost compared to methyl bromide, and public health and environmental safety.

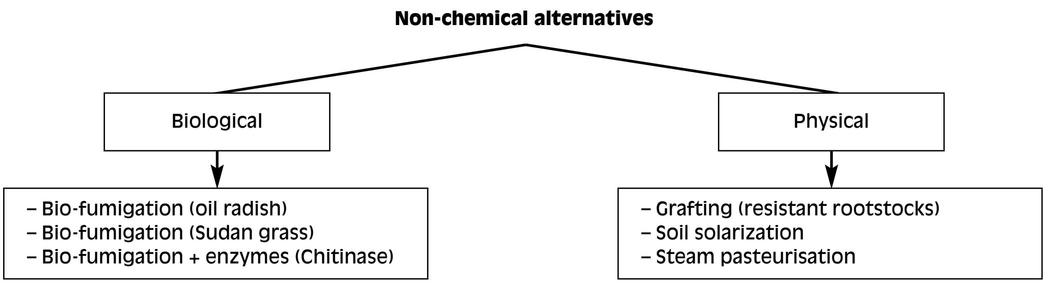
It should be noted that trials have been carried out in Lebanon on the combination of chemical and non-chemical alternatives in order to increase efficiency. Examples of such combinations include solarization and Oxamyl, bio-fumigation and Oxamyl, and solarization and 1-3 Dichloropropene.

This chapter presents a detailed description of the chemical and non-chemical alternatives to methyl bromide used in Lebanon, including mainly the method of application of each alternative and its effect on human health. The chapter concludes with a brief description of some of the alternatives that proved to be efficient in various countries but are not used in Lebanon.

4.2 Non-chemical alternatives

Non-chemical alternatives are divided into two main groups: biological alternatives and physical alternatives. Biological alternatives are mainly composed of either micro-organisms or plants that are applied using specific techniques. Physical alternatives, as indicated by the name, are related to the physical characteristics of the plants themselves or to other physical characteristics such as solar energy and steam. Figure 4.1 is a schematic diagram that shows the different non-chemical alternatives considered in the project.

Figure 4.1: Schematic diagram of the non-chemical alternatives to methyl bromide used in Lebanon



Source: Adapted from Lebanese Ministry of Environment and UNDP, 2001

4.3 Biological alternatives

4.3.1 Bio-fumigation

Bio-fumigation is one of the most commonly used replacement methods for methyl bromide in soil fumigation. It consists in growing specific crops that are later mixed in with the soil and covered for a certain period to produce gases that control several soil-born pests and pathogens. Oil radish and Sudan grass hybrids have been extensively commercialised and used for bio-fumigation.

Bio-fumigation is sometimes complemented with the addition of Chitinase, an enzyme used as an alternative to methyl bromide in the control of nematodes in the soil. This enzyme is derived from aquatic organisms and acts on the chitin present in the nematode cuticle, breaking it down and leading to the decay of the nematode. In Lebanon, bio-fumigation using oil radish combined with Chitinase has been tested on eggplants.

The bio-fumigation method involves first flooding the land with water, then preparing and ploughing it. Then the bio-fumigation seeds are sown at a ratio of 3 kg/dunum. When the plants reach a height of approximately 30-40 cm for oil radish or 100-150 cm for Sudan grass, they are chopped and incorporated in the soil at an approximate depth of 25 cm. The soil is then irrigated using a sprinkler system and covered with plastic sheets for ten days in order to prevent the dissipation of the gases formed by the fermentation of the bio-fumigation crop. During the fermentation process methyl iso-thiocyanate (MITC) is produced, a substance that efficiently controls a wide variety of soil-born pathogens.

One of the advantages of the bio-fumigation process is that it increases soil fertility since it adds a significant amount of organic matter to the treated area and improves the soil's physical and biological characteristics.

4.4 Physical alternatives

4.4.1 Grafting

Several varieties of resistant rootstocks currently exist for a wide variety of crops. This technique requires special care and hygienic measures particularly in the first stage. The temperature and humidity of the nursery must be constantly maintained to minimize the impact of evapo-transpiration on the newly grafted seedlings. Special seedling trays should be used for the rootstock to prevent roots from growing in a circular pattern. Trays should be kept lifted from the nursery tables and the nursery should be hermetically sealed with special nets to prevent the entry of any insect. Reflection or shade nets are recommended to reduce the light impact that might cause abnormal plant height and thinness.

Grafting techniques vary from one crop to another. Common techniques include median grafting for cucurbits and angle grafting for tomatoes. The entire grafting operation, from the production of grafted plants to their transplantation requires about one month.

In the Methyl Bromide Demonstration Project, the grafting technique was only tested on tomatoes and farmers usually buy already grafted seedlings that they plant directly in the greenhouses. This reduces care requirements and the risk of crop distortion.

4.4.2 Soil solarization

Soil solarization is based on the use of natural solar energy to increase the topsoil temperature in order to control the different soil-born pests, prevailing diseases, nematodes and weeds. It is conducted during the hot summer season (June, July, August).

The first step in soil solarization is cleaning the soil from leftovers of the previous season. Next, the soil is tilled, ploughed, and organic and chemical fertilizers are incorporated. The treatment area is divided into small portions and flooded beyond soil saturation. The soil is then covered and sealed for six to eight weeks with plastic sheets in order to prevent steam dissipation. Finally, the plastic sheets are removed and the soil is ready for transplantation.

It should be mentioned that soil solarization is best used as part of an Integrated Pest Management (IPM) system where it is supported with consequent application(s) of small doses of chemical alternatives, especially in the case of severe infestations.

Soil solarization is the alternative most commonly used by farmers selected for the Methyl Bromide Demonstration Project in Lebanon. Sixty-five per cent of the farmers in this project chose soil solarization as an alternative to methyl bromide. One possible reason for this choice might be the relatively low cost.

One limitation of soil solarization is that it is only partially effective against the root knot nematode Meloidogyne sp, so the addition of nematicides might be required in this case.

4.4.3 Steam pasteurisation

Steam pasteurisation involves injecting steam, with the use of boilers, into soil covered with heat resistant plastic sheets. Similarly to soil solarization, steam pasteurisation acts on increasing the soil temperature to control soil-born pathogens and is applied during the hot summer season (June, July, August), but is applied on dry rather than wet soil. The soil is prepared, ploughed, and fertilized before steam pasteurisation. In general, deep soil cultivation is required for optimum steaming results as it allows steam penetration and adequate horizontal and vertical heat diffusion. To effectively treat soils with steam, soil temperatures should be maintained at 70°C for at least 30 minutes in order to free the soil from plant pathogenic fungi, nematodes, bacteria, soil animals and weeds. Higher temperatures should be reached, especially in deep soil layers, in order to treat viruses, saprophytic fungi and some heat resistant bacteria. However, excessively high temperatures (85-100°C) kill too many beneficial micro-organisms, lead to the production of phytotoxic compounds, release toxic levels of manganese and may increase soil aggregation and destroy soil texture. For a one-year crop, it is sufficient to treat the soil at 70°C down to a depth of 30 cm. For a two-year crop, this temperature should be reached down to a depth of 50 cm.

Two soil-steaming methods exist: sheet steaming and negative pressure steaming.

4.4.3.1 Sheet steaming

The soil is covered with heat resistant polyvinyl chloride (PVC) or polypropylene (PP) sheets anchored to the ground along their edges. Steam is blown under the sheets and is left to penetrate the soil. The effectiveness of this system depends on several factors, the most important ones being soil type and soil cultivation technique. Sheet steaming is mainly recommended for clayey soils. It requires a relatively long application period that usually lasts about eight hours during which energy is lost by radiation.

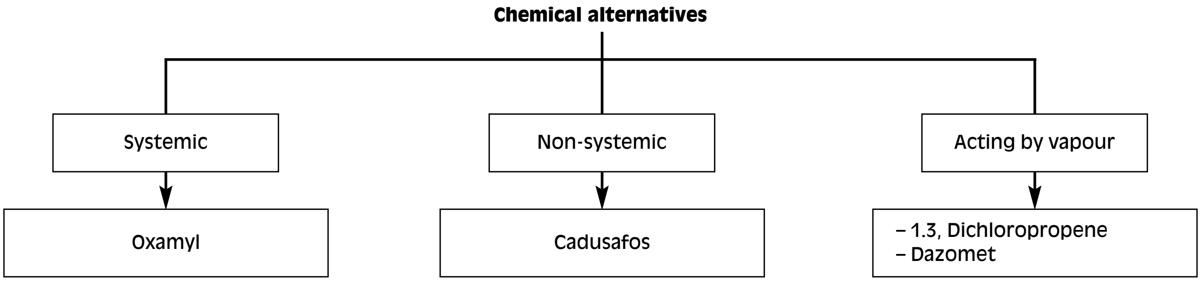
4.4.3.2 Negative pressure steaming

Steam is blown under the steam sheet and pulled into the soil by a negative pressure (vacuum). Negative pressure is created by a fan which sucks air out of the soil through buried perforated PP pipes placed at a depth of 40-60 cm depending on the cultivated crop and the cultivation depth. Negative pressure steaming is recommended for all soil types, and the steaming period is less than that for sheet steaming, i.e. between four and five hours. This reduces the energy lost due to radiation and consequently fuel consumption in comparison to sheet steaming.

4.5 Chemical alternatives

Chemical alternatives are categorised into three levels: systemic, non-systemic and acting by vapour (fumigants). The systemic and non-systemic alternatives must remain unaltered in the soil for a certain period in order to protect the root zone from soil-born pathogens. It should be noted that these alternatives do not have a broad-spectrum activity and hence only control specific target pests. The fumigants, or chemical alternatives that act by vapour, have a broader spectrum of soil-pest control (nematodes, diseases, weeds, etc.). They usually interact with soil humidity to release noxious gases that diffuse in the soil to control pests. Figure 4.2 represents the classification of the most commonly used methyl bromide chemical alternatives in Lebanon.

Figure 4.2: Schematic diagram of the chemical alternatives to methyl bromide used in Lebanon



Source: Adapted from the "Methyl Bromide Alternatives Project – Lebanon, 2001"

4.5.1 Systemic alternatives: Oxamyl

This product is efficient in controlling most nematode species in addition to a large number of sucking and chewing insects such as aphids and thrips. It is available in a granular formulation (banned in the United States), as well as in a liquid formulation that translocates into the plant tissues and spreads its action throughout the different parts of the plant. In the Methyl Bromide Demonstration Project, only the liquid formulation was tested.

Liquid Oxamyl is added to the fertilizer tank and applied through the drip irrigation system initially before planting, then as biweekly applications that should cease 30 days before the first harvest. The results of Oxamyl application are enhanced by the addition of phosphoric acid (PA) in order to lower the soil pH. The initial application rate (pre-planting) of Oxamyl is 500 ml with one litre of PA/dunum, while the rate of the biweekly applications is 250 ml of Oxamyl with 500 ml of PA/dunum.

Oxamyl has been rated as extremely toxic to humans, and can enter the body through inhalation, ingestion or through the skin. Excess applications of Oxamyl can lead to the accumulation of residues in foods. The maximum residue limit (MRL) for Oxamyl is 2 mg/kg (Lebanese Standards Institution).

Oxamyl is found in Lebanon under the trade name of Vydate®. It can be used in conjunction with soil solarization to increase its efficiency. In Lebanon, Oxamyl was only tested on cucumber as a single alternative, and was tested on tomato as part of a mixed alternative where it was used with soil solarization.

4.5.2 Non-systemic alternatives: Cadusafos

Cadusafos is an organophosphate that was only tested on cucumber in Lebanon. The active ingredient acts by contact as well as by ingestion on lesion and root knot nematodes, in addition to many other nematode species and soil insects. Cadusafos is applied at a rate of four to five litres/dunum in split applications, once before transplanting and again one month later. It is usually added to the fertilizer tank and applied through the drip irrigation system to a well-prepared wet soil. The treated area should be irrigated after the application of the product in order for the product to reach the root zone.

Cadusafos requires a waiting period of 40 days before harvest. It can be used in conjunction with soil solarization in order to increase its efficiency. Being a non-systemic pesticide, Cadusafos is usually not transferred from the roots to the other parts of the plant, and therefore leaves no residues in crops. A common trade name of Cadusafos in Lebanon is Rugby®, which has 10 per cent active ingredient.

4.6 Fumigant alternatives (acting by vapour)

4.6.1 1,3-Dichloropropene

Two formulations of 1,3-Dichloropropene exist. The first is a liquid formulation that turns into gas when applied to the soil. It controls root knot nematodes and some fungal diseases and is applied at a rate of 16-24 litres/dunum injected into a wet soil before planting. The application of this product necessitates a special injection device that is powered and pulled by a tractor. The disinfected area should be covered immediately with plastic sheets to avoid any dissipation of the gas released. The best results are obtained when the soil temperature is 25-27°C at the time of application. This formulation was not applied in Lebanon.

The formulation that was considered in the demonstration project in Lebanon does not necessitate the use of specific application equipment. It was tested on cucumber crops. This formulation can be applied directly through the drip irrigation system and is used on a soil that has been irrigated for two to three hours with clean water. It is applied at a rate of 10-20 litres/dunum. Following the application of the product, the soil should be irrigated again (through the drip irrigation system) for 15-30 minutes with clean water in order to isolate the gas that is released from the solution and to prevent its dissipation into the open air. As an alternative, this second irrigation with pure water can be replaced by covering the soil with plastic sheets for ten days. A waiting period of 21 days before planting is required for this formulation. No residues of 1,3-Dichloropropene have showed up in treated crops (Agency for Toxic Substances and Disease Registry, 1995). A common trade name in Lebanon for 1,3-Dichloropropene is Condor®.

4.6.2 Dazomet

Dazomet controls nematodes, soil fungi and weed seeds. It is a white granular powder formulation that releases a toxic gas when it reacts with soil humidity. It requires critical application details meaning that safety precautions must be followed during the application, since the granules convert to noxious gas upon contact with water. It is applied at rates ranging from 20-80 g/m^2 depending on the soil texture and level of infestation.

For example, before its application, the land should be prepared, ploughed, fertilized and thoroughly watered. Dazomet is then evenly distributed on the soil surface using a special applicator and incorporated into the soil at a depth of 10-20 cm using a tractor. Next, the soil is sprayed with overhead sprinklers to raise its humidity and covered with plastic sheets for ten days. The plastic sheets are used to capture the MITC gas that is released in the process. Once the plastic sheets have been removed the soil is turned over twice to a depth of 20 cm in order to help the remaining MITC dissipate into the air. It should be noted that disturbing the soil at a depth over 20 cm would cause re-infestation from the deeper layers. It is recommended to wait 8-30 days following this operation before transplantation. It is advisable to carry out a germination test using lettuce seeds, to make sure that the soil is completely free of any MITC that could interfere with the normal growth of the crop.

It should be noted that among the above-mentioned alternatives the following were those most used in the investment phase of the Methyl Bromide Phase-out Project: a combination of soil solarization and Oxamyl (used by 78 per cent of farmers), grafted plants (used by 11 per cent of farmers), 1,3-Dichloropropene (used by 10 per cent of farmers), and bio-fumigation (used by 1 per cent of farmers). However, the EIA and CBA included in this report were conducted on all the alternatives considered in the demonstration phase of the project (not only those considered in the investment phase).

4.7 Alternatives to methyl bromide not used in Lebanon

Several additional alternatives to methyl bromide exist. Some of these alternatives are somewhat common in several countries, but for various reasons were not introduced or tested in Lebanon.

4.7.1 Bacteria

Bacillus subtillis is one of the most common bacterium used to control soil-born diseases. It is usually applied to treat the seed before planting to protect it from attacks from various soil pathogens.

4.7.2 Beneficial fungi

Trichoderma is one of the commonly used fungi for the control of soil-born pathogens. It proliferates quickly in the soil and controls a wide range of soil-born pathogens such as Fusarium, Verticillium and nematodes.

With respect to the application procedure, the fungus should be evenly distributed over the plantation area through a drip irrigation system either before planting or during the growing season. The activity of this fungus is enhanced in moderate to warm climates and when applied to a wet soil.

4.7.3 Fenamiphos

This product is efficient in controlling all life stages of root knot nematodes in addition to some chewing and sucking insects such as aphids, thrips, and spider mites. It is available in liquid and granular formulations and can either be applied to the soil or, in the case of the liquid formulation, sprayed on the foliage. Fenamiphos is applied at a rate of one to two litres/dunum depending on the extent of infestation.

The liquid formulation is added to the fertilizer tank and pumped through the irrigation pipes into a moist soil after land preparation. A waiting period of 60 days is required before harvesting. The granular formulation is used as a pre-plant application for soil treatment only. Granules are evenly distributed over the soil surface and incorporated into the soil to a depth of 10-20 cm by tractor. A waiting period of 21 days is necessary before transplantation. Fenamiphos is classified as an “extremely toxic” product with a lethal dose (LD) (Rat) of 15.3 mg/Kg. A common trade name in Lebanon is Nemacure®.

4.7.4 Metam Sodium

This product controls soil fungi and insects as well as weed seeds, but has a limited effect on nematodes. Its efficiency, however, is subject to specific conditions such as adequate soil moisture and suitable climatic conditions. For example, application should be avoided in hot weather conditions because the product transforms into gas and becomes hazardous to the applicator. Metam Sodium is available in a liquid formulation that can either be applied through the drip irrigation system or by spraying the soil surface and incorporating it immediately. Similarly to Dazomet, Metam Sodium releases MITC, and the treated area should thus be covered with plastic sheets to prevent gas dissipation. The product is applied at a rate of 80-120 litres/dunum depending on the kind of crop grown and the level of infestation. A period of three to four weeks is required before transplantation. The product is classified as “harmful” with a LD (Rat) of 820 mg/Kg.

5. Environmental and socio-economic impact assessments of methyl bromide and its alternatives

5.1 Introduction

EIA is a formal process used to predict the environmental consequences of alternative proposed activities. EIA thus ensures that potential environmental problems are foreseen and addressed at an early stage in the activities or project's planning and design.

The main objective of conducting an EIA is to avoid or reduce environmental damage caused by an alternative to ensure that development initiatives and their benefits are sustainable. The directive of environmental management should be to achieve the greatest benefit presently possible in the use of natural resources without reducing their potential to meet future needs and the carrying capacity of the environment.

The following paragraphs represent an EIA of the alternatives to methyl bromide considered in this project.

5.2 The potential impact of Dazomet

Dazomet is classified by the US EPA as 'Harmful', with a LD (Rat) of 650 mg/kg. This primarily reflects the relatively low toxicity of the product prior to application. Once the dry micro-granules have been distributed using a special applicator, and the ground has been ploughed and irrigated, Dazomet quickly breaks down to give a range of by-products that include MITC, formaldehyde, hydrogen sulphide, carbon bisulphide and monomethylamine.

It is these by-products, primarily in the form of vapour, which are effective on a variety of nematodes, soil fungi and weed seeds. These by-products are toxic to all growing plants and highly or moderately toxic to invertebrates, mammals, birds and fish. Since the vapours evaporate quickly, there is little evidence that Dazomet by-products are carcinogenic or accumulate in the soil or in fish. They are unlikely to infiltrate to groundwater. The half-life of Dazomet is reported to be very short, only 90 minutes to nine hours, longer in dry, low temperatures and high alkaline soils. There is some indication that repeated treatment causes organisms to adapt, causing degradation of crop yield and quality with time.

The recommended procedure for the application of Dazomet is as follows:

Preparation	*Application*	*Dosage*	*Post-treatment*	*Special conditions*
Clean soil, fertilize, plough and thoroughly water.	Spread manually with special applicator prior to planting.	20-60 kg/dn.	Plough in to 10-20 cm. Irrigate to release gas and cover treated area with plastic sheets for 10 days. Plough to depth of 20 cm twice to dissipate remaining gas.	Requires special applicator. Application rates vary with soil texture. Pre-treatment irrigation is critical. Depth of post-treatment ploughing is critical. Germination tests are needed before planting.

Ideally, soil and air temperatures should be above 43°C. Average ambient temperatures in some parts of Lebanon may barely reach 40°C and in certain areas are significantly less than this. The time required for product breakdown may therefore be extended, as will the time over which the toxic vapours are given off. No crop can be planted until it has been ascertained via germination tests that all the breakdown vapours have dissipated. A waiting period of 8-30 days between ploughing to dissipate remaining gas and planting is recommended.

The by-products are also flammable and the requirement for post-treatment ploughing of the micro-granules after they have been spread can cause inflammable dust to rise over the treated area. Once the application process is complete, the treated area must be covered with plastic sheeting to maximize soil-vapour contact time.

The primary potential impacts of using Dazomet as an alternative to methyl bromide are summarized in Table 5.1.

5.3 Potential impact of Cadusafos

Cadusafos is an orthophosphatic compound, classified as Toxic, with a LD (Rat) of 679 mg/kg. It is not registered for use in the USA. A non-systemic liquid, it acts on contact and ingestion to control a range of nematodes and soil insects. It stays in the soil and remains active for long periods, although it may not significantly accumulate in the soil over successive applications.

The recommended procedure for the application of Cadusafos is as follows:

Preparation	*Application*	*Dosage*	*Post-treatment*	*Special conditions*
Clean soil, plough and irrigate.	Via drip irrigation with fertilizer prior to transplanting.	4-5 l/dn. Two applications, one month apart.	Irrigate to facilitate spreading.	Need to carefully adhere to application rates and waiting periods.

Cadusafos residues have reportedly been found in some harvested crops, particularly bananas, and a waiting period of at least 40 days between the final treatment and harvesting is recommended.

Cadusafos is easily incorporated into an integrated pest control (IPC) programme with soil solarization, in which case the rates of application can be reduced but the waiting period remains unchanged.

The primary potential impacts of using Cadusafos as an alternative to methyl bromide are summarized in Table 5.2.

Table 5.1: Potential impacts of Dazomet

Issue	Potential impact	Possible mitigation
Health and safety		
Storage and handling	Harmful. Releases toxic vapours when wet.	Store off the ground and keep dry. Secure against unauthorized entry.
Occupational hazard	Harmful to human health.	Those engaged in its application should wear protective clothing. The area to be treated should be well ventilated. Do not spread in humid conditions or when rain is forecast.
Public health and safety	Harmful to human health. Releases toxic vapours when wet.	Those not engaged in the application, especially children and domestic animals, should be kept away from the treated area. Seal greenhouse after treatment. Warning notices should be posted.
Pollution		
Soil/crop accumulation	Little or no accumulation. Soil organisms may adapt in time.	Periodically change crop and/or method of treatment.
Surface water	Harmful to fish and aquatic invertebrates if washed into watercourses.	Do not over-irrigate. Do not wash out or dispose of containers in the vicinity of surface water drainage channels. Do not use for treating areas of steep slope.
Groundwater	Unlikely to infiltrate to groundwater.	
Biodiversity	By-products toxic to all growing plants, animals and birds.	Ensure the spread micro-granules are immediately ploughed in. Seal greenhouse after treatment. Leave adequate untreated margin between treated area and natural vegetation.
Air and dust	Vapours and dust are flammable.	Water thoroughly prior to treatment to prevent dust. Ban workers engaged in the application from smoking. Avoid application in windy conditions. Seal greenhouse after treatment.
Natural resources		
Water	Irrigation required before and after application may diminish resources.	Properly manage the application of water so as not to over-irrigate.
Hydrocarbons	No significant use of hydrocarbons.	
Waste generation		
Liquid waste	Liquid waste generated only if containers washed out inappropriately.	Only wash out containers within treated areas.
Solid waste	Containers and plastic cover sheets.	Dispose of at facility licensed to take such materials. Ensure containers are empty.
Recycling	Little or no potential for recycling.	Due to their contact with toxic vapours, the plastic cover sheets should not be re-used for other purposes. Containers may be re-used with care.
Socio-economics		
Employment	Little potential for the generation of additional employment opportunities.	
Training	Untrained operators engaged in the application could risk the health of themselves and fellow workers.	Workers and others engaged in the application should be made aware of the need to abide by manufacturer's recommendations for handling and use, other health and safety issues, and environmental impact mitigation.

Table 5.2: Potential impacts of Cadusafos

Issue	Potential impact	Possible mitigation
Health and safety		
Storage and handling	Toxic. Works through contact and ingestion.	Store securely. Gloves, protective clothing and respirators should be worn whenever the liquid containers are handled.
Occupational hazard	Toxic to humans.	Store securely. Gloves, protective clothing and respirators should be worn when the liquid is added to the irrigation tank. No access to the greenhouse should be permitted during drip irrigation. If it is not possible to use a dedicated tank, the tank should be hosed out during post-treatment irrigation to prevent contamination of other crops watered from the same tank.
Public health and safety	Toxic to humans.	Those not engaged in the application, especially children and domestic animals, should be kept away from the treated area. Seal greenhouse after treatment. Warning notices should be posted. Adhere to recommended waiting periods.
Pollution		
Soil/crop accumulation	Known to stay in the soil and remain active for long periods. Residues may be taken up by some crops.	Adhere to recommended waiting periods. Allow treated ground to go fallow in accordance with normal procedures.
Surface water	Toxic to fish and aquatic invertebrates if washed into watercourses.	Do not over-irrigate. Do not wash out or dispose of containers in the vicinity of surface water drainage channels. Do not use for treating areas of steep slope.
Groundwater	Known to stay in the soil and remain active for long periods so probably has the potential to infiltrate to groundwater.	Do not over-irrigate. Do not wash out or dispose of containers in the vicinity of water wells. Consider alternative methods of treatment for areas underlain by karstic limestone.
Biodiversity	Toxic to other vertebrates and invertebrates.	Seal greenhouse after treatment. Leave adequate untreated margin between treated area and natural vegetation.
Air and dust	No air pollution is expected.	
Natural resources		
Water	The need to irrigate before, during and after application may diminish resources.	Properly manage the application of water so as not to over-irrigate.
Hydrocarbons	No significant use of hydrocarbons.	
Waste generation		
Liquid waste	Liquid waste generated only if containers washed out inappropriately.	Only wash out containers within treated areas.
Solid waste	Containers.	Dispose of at facility licensed to take such materials. Ensure containers are empty.
Recycling	Little or no potential for recycling.	Containers may be re-used with care.
Socio-economics		
Employment	Little potential for the generation of additional employment opportunities.	
Training	Untrained operators engaged in the application could risk the health of themselves and fellow workers.	Workers and others engaged in the application should be made aware of the need to abide by manufacturer's recommendations for handling and use, other health and safety issues, and environmental impact mitigation.

5.4 The potential impact of 1,3-Dichloropropene

1,3-Dichloropropene is a halogenated hydrocarbon that acts in much the same way as methyl bromide. It is a non-systemic liquid that is effective on a range of nematodes and has some effect on soil insects, fungi and weeds. It is classified as Toxic by the US EPA with a LD (Rat) of 170 mg/kg and is reported to be carcinogenic. No protective material is totally impervious to 1,3-Dichloropropene.

The recommended procedure for the application of 1,3-Dichloropropene is as follows:

Preparation	*Application*	*Dosage*	*Post-treatment*	*Special conditions*
Clean soil, plough and irrigate for 2-3 hours.	Via irrigation system with fertilizer.	10-20 l/dn.	Irrigate for 15-30 minutes to release gas or cover treated area with plastic sheets for 10 days.	None specified.

Rates of application vary with soil texture. Whilst the results of field trials are consistent and yields are sometimes better than those obtained with methyl bromide, repeated treatment leads to the degradation of crop yield and quality with the build-up of adapted organisms. A waiting period of 21 days between treatment and planting is recommended.

The product is usually marketed as a colourless, sweetly odorous liquid. It is easily inhaled and acutely and chronically toxic to humans as well as to other invertebrates, mammals, birds and fish. It is not absorbed well into the soil but is highly soluble in water. Since 1,3-Dichloropropene does not evaporate easily once in the soil, there is the potential for infiltration to groundwater and runoff to watercourses. Although the reported half-life is 3-70 days, residual concentrations have been found in groundwater ten metres below the surface 138 days after application. However, 1,3-Dichloropropene does evaporate during spray application. There is therefore a serious risk to down-wind vegetation, and residuals have been found in rainfall.

The primary potential impacts of using 1,3-Dichloropropene as an alternative to methyl bromide are summarized in Table 5.3.

Table 5.3: Potential impacts of 1,3-Dichloropropene

Issue	**Potential impact**	**Possible mitigation**
Health and safety		
Storage and handling	Acutely toxic to humans. Carcinogenic.	Store securely. Gloves, protective clothing and respirators should be worn whenever the liquid containers are handled.
Occupational hazard	Acutely toxic to humans. Carcinogenic.	Store securely. Gloves, protective clothing and respirators should be worn when the liquid is added to the irrigation tank. No access to the greenhouse should be permitted during drip irrigation. If it is not possible to use a dedicated tank, the tank should be hosed out during post-treatment irrigation to prevent contamination of other crops watered from the same tank.

Issue	Potential impact	Possible mitigation
Public health and safety	Acutely toxic to humans. Carcinogenic.	Those not engaged in the application, especially children and domestic animals, should be kept away from the treated area. Seal greenhouse after treatment. Warning notices should be posted. Adhere to recommended waiting periods.
Pollution		
Soil/crop accumulation	No significant accumulation recorded.	
Surface water	Since it does not evaporate easily once in the soil, there is the potential for washing into watercourses.	Do not over-irrigate. Do not wash out or dispose of containers in the vicinity of surface water drainage channels. Do not use for treating areas of steep slope.
Groundwater	Since it does not evaporate easily once in the soil, there is the potential for infiltration to groundwater.	Do not over-irrigate. Do not wash out or dispose of containers in the vicinity of water wells. Consider alternative methods of treatment for areas underlain by karstic limestone.
Biodiversity	Toxic to plants, mammals, birds and fish.	Seal greenhouse after treatment. Leave adequate untreated margin between treated area and natural vegetation.
Air and dust	Evaporates during spray irrigation.	Water thoroughly prior to treatment to prevent dust. Avoid application in windy conditions. Seal greenhouse after treatment.
Natural resources		
Water	The need to irrigate before, during and after application may diminish resources.	Properly manage the application of water so as not to over-irrigate. Use of plastic cover sheets in place of post-treatment irrigation reduces use of water.
Hydrocarbons	No significant use of hydrocarbons.	
Waste generation		
Liquid waste	Liquid waste generated only if containers washed out inappropriately.	Only wash out containers within treated areas.
Solid waste	Containers and, if used, plastic cover sheets.	Dispose of at facility licensed to take such materials. Ensure containers are empty.
Recycling	Little or no potential for recycling.	Due to their contact with toxic vapours, the plastic cover sheets should not be re-used for other purposes. Containers may be re-used with care.
Socio-economics		
Employment	Little potential for the generation of additional employment opportunities.	
Training	Untrained operators engaged in the application could risk the health of themselves and fellow workers.	Workers and others engaged in the application should be made aware of the need to abide by manufacturer's recommendations for handling and use, other health and safety issues, and environmental impact mitigation.

5.5 Potential impact of Oxamyl

Oxamyl is a systemic liquid that acts upon a range of nematodes and sucking and chewing insects. It is classified as extremely toxic by the US EPA, with a LD (Rat) of 37 mg/kg but is not carcinogenic. It is extremely poisonous to humans and also toxic to other invertebrates, mammals, birds and fish.

The recommended procedure for the application of Oxamyl is as follows:

Preparation	*Application*	*Dosage*	*Post-treatment*	*Special conditions*
Clean soil and plough.	Via drip irrigation with fertilizer. Applied with PA, pre-planting, then biweekly.	Pre-planting: 500 ml + 1 l PA/dn Thereafter: 250 ml + 500 ml PA/dn.	None specified.	Requires special attention to timing of applications.

PA is used to lower soil pH to enhance the effectiveness of Oxamyl. A waiting period of 30 days between the final treatment and crop harvesting is recommended.

Oxamyl does not bind to or penetrate the soil, but is highly soluble, so it can easily leach out and potentially infiltrate to groundwater. The US EPA set a limit for Oxamyl in potable water of 200 microns/l, but the overall potential for infiltration is thought to be small except where irrigation rates are high, groundwater levels shallow, or the soil particularly permeable. The latter may give particular cause for concern where the underlying stratum is karstic limestone, as is often the case in Lebanon. Oxamyl may also enter surface watercourses but, due to the higher presence of bacteria, it is expected to break down more quickly than in groundwater.

The primary potential impacts of using Oxamyl as an alternative to methyl bromide are summarized in Table 5.4.

5.6 Potential impact of soil solarization

Soil solarization makes use of the natural heat of the sun to pasteurise the soil by raising the temperature above 40°C in the upper 20-40 cm. At this temperature a range of nematodes, fungi and weeds can be controlled. Beneficial soil organisms are not harmed and the technique also improves soil fertility.

The recommended procedure for the use of soil solarization is as follows:

Preparation	*Application*	*Post-treatment*	*Special conditions*
Clean soil, plough and fertilize. Divide area by ditches, irrigate to beyond soil saturation.	Cover and seal with 50-micron plastic sheets. Treated sheets give better results than ordinary plastic. Leave for 6-8 weeks during June, July and August.	None. Ready for transplanting.	Surface-laid drip irrigation equipment may be melted. Greenhouse metals may corrode.

Clearly, the effectiveness of this method of pest and disease control will vary depending on the climate. The results are often inconsistent and thus farmer acceptance may be difficult. Soil solarization is satisfactory for low to medium levels of infestation, but is often inadequate for severe infestations. Other methods are required to avoid re-infestation throughout the growing season.

Table 5.4: Potential impacts of Oxamyl

Issue	Potential impact	Possible mitigation
Health and safety		
Storage and handling	Extremely toxic to humans.	Store securely. Gloves, protective clothing and respirators should be worn whenever the liquid containers are handled.
Occupational hazard	Extremely toxic to humans.	Store securely. Gloves, protective clothing and respirators should be worn when the liquid is added to the irrigation tank. No access to the greenhouse should be permitted during drip irrigation. If it is not possible to use a dedicated tank, the tank should be hosed out during post-treatment irrigation to prevent contamination of other crops watered from the same tank.
Public health and safety	Extremely toxic to humans.	Those not engaged in the application, especially children and domestic animals, should be kept away from the treated area. Seal greenhouse after treatment. Warning notices should be posted. Adhere to recommended waiting periods.
Pollution		
Soil/crop accumulation	Does not bind or penetrate the soil. Enters plant tissue.	Strictly adhere to waiting period between last treatment and harvesting
Surface water	Easily leached out by runoff and may be washed into watercourses.	Do not over-irrigate. Do not wash out or dispose of containers in the vicinity of surface water drainage channels. Do not use for treating areas of steep slope.
Groundwater	Easily leached out and may infiltrate to groundwater.	Do not over-irrigate. Do not wash out or dispose of containers in the vicinity of water wells. Consider alternative methods of treatment for areas underlain by karstic limestone.
Biodiversity	Extremely poisonous to invertebrates, mammals, birds and fish.	Seal greenhouse after treatment. Leave adequate untreated margin between treated area and natural vegetation.
Air and dust	Highly soluble and unlikely to evaporate.	
Natural resources		
Water	The need for repeated application with drip irrigation may diminish resources.	Properly manage the application of water so as not to over-irrigate.
Hydrocarbons	The need for repeated application requires the use of additional fuel.	
Waste generation		
Liquid waste	Liquid waste generated only if containers washed out inappropriately.	Only wash out containers within treated areas.
Solid waste	Containers.	Dispose of at facility licensed to take such materials. Ensure containers are empty.
Recycling	Little or no potential for recycling.	Containers may be re-used with care.
Socio-economics		
Employment	The need for repeated applications may offer additional employment opportunities.	Additional workers should be taken from the local community.
Training	Untrained operators engaged in the application could risk the health of themselves and fellow workers.	Workers and others engaged in the application should be made aware of the need to abide by manufacturers' recommendations for handling and use, other health and safety issues, and environmental impact mitigation.

Table 5.5: Potential impacts of soil solarization

Issue	Potential impact	Possible mitigation
Health and safety		
Storage and handling	None.	
Occupational hazard	None.	
Public health and safety	None.	
Pollution		
Soil/crop accumulation	None.	
Surface water	The need to irrigate to beyond soil saturation may cause soil erosion on slopes and result in suspended solids entering watercourses.	Properly manage the application of water and do not excessively over-irrigate.
Pollution		
Groundwater	None expected.	
Biodiversity	None expected.	
Air and dust	None expected.	
Natural resources		
Water	The need to irrigate to beyond soil saturation may diminish resources.	Properly manage the application of water and do not excessively over-irrigate.
Hydrocarbons	No significant use of hydrocarbons.	
Waste generation		
Liquid waste	None expected.	
Solid waste	Plastic cover sheets. Under extreme conditions, surface laid irrigation equipment and greenhouse metals may rust.	Dispose of at a facility licensed to take such materials.
Recycling	Plastic cover sheets.	Since the plastic cover sheets will not have been in contact with toxic chemicals, they may be re-used in another agricultural application. However, 50 microns is very thin and it is likely they will be damaged during removal.
Socio-economics		
Employment	Little potential for the generation of additional employment opportunities.	
Training	Little training required.	

The process takes some six to eight weeks and is best performed during the months of June, July and August. Crops can therefore only be planted towards the end of the summer. The rise in soil temperature is usually within the range 5-10°C. In parts of Lebanon that experience an average ambient temperature significantly less than 40°C this may not be enough to provide the required control. Conversely, the high temperatures experienced in some areas on the coastal plain may make this method too extreme and affect beneficial organisms. Soil solarization as an alternative to methyl bromide may therefore only be applicable in certain areas and for certain crops.

The use of treated nylon sheets in place of ordinary plastic has been shown to give a further rise in soil temperatures of 4-5°C.

The primary potential impacts of using soil solarization as an alternative to methyl bromide are summarized in Table 5.5.

5.6.1 Soil solarization with chemical treatment

For areas of severe infestation, relatively low ambient soil temperatures, and to protect against re-infestation, small doses of chemicals may be used in support of soil solarization. The most common chemicals so used are 1,3-Dichloropropene and Oxamyl.

Whilst chemical application rates are lower when used in conjunction with soil solarization compared to when using these chemicals alone, the potential environmental impacts and the recommended mitigation measures are essentially the same, although the impact may be less severe.

5.7 Potential impact of bio-fumigation

Bio-fumigation uses an early sacrificial crop such as oil radish or Sudan grass, which after approximately one month of growth is cut, ploughed in and allowed to decompose in the soil. The process of decomposition releases by-products, primarily vapours that permeate the soil and kill pests and diseases. In recent years, seed companies have developed new varieties of sacrificial crops for different soil types and/or climates.

The recommended procedure for the application of bio-fumigation is as follows:

Preparation	*Application*	*Post-treatment*	*Special conditions*
Clean soil, plough and fertilize. Irrigate to soil saturation. Plant sacrificial crop seeds at 3 kg/dn.	After one month, cut and plough crop in to a depth of 20-30 cm. Spray-irrigate and cover with plastic sheets for 10 days.	None. Ready for transplanting.	New sacrificial crop varieties now produced for a range of soils and climates. Method not really fully defined. May need additional time for full decomposition. Needs good irrigation management.

The by-products produced during decomposition include nitrates, ammonia, hydrogen sulphide, other volatile compounds and organic acids. Under certain conditions, phytotoxic compounds may also be released.

Since treated areas are covered with plastic sheeting to increase soil temperatures, speed the process of decomposition and retain the by-product to maximize soil-vapour contact-time, the process of bio-fumigation also uses the process of soil solarization.

The primary potential impacts of using bio-fumigation as an alternative to methyl bromide are summarized in Table 5.6.

Table 5.6: Potential impacts of bio-fumigation

Issue	Potential impact	Possible mitigation
Health and safety		
Storage and handling	None.	
Occupational hazard	Decomposition products may be dangerous to health.	Prevent unnecessary access to treated greenhouse.
Public health and safety	Decomposition products may be dangerous to health.	Those not engaged in the application, especially children and domestic animals, should be kept away from the treated area. Seal greenhouse after treatment.
Pollution		
Soil/crop accumulation	No soil or crop accumulation reported.	
Surface water	The need to irrigate to soil saturation may cause soil erosion on slopes and result in suspended solids entering watercourses.	Properly manage the application of water and do not over-irrigate.
Groundwater	No infiltration of decomposition product to groundwater reported.	
Biodiversity	None expected. Some impact from phytotoxic chemicals may be possible but considered unlikely.	Adhere to well-documented method of treatment.
Air and dust	None expected.	
Natural resources		
Water	The need to irrigate to soil saturation may diminish resources.	
Hydrocarbons	No significant use of hydrocarbons.	
Waste generation		
Liquid waste	None expected.	
Solid waste	Plastic cover sheets.	Dispose of at a facility licensed to take such materials.
Recycling	Plastic cover sheets.	Since the plastic sheets have only been in contact with natural decomposition by-products, they may be re-used in another, carefully selected agricultural application.
Socio-economics		
Employment	Little potential for additional employment opportunities.	
Training	Little training required.	

5.7.1 Bio-fumigation with Chitinase

Bio-fumigation is often undertaken in conjunction with the application of Chitinase, an enzyme derived from aquatic organisms, which acts on the chitin present in the cuticle of nematodes to break it down and speed nematode decay.

The potential impacts associated with the use of Chitinase are poorly recorded, but being a natural product, it is not expected to significantly detract from the advantage otherwise associated with bio-fumigation.

5.8 Potential impact of grafted plants

The use of grafted plants in place of methyl bromide is generally considered to be both 100 per cent environmentally friendly and very efficient. Several varieties of rootstock are available for a wide range of crops and grafted plants are immediately available for transplanting without any waiting period. Extensive pre-development of the crop root system also reduces the need for fertilizer throughout the growing season.

Table 5.7: Potential impacts of grafted plants

Issue	Potential impact	Possible mitigation
Health and safety		
Storage and handling	None expected.	
Occupational hazard	Grafting requires the use of sharp cutting tools.	Cutting tools should be securely stored when not in use.
Public health and safety	None expected.	
Pollution		
Soil/crop accumulation	None expected.	
Surface water	None expected.	
Groundwater	None expected.	
Biodiversity	None expected.	
Air and dust	None expected.	
Natural resources		
Water	The need to constantly mist irrigate may diminish resources.	
Hydrocarbons	No significant use of hydrocarbons.	
Waste generation		
Liquid waste	None.	
Solid waste	With time rootstock may become susceptible and need to be discarded. Netting will also need to be replaced in time.	Netting should be disposed of at a facility licensed to take such materials.
Recycling	Rootstock and netting.	Discarded rootstock may be composted. Netting may be re-used for other agricultural applications.
Socio-economics		
Employment	Little potential for the generation of additional employment opportunities.	
Training	Grafting is a specialist skill.	Training will be required throughout the agricultural community.

The recommended procedure for the use of grafted plants is as follows:

Preparation	*Application*	*Post-treatment*	*Special conditions*
Clean soil, plough and irrigate. Plant crop in special seed trays.	Crop is grafted onto rootstock 15-20 days after sowing and transplanted after a further month.	Seal nursery hermetically with netting to prevent insect entry. Constantly mist-irrigate to minimize evapo-transpiration.	Grafting is a specialized skill. Requires special seed trays and shade nets.

Different rootstock is needed to combat different pests and diseases. Hence it is important to accurately identify the problems that need to be addressed.

The process of grafting the crop cutting onto the rootstock is a special skilled craft and training courses will need to be organised throughout the farming community if it is to gain widespread acceptance as an alternative to methyl bromide. The crop has to be brought on in special seed trays, temperature and humidity need to be carefully controlled, and a mist irrigation system should operate constantly to minimize losses due to evapo-transpiration. The nursery needs to be hermetically sealed with netting to prevent insect entry and provide shade.

As new nematode species evolve, the selected rootstock may become susceptible with time and have to be replaced.

The primary potential impacts of using grafted plants as an alternative to methyl bromide are summarized in Table 5.7.

5.9 Potential impact of sheet steaming

Sheet steaming is expensive and energy intensive, and is often considered to only be economical for high value cash crops such as flowers and ornamental plants. It provides an excellent method of control on clayey soils, but is often less effective on more permeable sandy or loamy soils.

The recommended procedure for the use of sheet steaming is as follows:

Preparation	*Application*	*Post-treatment*	*Special conditions*
Clean soil and till to 30 cm to break aggregates.	Cover soil with plastic sheets. Apply steam under sheets. Depth of injection depends upon severity of infestation.	None. Keep soil covered until ready to plant.	Apply organic compost.

The primary potential impacts of using sheet steaming as an alternative to methyl bromide are summarized in Table 5.8.

5.10 Summary of potential environmental impacts

5.10.1 The impact of methyl bromide

Methyl bromide is one of the most dangerous known chemicals. It is toxic to all living organisms and has been used extensively for about 50 years as a soil fumigant to combat a wide range of pests and diseases. Its extreme toxicity makes it non-selective, and beneficial soil pathogens, such as nitrogen-fixing bacteria, are also affected so farmers have to apply organic fertilizers in order to replace them.

Table 5.8: Potential impacts of sheet steaming

Issue	Potential impact	Possible mitigation
Health and safety		
Storage and handling	None.	
Occupational hazard	Workers are at risk of being scalded while operating the steam boiler and applying the steam to the soil.	Heat protective gloves and overalls should be worn. Training, including health and safety issues should be given.
Public health and safety	Risk of scalding.	Those not engaged in the application, especially children and domestic animals, should be kept away from the area during treatment.
Pollution		
Soil/crop accumulation	None. Overheating may destroy soil structure and release phytotoxic compounds.	Strictly follow recommended procedures for steam application.
Surface water	None.	
Groundwater	None.	
Biodiversity	None.	
Air and dust	If soil not adequately covered dust may be raised while moving the steam injection pipe.	Soil should be adequately covered. A steam release valve away from the injection head will enable steam to be released safely until the head is in place.
Noise	The steam boiler and the application of steam to the soil will be inherently noisy.	All baffles and silencers should be fitted in accordance with manufacturers' recommendations and maintained in good order. Generators should comply with the provisions of Decision 15/1.
Natural resources		
Water	The generation of steam requires large quantities of water that may diminish resources.	Although requiring water, steam application does not require saturating soil with water, hence making it less water-consuming than other alternatives (such as soil solarization).
Hydrocarbons	The steam boiler requires use of fuel.	The equipment should be kept in good mechanical condition so as to be fuel-efficient.
Waste generation		
Liquid waste	None.	
Solid waste	Plastic cover sheets.	Plastic cover sheets should be disposed of at a facility licensed to take such materials.
Oil and grease	The steam boiler will generate some waste oil and grease.	Waste oil and grease should be collected, sealed and disposed of at a facility licensed to take such materials.
Recycling	Plastic cover sheets	Since the plastic cover sheets will not have been in contact with toxic chemicals, they may be re-used in another agricultural application. However, 50 microns is very thin and it is likely they will be damaged during removal.
Socio-economics		
Employment	There is some potential for the generation of additional employment opportunities.	Sheet steaming, primarily because of the need to move pipes, is labour intensive and additional staff may be required.
Training	Training is recommended.	Training in the best ways of applying the steam should be given. The need to adhere to health and safety issues will form an important part of such training.

However, the principal disadvantage of methyl bromide is that between 30 and 80 per cent of the chemical used in agriculture evaporates into the atmosphere. It has long been known to be an ODS and as such, the Montreal Protocol of 1997 reached widespread international agreement that its production and use would be phased out by 2015. Many countries, including Middle East states such as Syria, already ban its use as an agro-chemical.

In Lebanon, methyl bromide is widely used in agriculture, particularly for sterilising greenhouse soils before planting. Application rates are high, 80-100 kg/dn whereas the average elsewhere is 50-60 kg/dn. The effect of the phase-out will severely affect current agricultural practices throughout the country. Although there are a number of tried and tested alternatives, both chemical and non-chemical, no single method will adequately replace methyl bromide for all its applications.

5.10.2 Assumptions in assessing the impact of alternatives

In assessing the potential impacts of each of the selected alternatives to methyl bromide, a number of assumptions have necessarily been made. These are primarily as follows.

The selected alternatives will be used within the confines of greenhouses (poly-tunnels) and not on open fields. As such, no account has been taken of the visual impact. Conversely, for alternative methods that generate toxic vapours, the assessment takes into account a relative lack of ventilation in greenhouses as opposed to open fields.

The important impacts to take into account are those that are additional to normal agricultural activities. As such, no account has been taken of the noise generation, the depletion of hydrocarbon resources, or the generation of waste oil and grease from activities such as ploughing or irrigation pumping.

5.10.3 Limitations on the impact assessment

The assessment of the environmental impacts is also generalised. No allowance has been made for site-specific criteria such as soil texture and permeability, the importance of underlying bedrock as aquifers, or the proximity of the application site to surface watercourses or the sea.

Although the potential impacts have been noted where such criteria may be of particular significance, when considering a particular alternative for a specific site, the relative significance of the identified impacts may be subject to change. Nevertheless, the assessment of environmental impacts does provide useful guidance for decision-making on a countrywide scale.

5.10.4 Summary of potential impacts

The relative overall impact of the selected alternatives to methyl bromide is shown in Table 5.9 (impact matrix).

The matrix is necessarily comparative and subjective; highly toxic chemicals rate a higher negative score than those classified as harmful. This score and its differential between the various alternatives are also reflected in the potential impact on biodiversity and the likelihood of chemicals drifting onto natural vegetation and/or habitat.

No attempt is made to differentiate the relative importance between various issues, as this will be site-specific and will need to be reassessed for each site and for each proposed alternative.

The total score is also relative and there is no significance in the absolute numbers. The important difference is the relative score of the individual alternatives compared to one another.

Table 5.9: Potential impacts of alternatives to methyl bromide – an impact matrix

Issue	Dazomet	CAdusafos	Dichloro propene	Oxamyl	Soil solarization	Bio-fumigation	Grafted plants	Sheet steaming
Health and safety								
Storage & handling	-3	-4	-5	-5	0	0	0	0
Occupational hazard	-3	-4	-5	-5	0	-1	-1	-2
Public health & safety	-3	-4	-5	-5	0	-1	0	-1
Pollution								
Soil/crop	0	-3	0	-1	0	0	0	-1
Surface water	-1	-2	-3	-3	-1	-1	0	0
Groundwater	0	-2	-2	-2	0	0	0	0
Biodiversity	-2	-3	-4	-4	0	0	0	0
Air and dust	-2	0	-3	0	0	0	0	-1
Noise	0	0	0	0	0	0	0	-2
Natural resources								
Water	-2	-3	-3	-2	-3	-3	-2	-3
Hydrocarbons	0	0	0	-1	0	0	0	-2
Waste generation								
Liquid waste	-1	-1	-1	-1	0	0	0	0
Solid waste	-2	0	-2	-2	-2	-2	-2	-2
Oil & grease	0	0	0	0	0	0	0	-1
Recycling	-2	0	0	0	+1	+1	+1	+1
Socio-economics								
Employment	0	0	0	+1	0	0	0	+2
Training	+2	+2	+2	+2	0	0	+1	+2
TOTALS	**-19**	**-24**	**-31**	**-28**	**-5**	**-7**	**-3**	**-10**

Not surprisingly, the chemical alternatives represent the greatest potential for adverse environmental impacts. Other significant criteria are the relative use of water resources and the generation of waste. Any potential for recycling, additional employment opportunities and the need for training are considered to be positive impacts.

Based on the present assessment, the most environmentally friendly alternative is grafted plants, followed by soil solarization and bio-fumigation. The rating of chemical alternatives essentially reflects their relative toxicity.

5.11 Environmental management and mitigation

Measures for the mitigation of potential environmental impacts have been presented. Chemicals need to be stored, handled and applied in accordance with good practice and manufacturers' recommendations. Care is particularly required in the vicinity of watercourses, wells and areas of natural vegetation. Irrigation needs to be appropriately managed to prevent over-application.

The potential for recycling waste materials is limited. The plastic cover sheets commonly used are only 50 microns thick and are likely to be torn when removed. Cover sheets that have been in contact with toxic chemicals or their by-products should not be re-used for other agricultural applications. Plant debris, such as redundant rootstock, may be composted.

5.12 Environmental monitoring

Should one or more of the chemical alternatives to methyl bromide become commonly used, the MOE should consider setting limits for the presence of residues in potable water, and monitor selected areas to ensure early warning of any problems.

5.13 Capacity-building

Several of the selected alternatives require operators to be trained. Such training should include comprehensive coverage of health and safety aspects.

5.14 Advantages and disadvantages of methyl bromide and its alternatives by waiting period

The waiting period concept in this study is especially important. The waiting period is the time required for each alternative during which no agricultural operation can be performed. In other words, some fumigation alternatives require a certain lapse of time after application of the product before either planting or harvesting. It is very important in that some alternatives can be more advantageous than others since they allow the farmer a longer or a shorter planting season, thus taking advantage of higher market prices during the low season. If, for example, one farmer can harvest before the start of the high production season when the supply is not yet at its peak, or late in the season when production has decreased, he can benefit from higher prices on the market and maximize his profits. Inversely, if a farmer uses an alternative with a waiting period that results in harvest during the high season, his products will enter the market at a time when the prices are relatively low, and thus earn less profit. In general, however, farmers prefer alternatives with short waiting periods, so that they can plant over two seasons (one long and one short season) in the same year.

It is important to note that the waiting period can have a sizeable effect on the viability of the crop or its quality, especially with chemical alternatives. For alternatives requiring a waiting period prior to planting, non-respect of this period may result in lower seed germination rates or higher seedling mortality rates since chemicals still present in the site might be toxic to the seeds.

In the case of alternatives requiring a waiting period before harvesting, non-respect of these periods can lead to the accumulation of chemical residues in the fruits, which can result in several direct and indirect effects. For example, a direct effect may include the impact on consumers' health. As mentioned in Chapter 4 of this report, the chemicals used may be a tremendous health hazard if present above specified doses. One indirect consequence is the effect on the marketing of the products outside Lebanon. The presence of chemical residues above certain values can obstruct the export of these products to several countries.

Table 5.10 shows the ranking of methyl bromide and its alternatives in terms of waiting periods. As can be seen, grafted plants require no waiting period if they are bought as already grafted transplants and then

Table 5.10: Ranking of methyl bromide and its alternatives by waiting period (including 7 days for soil preparation)

Alternative	Waiting period (days)	Rank
Grafted plants	0	1
Methyl bromide	17	2
1,3-Dichloropropene (uncovered)	21	3
Oxamyl	21	3
Cadusaphos	21	3
Dazomet	21	3
1,3-Dichloropropene (covered)	31	4
Bio-fumigation	40	5
Bio-fumigation + Chitinase	40	5
Solarization	56	6
Solar + 1,3-Dichloropropene	56	6
Solar + Oxamyl	56	6

planted in the greenhouse. In this case, grafted plants represent the best alternative in terms of waiting period. However, if the plants were to be grafted at the site, then the entire grafting operation, from production of the grafted plants to their transplantation, would require about 30 days. In this case, grafting would no longer represent the best alternative with respect to waiting periods, and the chemical alternatives would be considered as the best in terms of waiting periods.

The table indicates that, besides grafting, methyl bromide has the shortest waiting period (7 days) before planting. The alternative with the longest waiting period before planting is soil solarization (56 days). In this case, not respecting the waiting period is not toxic to plants or humans, but rather results in poor pest control.

Table 5.10 also shows that chemical alternatives in general require shorter waiting periods than non-chemical alternatives, which represents one benefit of the chemical alternatives over non-chemical ones.

6. Profitability analysis for methyl bromide and its potential replacement alternatives in Lebanon

6.1 Introduction

Cost-benefit analysis (CBA) represents a powerful tool to determine the feasibility of a project or series of projects. The feasibility assessment performed in this study involved the estimation of the expected annual profit for each crop using each of the considered soil fumigation techniques (methyl bromide and alternatives). The study analysis was conducted based on the per unit net profit (above variable costs) for methyl bromide and each of the alternatives. Methyl bromide and its potential alternatives in Lebanon were then compared for each of the crops considered in this study (cucumbers, eggplants, strawberries, and tomatoes) to determine the most financially feasible alternative proposed for each crop. The financially feasible alternatives constitute potentials for export, particularly if the crop is produced in an environmentally friendly way.

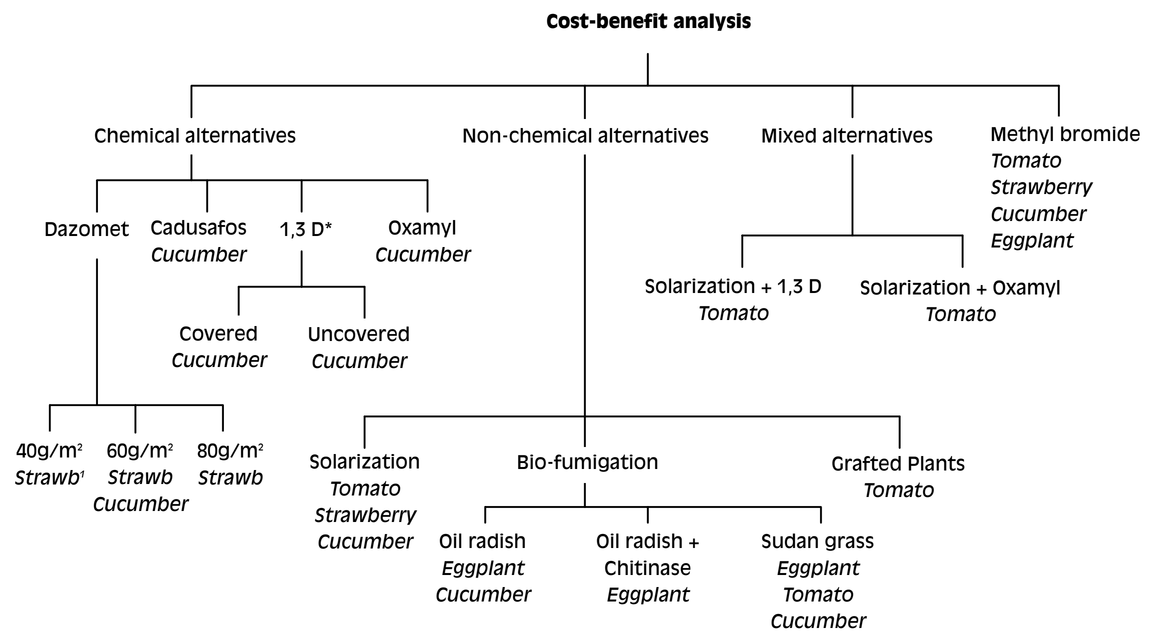
A financial CBA for the various considered treatments was also performed and was carried out using the net present value (NPV), benefit to cost ratio (BCR), and whenever applicable, the internal rate of return (IRR) techniques. Two main scenarios were considered in the CBA: Scenario 1 using average product and input prices of years 2000 and 2001 and Scenario 2 considering a 20 per cent increase in product prices, which is expected as a result of selling “clean” products once the Montreal Protocol requirements are met.

6.2 Classification of the study treatments

Fourteen different soil fumigation techniques were considered in addition to the current fumigation practice using methyl bromide. These techniques were divided into chemical, non-chemical and mixed alternatives in addition to methyl bromide. Methyl bromide was tested on the four considered crops (cucumbers, eggplants, strawberries and tomatoes), whereas the alternatives were tested on one, two or three crops based on available data resulting from the Methyl Bromide Demonstration Project, representing a total of 24 treatments.

Figure 6.1 represents a schematic diagram of the different treatments applied for the purpose of this study according to whether they were chemical, non-chemical, mixed, or methyl bromide and the crop(s) they were applied to. Table 6.1 lists these different treatments including the soil fumigation techniques and their respective crops. As can be seen from the figure and table, four of the 24 treatments are those of methyl bromide used in each of the four crops, while the remaining 20 are the alternatives, of which eight are chemical, ten are non-chemical and two are mixed.

Figure 6.1: Schematic diagram for the different treatments applied and their respective crops



** 1,3 D = 1,3-Dichloropropene, Strawb = Strawberry*

Table 6.1: Soil fumigation treatments considered in this study

Soil fumigation technique	Type	Crop	Treatment #
Dazomet 40 g/m²	Chemical	Strawberry	IA1
Dazomet 60 g/m²	Chemical	Strawberry Cucumber	IA2a IA2b
Dazomet 80 g/m²	Chemical	Strawberry	IA3
Cadusafos	Chemical	Cucumber	IB
1,3-Dichloropropene (covered)	Chemical	Cucumber	IC1
1,3-Dichloropropene (uncovered)	Chemical	Cucumber	IC2
Oxamyl	Chemical	Cucumber	ID
Soil solarization	Non-chemical	Tomato Strawberry Cucumber	IIA1 IIA2 IIA3
Bio-fumigation (oil radish)	Non-chemical	Eggplant Cucumber	IIB1a IIB1b
Bio-fumigation (oil radish + Chitinase)	Non-chemical	Eggplant	IIB2
Bio-fumigation (Sudan grass)	Non-chemical	Eggplant Tomato Cucumber	IIB3a IIB3b IIB3c
Grafting	Non-chemical	Tomato	IIC
Soil solarization + 1,3 Dichloropropene	Mixed	Tomato	IIIA
Soil solarization + Oxamyl	Mixed	Tomato	IIIB
Methyl bromide	Chemical	Tomato Strawberry Cucumber Eggplant	IVA IVB IVC IVD
Total number of treatments			24

6.3 Classification of the production costs

Two types of analyses were planned for this study: financial and economic. In the financial analysis, the costs considered were the direct or monetary costs that are related to the soil fumigation techniques used and the crop production costs. In the economic analysis, the costs considered were the indirect or social costs that include the environmental and health costs of the soil fumigation techniques, in addition to the financial ones. Monetary returns were considered the same in both the financial and economic analyses. However, in the social benefits, positive health and environmental impacts were considered. The economic analysis is described in Chapter 7 of this report. Figure 6.2 represents a schematic diagram of the cost classification considered in this study.

The financial costs were categorised into three main sets: incremental costs, other production costs, and fixed costs. The incremental costs are the additional costs that are directly related to the alternatives and include the cost of the input product (chemical or non-chemical substance used in the alternative), the cost of additional water and labour required for its application, as well as the cost of materials and equipment needed to apply the alternative. The other production costs are the variable costs that are required for the production operation of crops and are divided into pre-plant costs and cultural and harvest costs. The fixed costs are those related to the equipment, machinery and land rent.

6.4 Enterprise budgets for the study treatments

In order to calculate the annual net revenues (NR) for the various treatments, 24 budgets were developed in which the total revenue by crop and by alternative was estimated. The revenue for each crop was calculated by multiplying the yield obtained from each treatment (results of the Methyl Bromide Demonstration Project – Lebanon) by the average farm-gate prices of 2000-2001 obtained from the MOE.

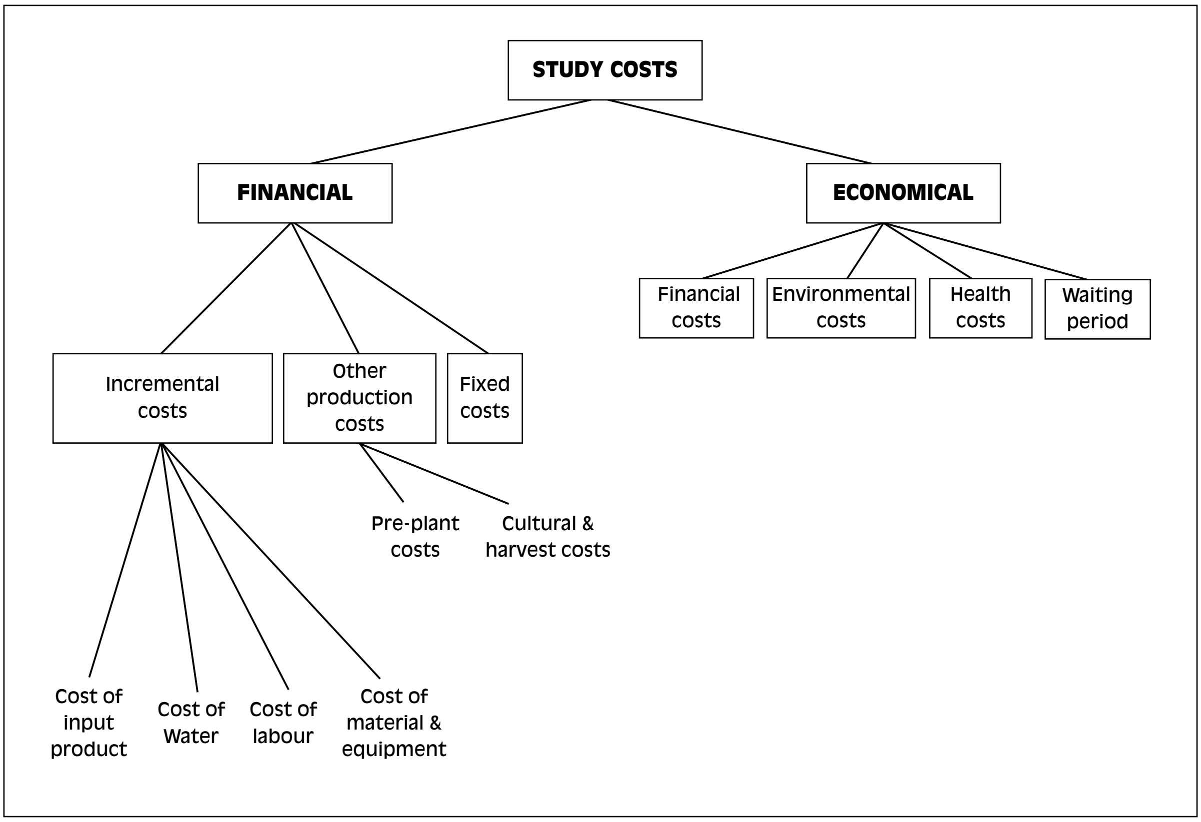
In addition to the financial costs previously described, three NRs were considered in the enterprise budgets:

- N_1: NR above incremental costs
- N_2: NR above incremental and other variable costs
- N_3: NRs above all costs.

The NRs, as defined in this context, represent the difference between the expected total revenues of a given crop and the considered cost of this crop based on the above classification (i.e. incremental cost, incremental + other production costs, total costs). The reason for the three considered revenues is that the first one, N_1, will determine the feasibility that is only due to the change in the fumigation technique considering all remaining costs as sunk costs (since all other costs are the same for each crop). The second and third NRs, N_2 and N_3, represent the profitability over variable and total costs respectively for a given crop using a specific soil fumigation technique.

Table 6.2 presents an example of the budget when methyl bromide is used on eggplants. As can be seen, the budgets in this study were divided into five major components. The first component is the total revenue. The second component constitutes the incremental costs that are only due to the fumigation technique (as previously defined). The third component is made up of the other production costs of each considered crop (common among all alternatives for the same crop). The fourth component represents the annual fixed costs that are related to the equipment, the machinery and the land. In case of owned land, an opportunity cost equal to the rent was considered (common among all treatments). The last component is the NR above all the costs (incremental costs + other variable costs + fixed costs).

Figure 6.2: Cost classification for the CBA



6.5 Enterprise budget assumptions and specifications

The annual financial feasibility of all the alternatives was carried out on a per dunum basis. Even though the experiments on methyl bromide alternatives were conducted in greenhouses in which the average area was about 500 m^2, the results have been standardized to one dunum. In other words, all the costs and revenues considered in the study are those of one dunum of land. The dunum is a unit of area measurement that is commonly used in agricultural areas of Lebanon; one dunum is almost 1,000 m^2.

6.6 Cost specifications and calculations

Three main sets of costs were considered: incremental costs, other variable costs, and fixed costs. Table 6.3 shows a description of the various estimated production and fixed costs considered in the enterprise budgets as well as certain specifications related to each of these costs.

Table 6.4 represents a detailed description of all the input coefficients of the soil fumigation techniques used in the study as well as the respective prices of each of the inputs used on a per dunum basis. In addition, the table displays each type of fumigation technique used as well as the crop or crops on which it was tested.

Table 6.2: Budget for eggplant using methyl bromide

Treatment IVD: methyl bromide / Crop: eggplant

Output/dunum

Item	Unit	Quantity	Price (US$/unit)	Total price (US$)
Yield	Kilograms	10,120	0.24	2,445.67
Total revenue				2,445.67

Costs related to the alternative per dunum

Item	Unit	Quantity	Price (US$/unit)	Total price (US$)
Methyl bromide	Dunum	1	500.00	**500.00**
Irrigation water	m^3	100	0.05	**5.00**
Plastic sheets	Dunum	1	100.00	**100.00**
Labour				
Labour to cover with plastic sheets	Hours	4.5	1.33	5.99
Labour to uncover plastic sheets	Hours	0.5	1.33	0.67
Total labour costs				**6.65**
Total costs				611.65
Return per alternative				**1,834.02**

Other variable costs per dunum

Item	Unit	Quantity	Price (US$/unit)	Total price (US$)
Pre-plant costs				
Cleaning soil from leftovers (labour)	Hours	16	1.33	21.28
Ploughing and tilling (tractor)	Hours	1	27.50	27.50
Preparatory organic fertilizer	Kg	222.5	0.54	120.15
Preparatory chemical fertilizer	Kg	75	0.33	24.75
Total pre-plant costs				193.68
Cultural and harvest costs				Seeds
Seed	1,700	0.01	19.59	
Fertilizers	Kg	315	1.00	315.00
Pesticides	Dunum	1	180.00	180.00
Irrigation	m^3	1,000	0.13	125.00
Trays	Tray	5	0.40	2.01
Cups	Cup	1,700	0.01	13.25
Potting Soil	Litres	242.85	0.13	31.57
Labour costs				
For seeding & transplanting to cups	Hours	2.5	1.33	3.33
For applying pesticides	Hours	20	1.33	26.60
For transplanting	Hours	6	1.33	7.98
For harvesting	Hours	150	1.33	199.50
Total labour costs				**237.41**
Cages/boxes for harvested crop	Box	2,024	0.07	134.93
Total cultural and harvest costs				1,057.68
Total costs				1,251.36
Return above variable costs				**582.66**

Fixed costs/dunum

Item	Unit	Quantity	Price (US$/unit)	Total price (US$)
Land rent	Dunum	1	91.70	91.70
Irrigation costs				
Irrigation pump	Pump	1	114.80	114.80
Labour for establishing irrigation system	Dunum	1	6.00	6.00
Irrigation system	System	1	65.95	65.95
Fertilizer mixer	Mixer	1	23.49	23.49
Total irrigation costs				210.24
Greenhouse infrastructure				
Steel	Dunum	1	549.12	549.12
Plastic	Dunum	1	382.01	382.01
Labour for establishing steel	Dunum	1	55.56	55.56
Labour for establishing plastic	Dunum	1	20.00	20.00
Nets for insect control	Dunum	1	94.64	94.64
Total greenhouse costs				1,101.33
Total costs				1,403.27
Return above all costs				**(820.62)**

Source: Results of the Methyl Bromide Demonstration Project – Lebanon, 2001 & Lebanese Agricultural Input Supplying Companies

Table 6.3: Estimation of some of the production and fixed costs

Item	Cost	Unit	Remarks
Production costs			
Water for irrigation			
Flood	0.05	US$/m³	Based on previous projects
Sprinkler	0.125	US$/m³	Based on previous projects
Tractor for ploughing	27.50	US$/hr	Average rental cost per hour
Labour	1.33	US$/hr	Based on an 8-hour working day
Fixed costs			
Land rent	91.70	US$/dunum	Based on average rental per year
Irrigation			
Pump	114.80	US$/pump	Amortized over 6-year lifespan with a 10 per cent interest rate
System	65.95	US$/system	Amortized over 5-year lifespan with a 10 per cent interest rate
Mixer	23.49	US$/mixer	Amortized over 20-year lifespan with a 10 per cent interest rate
Greenhouse infrastructure			
Steel	549.12	US$/dunum	Amortized over 20-year lifespan with a 10 per cent interest rate
Plastic	382.01	US$/dunum	Amortized over 3-year lifespan with a 10 per cent interest rate

Table 6.4: Input coefficients and prices for the different soil fumigation techniques per dunum

Technique	Type	Crop	Input	Quantity	Unit	Cost/unit (US$)	Total cost (US$)
Cadusafos	Chemical	Cucumber	Cadusafos	4.5	Litres	22.00	99.00
			Water	122.5	m³	0.13	15.31
Dazomet		Strawberry Strawberry Cucumber Strawberry	Dazomet	40 60 80	Kg Kg Kg	6.60 6.60 6.60	264.00 396.00 528.00
	Chemical		Applicator	1	Applicator	4.07*	4.07
			Tractor	0.25	Hour	27.50	6.88
			Plastic sheets	1	Dunum	100.00	100.00
			Water	70	m³	0.13	8.75
			Labour	7	Hour	1.33	9.31
1,3-Dichloropropene (covered)	Chemical	Cucumber	1,3-Dichloropropene	20	Litres	15.00	300.00
			Injection device	1	Device	34.73*	34.73
			Plastic sheets	1	Dunum	100.00	100.00
			Water	1.67	m³	0.13	0.21
			Labour	5	Hour	1.33	6.65
1,3-Dichloropropene (uncovered)	Chemical	Cucumber	1,3-Dichloropropene	20	Litres	15.00	300.00
			Injection device	1	Device	34.73*	34.73
			Water	101.67	m³	0.13	12.71
			Labour	0.5	Hour	1.33	0.67
Oxamyl	Chemical	Cucumber	Oxamyl	1.5	Litres	38.00	57.00
			PA	3	Litres	4.50	13.50
Soil solarization	Non-chemical	Tomato	Labour	15	Hour	1.33	19.95
		Strawberry	Water	100	m³	0.05	5.00
		Cucumber	Plastic sheets	1	Dunum	100.00	100.00
Bio-fumigation (oil radish)	Non-chemical	Eggplant Cucumber	Oil radish seeds	3	Kg	5.00	15.00
			Sprinkler system	1	Dunum	11.75*	11.75
			Tractor	1	Hour	27.50	27.50
			Plastic sheets	1	Dunum	100.00	100.00
			Labour	14	Hour	1.33	18.62
			Water (flood)	100	m³	0.05	5.00
			Water (sprinkler)	5.25	m³	0.13	0.66

Technique	Type	Crop	Input	Quantity	Unit	Cost/unit (US$)	Total cost (US$)
Bio-fumigation (oil radish + Chitinase)	Non-chemical	Eggplant Tomato Cucumber	Oil radish seeds	3	Kg	5.00	15.00
			Chitinase	1	Litres	20.00	20.00
			Sprinkler system	1	Dunum	11.75*	11.75
			Tractor	1	Hour	27.50	27.50
			Plastic sheets	1	Dunum	100.00	100.00
			Labour	14	Hour	1.33	18.62
			Water (flood)	100	m^3	0.05	5.00
			Water (sprinkler)	5.25	m^3	0.13	0.66
Bio-fumigation (Sudan grass)	Non-chemical	Eggplant	Oil radish seeds	3	Kg	5.00	15.00
			Sprinkler system	1	Dunum	11.75*	11.75
			Tractor	1	Hour	27.50	27.50
			Plastic sheets	1	Dunum	100.00	100.00
			Labour	14	Hour	1.33	18.62
			Water (flood)	100	m^3	0.05	5.00
			Water (sprinkler)	5.25	m^3	0.13	0.66
Grafting	Non-chemical	Tomato	Grafted plants	1250	Plant	0.35	437.50
Soil solarization + 1,3-Dichloropropene	Mixed	Tomato	1,3-Dichloropropene	20	Litres	15.00	300.00
			Injection device	1	Device	34.73*	34.73
			Plastic sheets	1	Dunum	100.00	100.00
			Water	100	m^3	0.05	5.00
			Labour	15	Hour	1.33	19.95
Soil Solarization + Oxamyl	Mixed	Tomato	Oxamyl	1.5	Litres	38.00	57.00
			PA	1.5	Litres	4.50	6.75
			Plastic sheets	1	Dunum	100.00	100.00
			Water	100	m^3	0.05	5.00
			Labour	15	Hour	1.33	19.95
Methyl Bromide	Chemical	Tomato Strawberry Cucumber Eggplant	Methyl bromide	1	Dunum	500.00	500.00
			Plastic sheets	1	Dunum	100.00	100.00
			Water	100	m^3	0.05	5.00
			Labour	5	Hour	1.33	6.65

* Dazomet applicator cost amortized over 10 years; 1,3-Dichloropropene injection device cost amortized over 9 years; Sprinkler system cost amortized over 20 years

6.7 Annual profit comparison among alternatives

A financial comparison among alternatives was conducted on total and per unit bases. Hence, ranking of methyl bromide and its alternatives was done based on the respective incremental costs and per unit NR above incremental and other variable costs.

6.7.1 Comparison of methyl bromide and its alternatives by incremental cost

As previously mentioned, fourteen soil fumigation alternatives in addition to methyl bromide were proposed and tested on different crops in the Methyl Bromide Alternatives Project – Lebanon. Table 6.5 shows the ranking of these alternatives by incremental cost. It should be noted that these costs include the cost of the input product in addition to all the costs (monetary values) related to the application of these alternatives such as the cost of water, labour and special equipment and materials for some of the alternatives. However, the unavailability of data and information for the estimation of environmental and health costs related to methyl bromide and the alternatives necessitated the exclusion of these costs from this table.

6.7.1.1 Ranking by total incremental cost (input cost of alternative)

Table 6.5 indicates that Oxamyl is the cheapest soil fumigation alternative (US$ 70.5/dn), and Dazomet, applied at a rate of 80g/m^2, is the most expensive one (US$ 657/dn). Methyl bromide is ranked 13th among the different soil fumigation techniques with a total cost of US$ 611.65/dn. The results indicate that all the considered alternatives (except for Dazomet 80g/m^2) are cheaper than methyl bromide in terms of the cost of application.

In comparing the incremental costs of the various alternatives versus those of methyl bromide, the percentage change between the costs of each of the alternatives and the costs of methyl bromide were estimated (Table 6.6). In this study every positive percentage change for a given alternative is considered as an advantage or a benefit that can add up to monetary benefits compared to methyl bromide, while every negative change for a given alternative is considered an additional cost that will reduce the benefits compared to methyl bromide.

In addition to comparing the total incremental costs, each of the four incremental cost components of the alternatives was compared against those of methyl bromide (cost of input product, water, labour and materials and equipment). Table 6.5 is a comprehensive analytical table that summarizes the incremental costs and their components for the soil fumigation techniques considered in this study. In addition, the table displays the percentage change of each alternative's incremental cost components and total incremental costs compared to methyl bromide. Ranking of the alternatives from the lowest (Rank No.1) to the highest cost required is also displayed in the table for the cost components and the total costs. This ranking enables not only the comparison of the alternatives to methyl bromide, but also the comparison of the alternatives among each other.

Table 6.5: Ranking of methyl bromide and its alternatives by total incremental cost

Soil fumigation techniques	Type of technique	Cost (US$/dn)	Treatment	Rank
Oxamyl	Chemical	70.50	ID	1
Cadusafos	Chemical	114.31	IB	2
Soil solarization	Non-chemical	124.95	IIA1 IIA2 IIA3	3
Soil solarization + Oxamyl	Mixed	178.06	IIIB	4
Bio-fumigation (oil radish)	Non-chemical	178.52	IIB1a IIB1b	5
Bio-fumigation (Sudan grass)	Non-chemical	178.52	IIB3a IIB3b IIB3c	5
Bio-fumigation + Chitinase	Non-chemical	198.52	IIB2	6
1,3-Dichloropropene (uncovered)	Chemical	348.10	IC2	7
Dazomet (40g/m^2)	Chemical	393.00	IA1	8
Grafted plants	Non-chemical	437.50	IIC	9
1,3-Dichloropropene (covered)	Chemical	441.59	IC1	10
Soil solarization + 1,3 D	Mixed	449.04	IIIA	11
Dazomet (60g/m^2)	Chemical	525.00	IA2a IA2b	12
Methyl bromide	Chemical	611.65	IVA IVB IVC IVD	13
Dazomet (80g/m^2)	Chemical	657.00	IA3	14

Table 6.6: Incremental costs of the soil fumigation techniques in US$/dunum.

		FUMIGATION TECHNIQUES													
			Chemical alternatives							Non-chemical alternatives				Mixed alternatives	
Incremental cost components		Methyl Brom.	Daz. 40	Daz. 60	Daz. 80	Cadus.	1,3-D cov.	1,3-D unc.	Oxamyl	Solariz	Bio-fum**	Bio-fum + Chit	Graft	Sol+1,3-D	Sol+Oxa
	Cost	500.00	264.00	396.00	528.00	99.00	300.00	300.00	70.50	0	15.00	35.00	437.50	300.00	63.75
	% change*	–	47.20	20.80	(5.60)	80.20	40.00	40.00	85.90	–	97.00	93.00	12.50	40.00	87.25
Input product cost	Rank	11	7	9	12	6	8	8	5	1	2	3	10	8	4
	Cost	5.00	8.75	8.75	8.75	15.31	0.21	12.71	0	5.00	5.66	5.66	0	5.00	5.00
	% change*	–	(75)	(75)	(75)	(206.2)	95.8	(154.2)	–	0	(13.2)	(13.2)	–	0	0
Water cost	Rank	3	5	5	5	7	2	6	1	3	4	4	1	3	3
	Cost	6.65	9.31	9.31	9.31	0	6.65	0.67	0	19.95	18.62	18.62	0	19.95	19.95
	% change*	–	(40)	(40)	(40)	–	0	90	–	(200)	(180)	(180)	–	(200)	(200)
Labour cost	Rank	3	4	4	4	1	3	2	1	6	5	5	1	6	6
	Cost	100	110.94	110.94	110.94	0	134.73	34.73	0	100	139.25	139.25	0	134.73	100
	% change*	–	(10.94)	(10.94)	(10.94)	–	(34.73)	65.27	–	0	(39.25)	(39.25)	–	(34.73)	0
Equipment & materials	Rank	3	4	4	4	1	5	2	1	3	6	6	1	5	3
Total cost* **		612	393	525	657	114	442	348	70.50	125	179	199	437.50	460	189
% change*		–	35.78	14.21	(7.35)	81.37	27.78	43.14	88.48	79.57	70.75	67.48	28.51	24.84	69.12
Rank		13	8	12	14	2	10	7	1	3	4	6	9	11	5

* Methyl bromide is considered the reference point, parentheses indicate a negative value.

** Bio-fumigation using oil radish and bio-fumigation using Sudan grass were considered as one alternative since they have identical costs

*** Rounded to the nearest dollar

6.7.1.2 Ranking by input product cost

The cost of the input product is the price of the alternative itself (chemical or non-chemical material used), excluding the rest of the incremental cost components.

As expected, soil solarization is the cheapest alternative since there is no cost involved, followed by bio-fumigation, which is 97 per cent less expensive than methyl bromide, and bio-fumigation with the addition of Chitinase (93 per cent cheaper than methyl bromide).

From Table 6.6 it can be seen that, with respect to the cost of the input products, the non-chemical alternatives are among the least expensive, except for grafting. The costs of the grafted plants (as input products) were only about 12 per cent less expensive than methyl bromide, and were more expensive than all other alternatives, except Dazomet applied at a rate of $80g/m^2$.

6.7.1.3 Ranking by water cost

Different soil fumigation techniques require varying amounts of additional water for their application. Among the alternatives that require no additional water preceding or following their application are Oxamyl and grafting (Table 6.6). These alternatives are considered 100 per cent better than methyl bromide in terms of water consumption costs.

It should be noted that the difference in the cost of water between the alternatives that ranked first (i.e. Oxamyl and grafting) and the alternative that ranked last (Cadusafos) is only about US$ 15 (US$ 0 and US$ 15.31 for Oxamyl/grafting and Cadusafos respectively). This difference might not be significant when considering the overall production costs.

It should also be noted that the cost of the additional water required by each alternative does not directly reflect the quantity of water consumed by that alternative since the cost of water applied through the drip irrigation system or the sprinkler irrigation system is different to the cost of water for flood irrigation (US$ 0.125 and $0.05/m^3$ respectively). The analysis based on the consumption of water quantities by each alternative was covered in Chapter 5 of this report (Environmental Impact Assessment).

6.7.1.4 Ranking by labour cost

Similarly to the cost of water, some of the alternatives considered in this study do not require any additional labour for their application, namely Cadusafos, Oxamyl, and grafting. With respect to grafting, previously grafted plants are used and they are only transplanted to the greenhouse. The labour required for transplanting is considered with the other variable costs described earlier in the chapter. It should be noted, however, that if the farmer were to graft the plants rather than buy them already grafted, the labour requirement and cost would change drastically as skilled labourers would be required to complete the different stages of the grafting process.

From Table 6.6 it can be seen that the non-chemical alternatives are more labour-intensive than the chemical alternatives, i.e. the cost of labour required for their application is higher. Methyl bromide ranks third among all alternatives with respect to labour. Here again, the difference between the lowest and highest labour cost is about US$ 20, which might not be significant when considering the overall production costs.

6.7.1.5 Ranking by cost of equipment and materials

Some of the soil fumigation techniques considered in this study require additional equipment and/or materials for their application. Bio-fumigation and bio-fumigation with Chitinase have the highest cost for additional equipment and material needed compared to methyl bromide and other fumigation techniques

(Table 6.6). The cost of equipment and materials for these two alternatives is approximately 40 per cent higher than for methyl bromide.

The alternatives that require no additional equipment and materials for their application are Cadusafos, Oxamyl and grafting (ranked #1). Methyl bromide ranks third among all alternatives.

From Table 6.6, it can be observed that the difference in cost between alternatives requiring no additional equipment and materials, and alternatives requiring the highest equipment and material costs is about US$ 140 per dunum. This value might have a significant effect on farmers' net returns when all productions costs are taken into account.

6.7.2 Comparison of methyl bromide and its alternatives by net revenue (crop/alternative basis)

As previously mentioned, the revenue considered in this study was that obtained from selling the crops. It was calculated by multiplying the yield obtained from each alternative by the average farm gate price for 2000 and 2001.

The yields considered were those of the results of the Methyl Bromide Demonstration Project – Lebanon (described in Chapter 4 of this report). The yields were taken in kilograms per dunum. In some alternatives, more than one replicate was carried out, therefore the average yield obtained for all the replicates was considered. In other alternatives, only one replicate was carried out, so the value included in the analysis represents a single trial. This may be a limitation to the study since several factors might have affected the results and a single value might not have been representative of the results of the alternative.

A per-unit analysis was carried out to calculate the NR per unit generated by each of the fumigation alternatives in order to determine the financially feasible and infeasible alternatives on each of the selected crops. The NR per unit is the difference between the unit price of each of the considered crops and the respective total average variable cost (AVC). The AVC is calculated by dividing the total variable cost (incremental variable cost + other variable cost) by the total yield obtained. A positive NR per unit indicates a financially feasible alternative (above all variable costs), while a negative NR per unit indicates a financially infeasible alternative.

In addition to the NR per unit, the break-even price (BEP) and break-even yield (BEY) were also calculated. The BEP is the output price needed to just cover all costs at a given output level, and the BEY is the yield necessary to cover all costs at a given output price. In other words, the BEP and the BEY constitute the points above which the farmers begin to make a profit. When the BEP is higher than the unit price, then the concerned alternative is financially infeasible.

The BEP and the BEY are calculated as follows:

$$\text{BEP (US\$)} = \frac{\text{Total Variable Cost * Yield}}{\text{Yield}}$$

$$\text{BEY (Kg)} = \frac{\text{Total Variable Cost * Yield}}{\text{Unit Price}}$$

Finally, the impact on crop production resulting from the use of each considered alternative was compared to the production obtained using methyl bromide. It was calculated as the percentage change in terms of yield for every alternative as compared to methyl bromide.

6.7.2.1 Cucumber

Nine different soil fumigation techniques were tested on cucumbers. Table 6.7 shows the ranking of methyl bromide and its alternatives based on the yield of cucumber resulting from each fumigation method. In addition, the table indicates the impact of using a certain alternative on production, calculated as the percentage change resulting from applying one of the considered alternatives compared to methyl bromide. Results show that methyl bromide gave the second best yield among all alternatives. The most effective alternative was obtained from applying Cadusafos (10,595 Kg/dn) and the third most effective was Oxamyl (9,650 Kg/dn). The alternative with the lowest yield was bio-fumigation using Sudan grass (1,117 Kg/dn). As shown in Table 6.7, only Cadusafos has a positive impact on production with 5.4 per cent higher yield than methyl bromide.

Table 6.7: Ranking of methyl bromide and its alternatives by yield for cucumber

Soil fumigation technique	Yield (Kg/dn)	Rank	Impact on production (US$)*
Cadusaphos	10,595	1	5.40
Methyl bromide	10,023	2	-
Oxamyl	9,650	3	(3.86)
Bio-fumigation (oil radish)	9,170	4	(9.30)
1,3-Dichloropropene (covered)	8,820	5	(13.64)
Dazomet (60g/m2)	7,940	6	(26.23)
1,3-Dichloropropene (uncovered)	7,605	7	(31.79)
Soil solarization	2,190	8	(357.66)
Bio-fumigation (Sudan grass)	1,117	9	(797.30)

*Methyl bromide is considered the reference point; parentheses indicate a negative value.

As can also be seen from Table 6.7, there is a big difference between the alternatives with the highest and lowest yields (a difference of 9,478 kg/dn or 90 per cent). In addition, chemical alternatives generally result in better yields than non-chemical alternatives (except for bio-fumigation using oil radish). The average yield of chemical alternatives was 9,100 kg/dn, with Cadusafos being the most effective alternative and 1,3-Dichloropropene being the least effective. The average yield of the non-chemical alternatives was 4,159 kg/dn, bio-fumigation using oil radish being the highest and bio-fumigation using Sudan grass being the lowest. This difference in cucumber yield between the chemical and non-chemical alternatives might be due to the vulnerability of cucumber plants to soil-born diseases, making non-chemical alternatives less effective.

Table 6.8 indicates the per-unit revenue and ranking of methyl bromide and its alternatives for cucumbers considering the average price for 2000 and 2001. The table shows that among chemical alternatives, Cadusafos, Oxamyl, and 1,3-Dichloropropene (covered) were financially feasible alternatives with per unit revenues higher than methyl bromide. Among the non-chemical alternatives, only bio-fumigation using oil radish was feasible with a NR per unit of US$ 0.048 (also higher than methyl bromide). According to the table, the most feasible alternative to methyl bromide tested on cucumbers, was Cadusafos (NR = US$ 0.074).

It can therefore be concluded that, considering only the financial costs, the best alternative as a replacement to methyl bromide on cucumbers is Cadusafos. Oxamyl and bio-fumigation using oil radish would also be feasible. The use of other soil fumigation techniques might lead to financial losses.

Table 6.8: Per unit cost, per unit revenue and ranking of methyl bromide alternatives for cucumber using 2000-2001 price levels [1]

Alternative		Yield (Kg/dn)	Impact on production (%)	AVC[2] Incremental AVC (US$)	AVC[2] Other AVC (US$)	AVC[2] Total AVC (US$)	Price/unit (US$/Kg)	NR per unit[3] (US$/Kg)	BEP (US$)	BEY (Kg)	Rank among alternative types	Overall rank	Feasibility[4]
	Methyl Bromide	10,023		0.061	0.126	0.187	0.20	0.017	0.187	9,169.8			
Chemical	Cadusafos	10,595	5.40	0.011	0.120	0.131	0.20	0.074	0.131	6,773.2	1	1	FF
	Oxamyl	9,650	(3.86)	0.007	0.130	0.138	0.20	0.067	0.138	6,497.1	2	2	FF
	1,3-Dichloropropene (covered)	8,820	(13.64)	0.050	0.141	0.19	0.20	0.013	0.191	8,259.0	3	4	FF
	1,3-Dichloropropene (uncovered)	7,605	(31.79)	0.046	0.162	0.207	0.20	(0.003)	0.207	7,722.2	4	5	FNF
	Dazomet (60g/m²)	7,940	(26.23)	0.066	0.155	0.22	0.20	(0.017)	0.222	8,609.8	5	6	FNF
Non-chemical	Bio-fumigation (oil radish)	9,170	(9.30)	0.019	0.136	0.156	0.20	0.048	0.156	6,994.4	1	3	FF
	Soil solarization	2,190	(357.66)	0.057	0.529	0.586	0.20	(0.381)	0.586	6,276.8	2	7	FNF
	Bio-fumigation (Sudan grass)	1,117	(797.30)	0.160	1.024	1.183	0.20	(0.979)	1.183	6,468.9	3	8	FNF

[1] Source of "Yield" and "AVCs":Lebanese Ministry of Environment and UNDP, 2001; source of Price/Unit: Lebanese MOA
[2] Incremental AVC is the incremental AVC that is only due to the application of the alternative
Other AVC is the AVC due to production operations other than the application of the alternatives
Total AVC is the total variable cost due to all production operations (i.e. including application of the alternative)
[3] NR/Unit = Price/unit - Total AVC
[4] FF = Financially Feasible, FNF = Financially Not Feasible

6.7.2.2 Eggplant

In addition to methyl bromide, only the bio-fumigation technique was tested on eggplants. Three different bio-fumigation methods were conducted, however: oil radish, Sudan grass, and with the addition of the enzyme Chitinase. No chemical alternatives were tested on eggplant. The reason behind this might be the relatively high level of resistance of eggplants to soil-born diseases rendering the non-chemical alternatives effective in preventing the attack of soil-born pathogens.

Table 6.9 shows the yields and ranking (based on yield) of the four fumigation methods as well as the impact on production. As can be seen from the table, all the alternatives tested on eggplant were more effective than methyl bromide, bio-fumigation with Chitinase giving the highest yield (12,690 kg/dn) and highest impact on production (20.25 per cent more than methyl bromide).

Table 6.9: Ranking of methyl bromide and its alternatives by yield for eggplant

Alternative	Yield (Kg/dn)	Rank	Impact on production (US$)*
Bio-fumigation + Chitinase	12,690	1	20.25
Bio-fumigation (Sudan grass)	11,790	2	14.16
Bio-fumigation (oil radish)	11,300	3	10.44
Methyl bromide	10,120	4	–

*Methyl bromide is considered the reference point; parentheses indicate a negative value.

Table 6.10 (see page 57) shows the per-unit revenue and ranking of methyl bromide and its alternatives for eggplants, considering the average price for 2000 and 2001. This table shows that the three alternatives tested on eggplant production were financially feasible (i.e. positive NR for the three tested alternatives) and resulted in higher per-unit revenues than methyl bromide. Bio-fumigation using oil radish plus Chitinase was the best alternative on eggplants with a NR of US$ 0.124.

It can therefore be concluded that, considering only the financial costs, the best alternative to the use of methyl bromide on eggplants is bio-fumigation plus Chitinase.

6.7.2.3 Strawberries

Only two alternatives were tested on strawberries: one chemical alternative (Dazomet applied at the rates of 40g/m^2, 60g/m^2 and 80g/m^2), and a non-chemical alternative, soil solarization. Table 6.11 presents the yields and the respective ranking of methyl bromide and the alternatives used as well as the impact on production. The table indicates that the highest yield was obtained with methyl bromide (8,040 Kg/dn) while the lowest one was obtained using soil solarization (4,320 Kg/dn). Dazomet applied at the rates of 60, 80 and 40 g/m^2 gave the respective yields of 6,840, 6,240 and 4,800 Kg/dn. In this case, eliminating methyl bromide had a sizable impact on the production since all the alternatives tested yielded less than methyl bromide.

Table 6.11: Ranking of methyl bromide and its alternatives by yield for strawberries

Alternative	Yield (Kg/dn)	Rank	Impact on production (US$)*
Methyl bromide	8,040	1	–
Dazomet (60g/m^2)	6,840	2	(17.54)
Dazomet (80g/m^2)	6,240	3	(28.85)
Dazomet (40g/m^2)	4,800	4	(67.50)
Soil solarization	4,320	5	(86.11)

*Methyl bromide is considered as the reference point; parentheses indicate a negative value.

Table 6.10: Per unit cost, per unit revenue and ranking of methyl bromide alternatives for eggplants using 2000-2001 price levels[1]

Alternative		Yield (Kg/dn)	Impact on production (%)	AVC[2] Incremental AVC (US$)	AVC[2] Other AVC (US$)	Total AVC (US$)	Price/unit (US$/Kg)	NR per unit[3] (US$/Kg)	BEP (US$)	BEY (Kg)	Rank among alternative types	Overall rank	Feasibility[4]
	Methyl bromide	10,120	–	0.060	0.124	0.184	0.24	0.058	0.184	7,709			
Non-chemical	Bio-fumigation (oil radish + Chitinase)	12,690	20.25	0.016	0.102	0.118	0.24	0.124	0.118	6,187	1	1	FF
	Bio-fumigation (Sudan grass)	11,790	14.16	0.015	0.109	0.124	0.24	0.118	0.124	6,054	2	2	FF
	Bio-fumigation (oil radish)	11,300	10.44	0.016	0.113	0.129	0.24	0.113	0.129	6,027	3	3	FF

[1] Source of "Yield" and "AVCs": Lebanese Ministry of Environment and UNDP, 2001; source of Price/Unit: Lebanese MOA
[2] Incremental AVC is the incremental AVC that is only due to the application of the alternative
Other AVC is the AVC due to production operations other than the application of the alternatives
Total AVC is the total variable cost due to all production operations (i.e. including application of the alternative)
[3] NR/Unit = Price/unit - Total AVC
[4] FF = Financially Feasible, FNF = Financially Not Feasible

Table 6.12: Per unit cost, per unit revenue and ranking of methyl bromide alternatives for strawberry using 2000 - 2001 price levels[1]

Alternative		Yield (Kg/dn)	Impact on production (%)	AVC[2] Incremental AVC (US$)	AVC[2] Other AVC (US$)	AVC[2] Total AVC (US$)	Price/unit (US$/Kg)	NR per unit[3] (US$/Kg)	BEP (US$)	BEY (Kg)	Rank among alternative types	Overall rank	Feasibility[4]
	Methyl bromide	8,040		0.076	0.536	0.613	0.96	0.352	0.613	5,104.9			
Chemical	Dazomet (60g/m²)	6,840	(17.54)	0.077	0.621	0.698	0.96	0.267	0.698	4,947.9	1	2	FF
	Dazomet (80g/m²)	6,240	(28.85)	0.105	0.621	0.726	0.96	0.238	0.726	4,698.4	2	3	FF
	Dazomet (40g/m²)	4,800	(67.50)	0.082	0.862	0.944	0.96	0.021	0.944	4,696.9	3	4	FF
N-ch	Soil solarization	4,320	(86.11)	0.029	0.621	0.650	0.96	0.315	0.650	2,910.8	1	1	FF

[1] Source of "Yield" and "AVCs":Lebanese Ministry of Environment and UNDP, 2001; source of Price/Unit: Lebanese MOA
[2] Incremental AVC is the incremental AVC that is only due to the application of the alternative
Other AVC is the AVC due to production operations other than the application of the alternatives
Total AVC is the total variable cost due to all production operations (i.e. including application of the alternative)
[3] NR/Unit = Price/unit - Total AVC
[4] FF = Financially Feasible, FNF = Financially Not Feasible

It should be noted that the UNIDO Project on strawberries will test the sheet steaming technique as a replacement for methyl bromide in soil fumigation. This technique may be the most suitable on strawberries in Lebanon.

Table 6.12 shows the per-unit revenue and ranking of methyl bromide and its alternatives for strawberry, considering the average price for 2000 and 2001. The table shows that the four alternatives tested on strawberries were financially feasible (i.e. positive NRs for the three tested alternatives), but with per unit NRs lower than methyl bromide. The alternative with the highest per unit NR was soil solarization.

6.7.2.4 Tomato

Five alternatives to methyl bromide were tested on tomatoes: non-chemical alternatives (grafted plants, soil solarization and bio-fumigation) and mixed alternatives (solarization with Oxamyl and with 1,3-Dichloropropene). Table 6.13 presents the ranking of the soil fumigation techniques used in addition to their respective yields and their impact on production.

Table 6.13: Ranking of methyl bromide and its alternatives by yield for tomato

Alternative	Yield (Kg/dn)	Rank	Impact on production (US$)*
Grafted plants	16,330	1	21.73
Methyl bromide	12,782	2	–
Soil solarization	12,236	3	(4.46)
Bio-fumigation (Sudan grass)	12,150	4	(5.20)
Soil solarization + 1,3-D	11,050	5	(15.67)
Soil solarization + Oxamyl	9,600	6	(33.15)

*Methyl bromide is considered as the reference point; parentheses indicate a negative value.

Table 6.13 indicates that the highest tomato yield is obtained using the grafted plants technique (16,330 Kg/dn), which yielded 21.73 per cent higher than methyl bromide. The table also shows that soil solarization performs better without the addition of any chemical to complement its action. Hence, according to the results obtained in the Methyl Bromide Demonstration Project - Lebanon, and contrary to expectations, the addition of a chemical to soil solarization on tomatoes did not enhance the performance of the non-chemical alternative. However, these results could change with a modification in the rates at which the chemicals are applied.

Table 6.14 shows the per-unit revenue and ranking of methyl bromide and its alternatives for tomato, considering the average price for 2000 and 2001. The table shows that the five alternatives tested on tomatoes were financially feasible (i.e. positive NRs for the five tested alternatives). Grafting ranked first with a NR of US$ 0.097. The three non-chemical alternatives tested generated more per unit revenue than methyl bromide, while the two mixed alternatives, although feasible, generated less per unit revenue than methyl bromide.

Therefore, it can be concluded that considering only the financial costs, the best alternative to use as a replacement to methyl bromide on tomato is the non-chemical alternative of grafting.

Table 6.14: Per unit cost, per unit revenue and ranking of methyl bromide alternatives for tomato using 2000 - 2001 price levels[1]

Alternative		Yield (Kg/dn)	Impact on production (%)	AVC[2] Incremental AVC (US$)	AVC[2] Other AVC (US$)	AVC[2] Total AVC (US$)	Price/unit (US$/Kg)	NR per unit[3] (US$/Kg)	BEP (US$)	BEY (Kg)	Rank among alternative types	Overall rank	Feasibility[4]
	Methyl bromide	12,782		0.048	0.135	0.183	0.22	0.037	0.183	10,628.9			
Non-chemical	Grafting	16,330	21.73	0.027	0.097	0.123	0.22	0.097	0.123	9,155.1	1	1	FF
	Soil solarization	12,236	(4.46)	0.010	0.140	0.150	0.22	0.070	0.150	8,343.1	2	2	FF
	Bio-fumigation (Sudan grass)	12,150	(5.20)	0.015	0.141	0.155	0.22	0.065	0.155	8,575.1	3	3	FF
Mixed	Soil solarization + Oxamyl	9,600	(33.15)	0.0197	0.1700	0.1897	0.22	0.030	0.190	8,277.9	1	4	FF
	Soil solarization+1,3 Dichloropropene	11,050	(15.67)	0.0416	0.1516	0.1932	0.22	0.027	0.193	9,704.9	2	5	FF

1 Source of "Yield" and "AVCs":Lebanese Ministry of Environment and UNDP, 2001; source of Price/Unit: Lebanese MOA
2 Incremental AVC is the incremental AVC that is only due to the application of the alternative
Other AVC is the AVC due to production operations other than the application of the alternatives
Total AVC is the total variable cost due to all production operations (i.e. including application of the alternative)
3 NR/Unit = Price/unit - Total AVC
4 FF = Financially Feasible, FNF = Financially Not Feasible

6.7.2.5 Summary of ranking methyl bromide and its alternatives by net revenue

The NR per unit for methyl bromide and its alternatives for all the selected crops are summarized in Table 6.15. The table also shows the best alternative to methyl bromide for each crop taking into consideration the financial costs only. In addition, the table indicates that despite the high net return of the suggested alternatives compared to methyl bromide, each alternative has a financial limitation in one type of incremental cost component.

As previously mentioned, the UNIDO project on strawberries in Lebanon will test the sheet steaming technique which might be more profitable than the already tested alternatives or even more profitable than methyl bromide. Hence, further analysis should be conducted once data from the sheet steaming technique becomes available.

Table 6.15: Net revenue per unit for methyl bromide and its alternatives for the selected crops

Crop	Chemical		Non-chemical		Mixed		Best	Remarks on best
	Alternative	NR (US$/Kg)	Alternative	NR (US$/Kg)	Alternative	NR (US$/Kg)	financial alternative	financial alternative
Tomato	Methyl bromide	0.037	Solarization	0.070	Solarization + 1,3-D	0.027	Grafting	High cost of input product
			Bio-fumigation (SG)	0.065	Solarization + Oxa	0.030		
			Grafting	0.097				
Cucumber	Methyl bromide	0.017	Solarization	(0.381)			Cadusafos	High cost of water
	Dazomet 60	(0.017)						
	Cadusafos	0.074	Bio-fumigation (OR)	0.048				
	1,3-D covered	0.013						
	1,3- D uncovered	(0.003)	Bio-fumigation (SG)	(0.979)				
	Oxamyl	0.067						
Eggplant	Methyl bromide	0.058	Bio-fumigation (OR)	0.113			Bio-fumigation with Chitinase	High cost of equipment and materials
			Bio-fumigation (SG)	0.118				
			Bio-fumigation + Ch	0.124				
Strawberry	Methyl bromide	0.352	Solarization	0.315			Solarization	_
	Dazomet 40	0.02						
	Dazomet 60	0.267						
	Dazomet 80	0.238						

6.8 Financial cost-benefit analysis for the study treatments

A financial CBA for the 24 considered treatments was carried out using the NPV, the BCR, and whenever applicable, the IRR tools, at a 10 per cent discount rate. The NPV and BCR were calculated as follows:

$$NPV = \sum_{t=1}^{20} \frac{TB - TC}{(1+r)^t}$$

$$BCR = \frac{\sum_{t=1}^{20} \frac{TB}{(1+r)^t}}{\sum_{t=1}^{20} \frac{TC}{(1+r)^t}}$$

Where: TB = cash inflow (total benefits)
TC = expenditure outflow (total costs)
r = discount rate
t = number of years (1, 2, …, 20)

The IRR is the discount rate at which the discounted benefits would be equal to the discounted costs; i.e. NPV = 0 and BCR = 1. This rate could only be calculated for the CBAs that produce positive NPV results.

6.8.1 Financial CBA assumptions and justification

The CBA was calculated on a one-dunum basis for a period of 20 years (considered as the economic life of the greenhouse). All CBA analysis was conducted at a 10 per cent discount rate to reflect an average between the Government and private bank credit interest rates.

CBA was tested under two main scenarios. Scenario 1 was conducted using the average product prices (revenue) for the years 2000 and 2001. Scenario 2 was done as a sensitivity analysis for the fluctuation in product and input prices, and was thus conducted assuming a potential 20 per cent increase in the product prices, which might arise from selling/exporting eco-labelled products once alternatives to methyl bromide are used and once export markets are identified. It was assumed that farmers using alternatives to methyl bromide would have full access to these markets within a maximum of five years from switching. It should be noted that the export products would only enjoy eco-label prices if all other phytosanitary conditions (particularly pesticide residues) were satisfied.

6.8.2 Financial cost and benefit specifications and calculations

Financial costs in the CBA were divided into investment costs, operation costs and land rent. The investment costs comprised the investment costs related to application of the fumigation technique (incremental), the crop production (variable), and the greenhouse establishment (fixed). The operation costs comprised those of applying a soil fumigation technique and producing the crops.

The benefits included the total revenue obtained from selling the crops in addition to the US$ 150 subsidy provided by the MLF for five years. This subsidy was not included in the CBA for methyl bromide since it is not applicable.

6.8.3 Financial CBA comparison among alternatives

A financial CBA was carried out using an incremental approach for each of the 24 study treatments under the two scenarios described above. Methyl bromide was only conducted under two scenarios not considering an increase in the product prices since the products obtained would not be eco-labelled. This CBA allowed a comparison between the use of methyl bromide and its alternatives.

The NPV and BCR results of the considered crops for both scenarios are summarised in Table 6.16. As can seen from the table, the feasibility of several alternatives changes when we assume a 20 per cent increase in the product price. This indicates that, once methyl bromide has been banned and assuming new premium prices, Lebanese farmers could enjoy higher revenues rendering their agricultural businesses more profitable. The table also indicates the percentage change in revenues between methyl bromide and each of the alternatives for the selected crops. For example, for cucumber the percentage change between methyl bromide and Cadusaphos was about 64 per cent indicating that farmers would benefit from using Cadusaphos instead of methyl bromide. For tomatoes, almost all alternatives resulted in better revenues than methyl bromide.

It should be noted that medical expenses resulting from the use of methyl bromide (in terms of insurance, lost work days, and/or medical fees) were not included in the NPV and BCR calculations. Using alternatives to methyl bromide may lead to savings on health expenses. Moreover, environmental benefits resulting from the use of methyl bromide alternatives were not quantified in this study due to the lack of documented data on this subject and were therefore not included in the CBA. The use of methyl bromide alternatives could result in a decrease in the costs of environmental degradation. Therefore, it is worth mentioning that including the decrease in medical expenses and the increase in environmental benefits in quantitative rather than qualitative terms (in the CBA) could tilt the balance between the feasibility of methyl bromide and its alternatives in favour of the alternatives. Moreover, due to the lack of quantifiable data the long-term effects of pesticides, including methyl bromide, were not considered. In this respect, since methyl bromide is non-selective it eliminates even useful nitrogen-fixing bacteria leading to the additional use of nitrogen fertilizers to enhance fertility and thus increasing the risk of polluting water resources.

Table 6.16: Summary of the CBA findings for the selected crops

	Scenario 1[1]					Scenario 2[2]		
Fumigation technique	NPV	BCR	Feasibility	IRR	% change in revenue[3]	NPV	BCR	Feasibility
Cucumber								
Dazomet 60 g/m²	(10,990)	0.57	FNF	N.A.	-23.31	(9,457)	0.63	FNF
Cadusafos	(3,179)	0.86	FNF	N.A.	64.33	(1,134)	0.95	FNF
1,3-Dichloropropene (covered)	(8,848)	0.64	FNF	N.A.	0.72	(7,714)	0.69	FNF
1,3-Dichloropropene (uncovered)	(10,027)	0.58	FNF	N.A.	-12.51	(8,560)	0.64	FNF
Oxamyl	(4,343)	0.80	FNF	N.A.	51.27	(2,480)	0.89	FNF
Soil solarization	(16,937)	0.21	FNF	N.A.	-90.04	(14,823)	0.30	FNF
Bio-fumigation (oil radish)	(6,034)	0.73	FNF	N.A.	32.30	(4,264)	0.81	FNF
Bio-fumigation (Sudan grass)	(19,129)	0.12	FNF	N.A.	-114.64	(18,913)	0.13	FNF
Methyl bromide	(8,912)	0.66	FNF	N.A.		–	–	–
Eggplant								
Bio-fumigation (oil radish)	573	1.02	FF	11.807 %	109.66	3,153	1.14	FF
Bio-fumigation (oil radish + Chitinase)	3,105	1.13	FF	19.53 %	152.31	5,999	1.25	FF
Bio-fumigation (Sudan grass)	1,526	1.07	FF	14.738 %	125.70	4,217	1.18	FF
Methyl bromide	(5,936)	0.78	FNF	N.A.		–	–	–
Strawberry								
Dazomet 40 g/m²	(8,989)	0.82	FNF	N.A.	-165.63	(4,616)	0.91	FNF
Dazomet 60 g/m²	5,703	1.11	FF	28.10 %	-58.36	11,935	1.23	FF
Dazomet 80 g/m²	(348)	0.99	FNF	N.A.	-102.54	5,337	1.10	FF
Soil solarization	(10,432)	0.78	FNF	N.A.	-176.16	(16,514)	0.23	FNF
Methyl bromide	13,697	1.26	FF	56.50 %		–	–	–
Tomato								
Soil solarization	(2,535)	0.90	FNF	N.A.	60.16	8	1.00	FF
Bio-fumigation (Sudan grass)	(3,121)	0.88	FNF	N.A.	50.94	(597)	0.98	FNF
Grafting	3,599	1.13	FF	21.36 %	156.57	6,992	1.25	FF
Solarization + 1,3-Dichloropropene	(7,303)	0.74	FNF	N.A.	-14.78	(5,007)	0.82	FNF
Solarization + Oxamyl	(4,924)	0.81	FNF	N.A.	22.60	(5,355)	0.79	FNF
Methyl Bromide	(6,362)	0.79	FNF	N.A.		–	–	–

[1] Scenario 1: Using average product prices for the years 2000 and 2001
[2] Scenario 2: 20 per cent increase in product prices
[3] Percentage change in revenue compared to methyl bromide

6.9 Conclusion

The feasibility assessment conducted in this study on the results of the Methyl Bromide Demonstration Project – Lebanon has indicated the following:

1. The comparison of annual NRs indicated the feasibility of almost all alternatives tested on the four considered crops (except for cucumbers under 1,3-Dichloropropene, Dazomet, soil solarization, and bio-fumigation using Sudan grass). This provides the farmers with a wider choice of alternatives.

2. Although financially feasible, several of the alternatives yielded lower annual NRs than methyl bromide (except for eggplants).

3. Numerous alternatives had a negative impact on production compared to methyl bromide (except Cadusafos on cucumber, grafting on tomato, and bio-fumigation on eggplant).

4. The financial CBA indicated that most of the alternatives tested on cucumbers, strawberries and tomatoes were financially infeasible when considering the average market prices for 2000 and 2001. However, these alternatives become feasible once these crops enjoy premium prices as eco-labelled products (except for cucumbers in which not all alternatives become feasible).

5. The financial CBA also indicated that all alternatives tested on eggplants were financially feasible when considering the average prices for 2000 and 2001, whereas methyl bromide was not financially feasible under these prices.

7. Impact assessment of trade liberalization policies and multilateral trade rules for products where methyl bromide is used

7.1 Introduction

Trade liberalization in general can have positive and negative environmental and socio-economic effects in any country. On the one hand, trade can promote an efficient allocation of natural resources, expand production and create new employment opportunities thus improving people's economic status and raising the society's standard of living. However, the increased production resulting from trade may bring about over-exploitation of resources and increased waste emissions aggravating environmental degradation and resource depletion.

On the other hand, trade liberalization may not necessarily lead to an increase in trade balance. Dropping all barriers to trade results in an aggressive competition within the local market in that the latter would be flooded with competitive products from other countries. This negative effect of trade liberalization would have damaging consequences on some local industries and consequently on the employment and economic status of individuals.

7.2 Trade liberalization and multilateral trade rules in Lebanon

The Lebanese Government is currently putting a great deal of effort into liberalizing trade. In this context, Lebanon signed the Association Agreement with the EU on 17 June 2002 and is actively working on the WTO accession process. Other goals include reactivating the bilateral economic agreements and finalizing the establishment of the Greater Arab Free Trade Area. Considering Lebanon has always enjoyed a relatively open economy, liberalizing trade should not be problematic.

7.2.1 The World Trade Organization

Lebanon had initially signed the GATT (General Agreement on Tariffs and Trade) Agreement in 1947 and then left in 1951. During the early seventies Lebanon expressed its interest to join again, but this accession was hindered by the breakout of the civil war. Following the end of the war, Lebanon again expressed its interest to join the WTO. Lebanon's official request was submitted in February 1999, and approved by the General Council in April 1999. For the time being Lebanon has an observer status that extends for five years.

Accordingly, Lebanon is in the process of implementing reforms required for WTO accession, which will entail enactment and modernization of its legislation and strengthening of the institutional framework. Thus, following a series of Working Party meetings, Lebanon is expected to join the WTO in 2005.

In this context, the Lebanese Government is currently finalizing, updating and enacting new laws which basically cover:

- licensing
- technical barriers to trade
- sanitary and phytosanitary measures
- trade related intellectual properties
- subsidies and countervailing measures
- anti-dumping.

7.2.2 The Association Agreement

Lebanon recently signed the Euro-Mediterranean Association Agreement that is characterized by a process to liberalize trade and covers political, social, economic and cultural aspects of Lebanon-EU relations. It will provide Lebanon with the opportunity to benefit from the potential EU market for its exports. Consequently, a market of 25 European countries is open to Lebanese products. The objectives of the Association Agreement are as follows:

- Establish a common Euro-Mediterranean area of peace and stability based on fundamental principles including respect for human rights and democracy (political and security partnership).
- Create an area of shared prosperity through the progressive establishment of a free-trade area between the EU and its Partners and among the Mediterranean Partners themselves, accompanied by substantial EU financial support for the economic transition and for the social and economic consequences of the reform process (economic and financial partnership).
- Develop human resources; promote understanding between cultures and rapprochement of the people in the Euro-Mediterranean region.

The Association Agreement is a major achievement for Lebanon on various levels. The country should benefit from the numerous opportunities the Agreement offers, particularly in trade. Accordingly, all Lebanese agricultural products will benefit from entry into the EU duty-free with the exception of 25 products, whereas agricultural EU imports to Lebanon will benefit from a gradual reduction five years after signing the Agreement.

7.3 Environmental and socio-economic impact assessment of trade liberalization and methyl bromide use in Lebanon

As discussed in Chapter 2 of this report, the Montreal Protocol regulates the use of methyl bromide in an effort to eliminate its use after a certain period. All parties to the Montreal Protocol should respect this agreement in terms of not using methyl bromide and not receiving any product for which production involved the use of methyl bromide. Therefore, once the use of methyl bromide has been banned, potential exports to parties of the Montreal Protocol (among which are the EU countries) would only be open for products on which no methyl bromide is used.

The environmental and socio-economic impact assessment of trade liberalization and methyl bromide use in Lebanon was based on the results of the Methyl Bromide Demonstration Project – Lebanon 2000.

However, this project was only carried out on four crops; hence the macro-impact could not be estimated, but was instead conceptually described and assessed. This conceptualisation is a first step towards identifying the needs for estimating this impact.

Table 7.1 is a matrix showing the positive and negative environmental and socio-economic effects of trade liberalization and the use of methyl bromide. The matrix is divided into two main parts: without trade liberalization and with trade liberalization, with the continued use of methyl bromide and without the use of methyl bromide. Since Lebanon has always had an open economy with relatively low barriers to trade even before signing the Association Agreement, the case of no trade liberalization and no use of methyl bromide was not considered in this study.

In terms of environmental impacts, the effect of using methyl bromide on both the natural resources and human health has already been described in Chapters 2 and 5 of this report. In summary, methyl bromide cleans the soil from a wide range of soil-born pathogens and thus controls almost all soil-born diseases. However, it also causes ozone depletion, which results in increased UV radiation and, consequently, in indirect effects on humans and animals, and may cause various health problems for workers directly in contact with it. Moreover, the application of methyl bromide for fumigation generates solid waste in the form of plastic sheets that are used to cover the ground during application.

When considering the effects of trade liberalization, two scenarios were considered: continued use of methyl bromide and eliminating the use of methyl bromide. Continuing the use of methyl bromide under trade liberalization produces the same environmental and socio-economic effects as not liberalizing trade since Lebanon would not be able to export products to European countries, because the latter are parties to the Montreal Protocol, and thus Lebanon would not benefit from the Association Agreement. Consequently, the use of methyl bromide is expected to decrease with time as a result of this Agreement

In the scenario in which the use of methyl bromide is discontinued and trade is liberalized, the effects of using chemical and non-chemical alternatives were considered separately. In terms of environmental impacts, chemical alternatives might contaminate the soil and groundwater, leave pesticide residues in the produce, and even directly harm human health. Similarly to methyl bromide, both chemical and non-chemical alternatives generate plastic waste thus increasing the cost of cleaning the environment. Neither alternative is as effective on all soil-born pests as methyl bromide, but non-chemical alternatives might enhance soil fertility, as is the case with bio-fumigation.

In terms of socio-economic impacts, both alternatives generated higher yields in some cases. The effects of methyl bromide on the environment are directly linked to the socio-economic effects. For example, the generation of waste increases the cost of cleaning the environment, and the effects on human health would lead to an increase in the number of days workers lose due to sickness, resulting in lower farm labour productivity.

7.4 Impact assessment of trade liberalization and methyl bromide use on the import and export of selected crops in Lebanon

7.4.1 Promoting exports to Europe

The primary export destination of Lebanese agricultural products is currently Arab countries. The next potential export partner is the EU due to its proximity and its political, cultural and socio-economic relations with Lebanon, in addition to the recent signing of the Association Agreement.

The basis for competitiveness for Lebanese agricultural products is the high quality of its products that makes them acceptable to European markets. Moreover, the Association Agreement has abolished customs

Table 7.1: Conceivable environmental, social, and economic effects of the use of methyl bromide and its proposed alternatives under "with" and "without" trade liberalization scenarios

	No trade liberalization		Trade liberalization					
					No use of methyl bromide			
	Continued use of methyl bromide		Continued use of methyl bromide		Chemical alternatives*		Non-chemical alternatives*	
Expected effect	**Positive**	**Negative**	**Positive**	**Negative**	**Positive**	**Negative**	**Positive**	**Negative**
Environment								
Natural resources	Cleans soil from a wide range of soil-born pests.	Causes ozone depletion. Generates waste (plastic residues).	Cleans soil from a wide range of soil-born pests.	Causes ozone depletion. Generates waste (plastic residues).	No known effects on the ozone. Effective control on specific targeted pests.	Possible soil and groundwater contamination. Generates waste (plastic residues).	No chemical use. Might enhance soil fertility (case of bio-fumigation).	Generates waste (plastic residues). Threatens narrower soil-pest range than methyl bromide.
Health & safety	Not applicable.	Direct effect on farm labour. Indirect effect from UV radiation.	Not applicable.	Direct effect on farm labour. Indirect effect from UV radiation.	No known effects.	Possible direct effect on farm labour. Possible pesticide residues.	No potential direct hazard on farm labour.	Not applicable.
Socio-economics								
	Cost effective method since it treats a wide range of soil-born pests. More revenue due to yield increase compared to some other alternatives for a given crop.	Increased cost of cleaning the environment. Increased number of sick leave days. Decreased farm labour producti-vity. Potential increase in medication bill. Major losses for farmers who do not adapt before the eventual reduction and restriction of methyl bromide.	Cost effective method since it treats a wide range of soil-born pests. More revenue due to yield increase compared to some other alternatives for a given crop.	Increased cost of cleaning the environment. Increased number of sick leave days. Decreased farm labour productivity. Potential increase in medication bill. Major losses for farmers who do not test, adapt and adjust before the eventual reduction and restriction of methyl bromide.	More revenue when compared to some other alternatives for a given crop. More employment opportunities with boom in exports. More earned income. Cost effective since more specialized when used for specific pests.	Increased cost of cleaning the environment. Increased number of sick leave days. Ineffective against certain pests. Potential increase in medication bill.	More revenue due to yield increase compared to some other alternatives for a given crop. More employment opportunities with boom in exports. More income. Bio products, especially those that follow recognized independent certification schemes, have potential for increased revenue.	Increased cost since ineffective against certain pests.

* Expected effects reported are those of the impact of fumigation techniques, excluding the rest of the production operations

duties on most agricultural imports into the European Community of agricultural products originating in Lebanon except for some 25 products listed in the Protocol 1.

Despite the positive outcome of identifying new potential markets for agricultural products, increasing exports can increase pressures on the environment. Nonetheless, the EU's relatively stricter norms regarding agricultural products will compel the Lebanese agricultural sector to be more environmentally friendly and use cleaner production practices so as to comply with the norms and standards required.

In sum, international competitiveness is often achieved by linking the local production sector to foreign modes of production. The agricultural sector should build on the Association Agreement. Thus, the role of the State in enhancing international competitiveness is to enable the private sector to respond in due time to changes in the international arena in order to increase investment and promote growth, productivity, profits, employment and exports.

7.4.2 Conceivable impact assessment of trade liberalization and methyl bromide use on the import and export of selected crops

The assessment of trade liberalization and the use of methyl bromide on the import and export of the selected crops (cucumber, eggplant, strawberry and tomato) in Lebanon was mainly carried out on a descriptive basis. Little numerical analysis was performed due to the inaccessibility to the data on import/export trends of EU and Euro-Mediterranean member states. The positive and negative effects of trade liberalization and the use of methyl bromide on the import and export of the selected crops are summarized in Table 7.1 above.

With further trade liberalization a net decrease in exports is expected due to this potential market loss. With respect to Lebanese imports, trade liberalization will lead to harsh competition within local and international markets, and the Lebanese market will be flooded with similar rivals from different countries. This negative effect of trade liberalization would have damaging consequences on the employment and economic status of individuals.

Non-chemical alternatives enjoy potential benefits over chemical alternatives since the latter might be banned in the future resulting in more market losses, and the former might enjoy potential higher premium prices, especially if banning the use of methyl bromide was coupled with organic crop production.

Figure 7.1 shows a schematic diagram of the environment and socio-economic effects of using methyl bromide under trade liberalization. This figure shows that the continued use of methyl bromide under trade liberalization will cause production losses, which would mean lower revenues for farmers mostly resulting from the imminent reduction of methyl bromide supplies and the subsequent losses associated with adapting to new alternatives. These lower revenues will press farmers to search for another source of income, namely abandoning agriculture and migrating from rural to urban areas.

Farmers may be better off using alternatives to methyl bromide and adapting sooner rather than later in order not to create distortions in the production cycles and resulting in the irreversible loss of markets. Alternatively, creating potential new markets for farmers is translated into increased marketable volumes. Hence farmers would be encouraged to allocate more land to the production of crops that might be marketed to European countries, eventually increasing the overall production of crops (although alternatives to methyl bromide produce lower yields per area of land than methyl bromide). An overall increased production would, in the long run, increase the farmers' incomes and thus encourage farmers to remain in rural areas.

On the environmental level, Figure 7.1 clearly shows that both methyl bromide and the chemical alternatives have negative impacts on the environment. However, it is important to highlight the benefits of using alternative methods causing the least damage to the environment (non-chemical alternatives).

It should be noted that methyl bromide is only one of numerous chemicals used in agricultural production. Banning methyl bromide would have positive environmental and human health impacts, but these will be minimal if other chemicals continue to be used in uncontrolled ways, as is the case in Lebanon. Therefore, the regulation of other agro-chemicals should be considered and studied in order to analyse the overall effects. The impact of agro-chemicals other than methyl bromide can be more clearly observed in the impact on exports, since chemical residues constitute one significant phytosanitary barrier to trade for agricultural products, especially those destined to the EU.

7.4.3 Quantitative impact assessment of trade liberalization and methyl bromide use on exports of selected crops

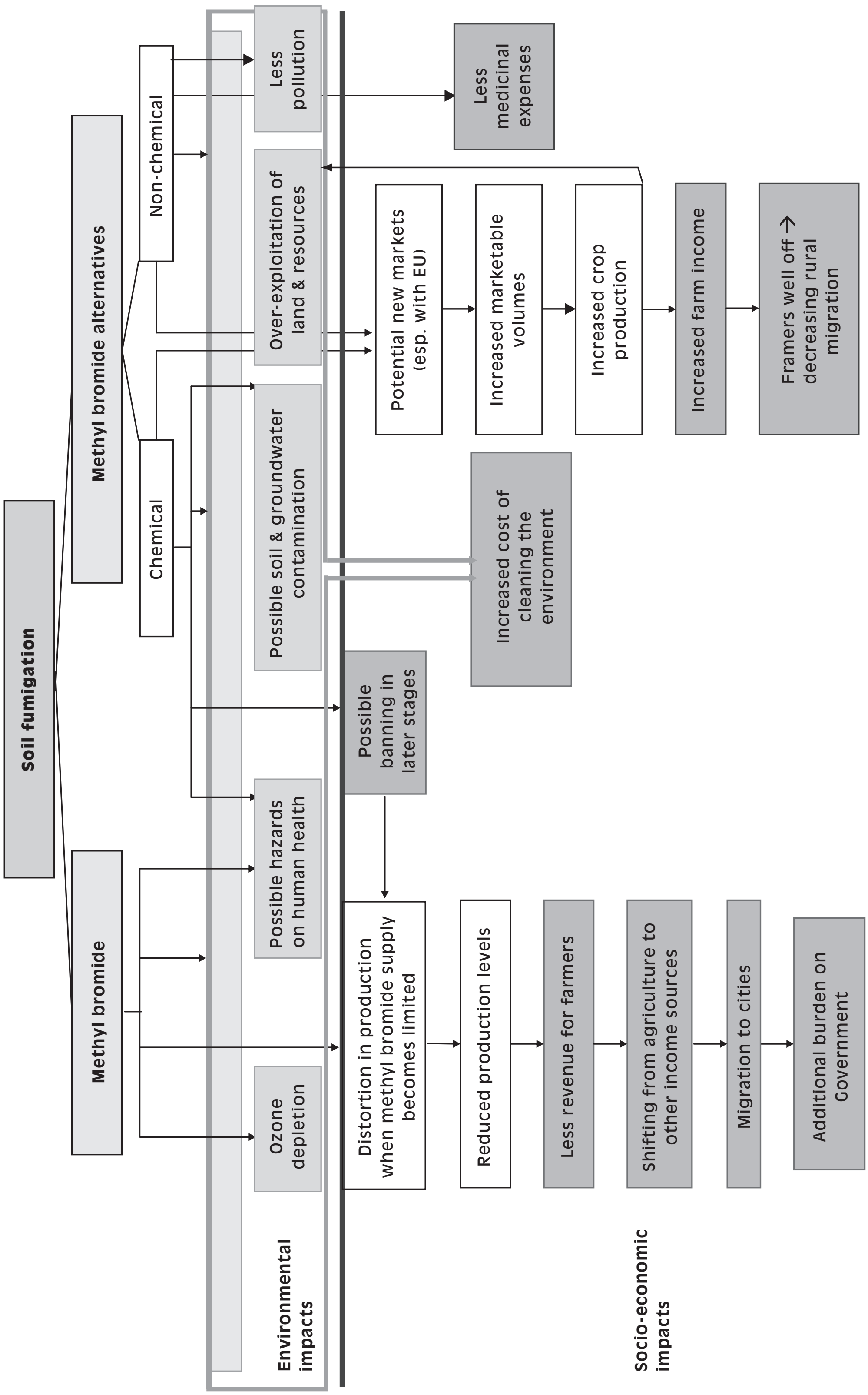
The impact assessment of trade liberalization and methyl bromide use on the export of selected agricultural crops in Lebanon is described in Tables 7.2, 7.3, 7.4 and 7.5. The tables show the feasibility of exporting the selected crops to Europe, taking into consideration the prices in the European market for the year 2002. It should be mentioned that the Association Agreement gives Lebanon a grace period until 2008 before the tariff reductions on European products come into effect. The gradual reduction will take place from 2008 to 2012. Until 2012 it is necessary that Lebanese farmers benefit from the advantages provided under the Association Agreement by improving the quality of their products so that these can be exported to European markets and thus lessen the negative impact of 2012. It is important to note, however, that although the Lebanese Government has signed the Association Agreement and is in the process of acceding to the WTO, trade in Lebanon is relatively open since Lebanese products receive minimal protection from the Government and imports already flood Lebanese markets. It is also important to mention that no projections were made in this study to show the feasibility of exporting Lebanese products to Europe until 2012 (complete trade liberalization) due to the lack of data on any input/output price trends in Lebanon.

Tables 7.2, 7.3, 7.4 and 7.5 expose the incremental, fixed and other variable costs of each fumigation technique (methyl bromide and alternatives), as well as the cost of transporting the products from the farm and shipping them to the target markets. The calculations of the CBA included the financial incentives that the farmers will receive from the MLF.

As can be seen from these tables, only tomato came out as financially not viable in terms of exports to Europe, whereas cucumbers, eggplants and strawberries were feasible. The values in the tables represent the current situation, however it should be noted that in the near future Lebanon might be at an advantage compared to European countries, since prices of agricultural products in Europe may increase with further trade liberalization. This is primarily due to the high subsidies currently applied in Europe that would decrease or even cease as trade liberalization is implemented (prices of Lebanese products are expected to remain the same since they benefit from little subsidization. Moreover, it is important to point out that European countries currently tax all lower-priced products that are exported to these countries in order to protect their local production and eliminate competition from cheap imports, a concept known as the minimum import price. However, this tax should be removed as the WTO regulations come into effect, so in the near future Lebanese products exported to European countries will benefit from an additional advantage.

It is also worth mentioning that, in the case of cucumbers, the cost-benefit analyses presented in Chapter 6 of this report were mostly infeasible, but a comparison between the cost of producing cucumbers and

Figure 7.1: Conceivable environmental and socio-economic impacts of methyl bromide and the alternatives under trade liberalization



European prices (Table 7.3) shows that European prices are considerably higher than Lebanese prices. This indicates that, even though losses have been shown in the CBA, Lebanon could develop a comparative advantage in cucumbers especially as cucumber exports have noticeably increased over the past two years indicating a growing demand for cucumbers abroad. Hence, farmers growing cucumbers would have to seek international rather than local markets to maximize their profits.

Table 7.2: Feasibility of exporting tomatoes to Europe

Alternative	Incremental costs	Other variable costs[1]	Fixed costs	Local transportation cost[2]	Shipping costs	Total costs	Total costs per Kg	2002 price in Europe	Remarks[3]
	US$/Dunum						US$/Kg	US$/Kg	
Methyl bromide	611.65	1,686.72	1,372.72	48	8,308.3	12,027.32	0.94	0.62	NF
Non-chemical									
Soil solarization	124.95	1,670.54	1,372.72	46	7,953.4	11,167.50	0.91	0.62	NF
Bio-fumigation (Sudan grass)	178.52	1,667.99	1,372.72	46	7,897.5	11,162.29	0.92	0.62	NF
Grafting	437.5	1,536.61	1,372.72	61	10,614.5	14,022.57	0.86	0.62	NF
Mixed									
Soil solarization + 1,3-Dichloropropene	459.68	1,635.40	1,372.72	41	7,182.5	10,691.74	0.97	0.62	NF
Soil solarization + Oxamyl	188.70	1,592.44	1,372.72	36	6,240	9,429.86	0.98	0.62	NF

[1] Cost of pesticide considered US$ 220/dunum instead of US$ 260/dunum, based on a preventive rather than curative treatment programme
[2] Transportation costs being US$ 75 for 20,000 Kg
[3] NF = Not Feasible

Table 7.3: Feasibility of exporting cucumbers to Europe

Alternative	Incremental costs	Other variable costs[1]	Fixed costs	Local transportation cost[2]	Shipping costs	Total costs	Total costs per Kg	2002 price in Europe	Remarks[3]
	US$/Dunum						US$/Kg	US$/Kg	
Methyl bromide	611.65	1,240.04	1,278.08	38	6,514.86	9,682.21	0.97	4.10	F, but not accessible
Chemical									
Dazomet (60g/m²)	525.00	1,212.27	1,278.08	30	5,161	8,206.13	1.03	4.10	F
Cadusaphos	114.31	1,247.67	1,278.08	40	6,886.75	9,566.54	0.90	4.10	F
1,3-D covered	441.59	1,224.01	1,278.08	33	5,733	8,709.76	0.99	4.10	F
1,3-D uncovered	348.10	1,207.81	1,278.08	29	4,943.25	7,805.76	1.03	4.10	F
	Oxamyl	70.50	1,235.07	1,278.08	36	6,272.50	8,892.34	0.92	4.10 F
Non-chemical									
Soil solarization	124.95	1,135.61	1,278.08	8	1,423.50	3,970.35	1.81	4.10	F
Bio-fumigation (oil radish)	178.52	1,228.67	1,278.08	34	5,960.50	8,680.16	0.95	4.10	F
Bio-fumigation (Sudan grass)	178.52	1,121.30	1,278.08	4	726.05	3,308.14	2.96	4.10	F

[1] Cost of pesticide considered US$ 128/dunum instead of US$ 150/dunum, based on a preventive rather than curative treatment programme
[2] Transportation costs being US$ 75 for 20,000 Kg
[3] F = Feasible

In summary, it is believed that with trade liberalization Lebanese products are not only expected to be competitive in international markets (assuming their production abides by environmental regulations and international standards), but also achieve higher prices compared to market prices in Lebanon. This will aid farmers in Lebanon in attaining higher profit margins (or even convert their losses to profits) if their products were marketed in international markets, particularly European countries.

Table 7.4: Feasibility of exporting eggplants to Europe

Alternative	Incremental costs	Other variable costs[1]	Fixed costs	Local transportation cost[2]	Shipping costs	Total costs	Total costs per Kg	2002 price in Europe	Remarks[3]
	US$/Dunum						US$/Kg	US$/Kg	
Methyl bromide	611.65	1,313.36	1,372.72	38	6,578	9,913.68	0.98	1.33	F, but not accessible
Non-chemical									
Bio-fumigation (oil radish)	178.52	1,340.00	1,372.72	42	7,345	10,278.62	0.91	1.33	F
Bio-fumigation (oil radish + Chitinase)	198.52	1,358.63	1,372.72	48	8,248.50	11,225.96	0.88	1.33	F
Bio-fumigation (Sudan grass)	178.52	1,346.63	1,372.72	44	7,663.50	10,605.58	0.90	1.33	F

[1] Cost of pesticide considered US$ 242/dunum instead of US$ 180/dunum, based on a preventive rather than curative treatment programme
[2] Transportation costs being US$ 75 for 20,000 Kg
[3] F = Feasible

Table 7.5: Feasibility of exporting strawberries to Europe

Alternative	Incremental costs	Other variable costs[1]	Fixed costs	Local transportation cost[1]	Shipping costs	Total costs	Total costs per Kg	2002 price in Europe	Remarks[2]
	US$/Dunum						US$/Kg	US$/Kg	
Methyl bromide	611.65	4,312.87	1,278.08	30	5,226	11,458.75	1.43	5.48	F, but not accessible
Chemical									
Dazomet (40g/m²)	393	4,137.91	1,278.08	18	3,120	8,946.99	1.86	5.48	F
Dazomet (60g/m²)	525	4,248.07	1,278.08	26	4,446	10,522.8	1.54	5.48	F
Dazomet (80g/m²)	657	4,215.67	1,278.08	23	4,056	10,230.15	1.64	5.48	F
Non-chemical									
Soil solarization	124.95	4,111.99	1,278.08	16	2,808	8,339.22	1.93	5.48	F

[1] Transportation costs being US$ 75 for 20,000 Kg
[2] F = Feasible

8. Policy proposal and action plan

8.1 Introduction

As previously mentioned, several steps have already been taken in Lebanon to phase out methyl bromide, as agreed by parties to the Montreal Protocol. These steps involve the demonstration project conducted in 1999–2000 as well as the implementation projects on vegetables, tobacco and strawberries. These projects already constitute a sizeable part of the phase-out schedule.

However, in order to ensure the efficiency and sustainability of the phase-out, a national policy and an action plan should be put in place to organise and regulate it. Preparing the policy and the action plan would provide appropriate strategies for the phase-out reflecting the agricultural, economic and social characteristics of Lebanon. The policy and action plan will also coordinate the efforts of Government agencies, methyl bromide users and stakeholders, avoiding duplication of work and gaps among the different parties. The action plan could be complemented with effective legislation and regulations to control the use of methyl bromide and its alternatives.

Having a policy framework, especially effective legislation and regulations, has been found to be one of the most important factors in bringing about the smooth phase-out of ODSs. "Experience with other ODSs has shown that countries that take early action in phasing out the substance are best placed to gain a market lead" (UNEP, 1999).

In order to establish a policy framework for the reductions and phase-out of methyl bromide, the following should be considered:

- monitoring and controlling procedures for methyl bromide imports
- adopting early phase-out steps
- preventing new uses of methyl bromide.

These three processes will be described in detail throughout this chapter.

8.2 Action plan to phase-out methyl bromide

A two-phase policy is suggested for the complete and efficient phase-out of methyl bromide. The estimated duration of the policy is expected to be 10 years. The first phase of the policy (estimated to be 5 years) will involve some kind of training for the farmers to expand on their use of the methyl bromide alternatives. This phase is considered as a preparation period to switch from methyl bromide to the alternatives. During this phase, the MLF will provide the farmers with financial incentives in the form of inputs or supplies for the alternatives (already started in May 2002). The financial support will cease at the end of this phase. In addition, an identification of potential stakeholders (as will be described later on in this chapter) should be made, and a coordination and communication mechanism should be established among all parties. Finally, during Phase I, concerned parties should explore and identify potential local and foreign markets for products where methyl bromide alternatives have been used, especially markets that may offer premium prices for these eco-labelled products.

In summary, Phase I will include the following processes:

- promoting alternatives among farmers using MLF incentives
- identifying and establishing a network that would include two main groups: production and marketing
- establishing a mechanism to communicate and coordinate between network stakeholders
- identifying and exploring potential export markets.

The second phase will extend from 2007 until 2012. During this phase farmers will receive no financial support from the MLF, but will enjoy an advantage in exports to European countries (markets explored in Phase I) as identified by the Association Agreement (described in Chapter 6), and will receive assistance to participate in the new export markets. This will allow farmers to establish themselves in the new trade system before all tariff barriers are dropped and markets open up. Figure 8.1 represents a simplified diagram of the two phases considered in this policy.

It is important to mention that two of the major problems faced by the agricultural sector in Lebanon are the high production costs and the low market prices. These problems render competition in the local markets with countries that enjoy subsidies and low production costs (namely Jordan and Syria) very difficult. With the Association Agreement, Lebanon will be able to go beyond local markets and export to the European markets, and thus receive premium returns. However the farmers should be aware of the varieties that are demanded and the SPS requirements in order to enter these markets. For example, with respect to cucumber producers, despite the losses shown in the CBA, producers will be able to export to European markets and increase their revenues if they improve the quality of their production (e.g. by reducing the use of pesticides).

8.2.1 Phase I (2002 – 2007): switching from methyl bromide to alternatives

The duration of Phase I is estimated to be five years starting from year 2002. The main objective of this phase is to build the farmers' capacity to switch efficiently from methyl bromide to any of the suggested alternatives. During this phase, farmers will benefit from an annual US$ 150/dunum subsidy from the MLF. However, the subsidy is provided in terms of input supplies and not as cash, as an incentive for the farmer to switch to methyl bromide alternatives.

Several main tasks should be accomplished throughout this phase, such as building a network between the various stakeholders producing and marketing crops using the methyl bromide alternatives, identifying the

Figure 8.1: Schematic diagram of the overall suggested policy of promoting methyl bromide alternatives

	Phase I	Phase II	
Proposed actions	Use MLF incentives to motivate farmers to switch from methyl bromide to alternatives. Establish networking. Explore and identify potential export markets.	Guidance and information about newly explored export markets. Continued exploration of potential export markets. Establish a database that could be accessible to network stakeholders.	Farmers ready to compete in free-trade markets.
	Year 2002	Year 2007	Year 2012

most desirable crops for export markets and the most advantageous alternatives, promoting these alternatives among farmers, and exploring new potential export markets.

8.2.1.1 Building stakeholder networks

The development of any policy or national action plan should involve identifying and coordinating among all the stakeholders to ensure the effectiveness and practicality of the production and marketing process, and hence guaranteeing the success of the proposed action plan. The stakeholders in the methyl bromide alternatives include the following:

- farmers using methyl bromide or any alternative
- importers of methyl bromide
- agricultural trainers and extension agents
- experts in alternatives
- NGOs working on environmental and agricultural issues
- companies offering alternative services or products.

In addition, these stakeholders are divided into two main groups or networks. The first group is concerned with the production of crops and includes all the above-mentioned stakeholders, while the second is concerned with the marketing of these crops and includes, in addition to the above-mentioned stakeholders, middlemen and exporters of agricultural products.

Networks linking the different stakeholders are essential for a successful phase-out of methyl bromide. These networks should provide cooperation and coordination between the stakeholders, offering them a reliable information system to help identify potential new markets. The networks should also link farmers with export agencies to facilitate the export of products.

The main responsibility of these networks is to implement the methyl bromide phase-out schedule and create a link between the various stakeholders. The network related to the production of crops should include representatives of all the stakeholder groups previously mentioned i.e. the farmers that are using methyl bromide or any alternative, the agricultural companies importing methyl bromide and those offering alternative services or products, the agricultural trainers, the extension service staff, the experts in alternatives, and the NGOs working on environmental and agricultural issues.

The network related to the marketing of crops should explore potential markets to which the farmers can sell their products, particularly export markets. In addition to potential export markets, the network can establish a market information system that would allow farmers to inform themselves on the market's needs and requirements at different time periods, adapt their production, and hence better market their products.

8.2.1.2 Identifying potential export markets

New potential export markets result from the bilateral and multilateral agreements between Lebanon and other countries, the most important one being the recently signed Association Agreement between Lebanon and EU countries. As explained in Chapter 6, this Agreement opens up a significant potential export market for Lebanese products once all conditions are satisfied.

Lebanon has also signed several other bilateral agreements, mostly with Arab countries. These provide potential markets to be explored by Lebanese exporters and might be easier to access than the European market, since they have less strict environmental regulations and SPS measures for imports at present. Other new potential markets for Lebanese exporters should be sought through continuous negotiations and the signing of new bilateral agreements.

8.2.1.3 Identifying and promoting the most desirable crops for export

One important task to be conducted in the first phase of the project is to identify the most desirable crops or crop varieties for export to the European market. This can be done by establishing a market information system via the Lebanese commercial attachés in European countries. The attachés can conduct market surveys to identify the crops or crop varieties with high demand and high prices, as well as their supply-shortage periods. The identified crops or crop varieties may be for the fresh or processed food markets.

Once a list of the most desirable crops and crop varieties is available, these should be promoted among farmers, encouraging them to switch to their production accordingly. This list could be circulated through the producers' network, and technical assistance regarding the production of these crops and access to seeds should be ensured.

The UNDP financial incentives in Phase I of the proposed action plan could be used to promote the most desirable crops and demote the less desirable ones, by providing incentives to farmers planting the desirable crops and not providing any to those cultivating the less desirable crops.

8.2.1.4 Identifying and promoting the most desirable methyl bromide alternatives

Identifying the most desirable methyl bromide alternatives

It is equally important to identify both the most desirable crops to be marketed abroad and the most desirable alternative(s) to methyl bromide. Moreover, demoting the use of methyl bromide should take place in a way that allows farmers to test, adapt and adopt alternatives before the supply of methyl bromide decreases and eventually comes to a halt.

Research on the efficiency of the alternatives to methyl bromide in Lebanon should be continued in order to identify the most desirable one(s). In other words, projects similar to the methyl bromide demonstration project should be conducted using clear experimental designs that would allow for a proper comparison among different alternatives for the same crop. The projects should also include crops that were not included in the previous project as well as potential desirable crops, if identified. University staff or research centres could conduct these projects, which should run for more than one growing season to determine more significantly the input/output relationship trend of each alternative, and then transform this relationship to costs.

Technical assistance and support for farmers using the alternatives could be delivered through the agricultural extension department of the MOA or through the NGOs.

Promoting the most desirable methyl bromide alternatives

Promoting the most desirable or most efficient methyl bromide alternative(s) can be done in parallel to demoting the use of methyl bromide. The choice of alternative should not be dictated to the farmer who should be left to decide which alternative to use (among a series of efficient alternatives tested by research projects). Any methyl bromide alternative should be technically feasible, safe and cost-effective for controlling soil pests, so that farmers can make a living from selling the crops they produce using these alternatives.

In Lebanon, the MOA controls the import of methyl bromide by issuing permits for its import. Only four agricultural companies are permitted to import methyl bromide: Debbaneh, Robinson, the Agricultural Materials Company, and Agri-Italia Services (Lebanese Ministry of Environment and UNDP, 2001). One benefit of banning the import and use of methyl bromide is that it may provide an opportunity for more small and medium-sized enterprises to import the alternative products and supply them to the market. This increases competitiveness in input market prices, which will help to reduce production costs. In addition, some of the alternatives could perhaps be manufactured in Lebanon depending on the technological requirements. This would further reduce the price of the alternatives and the production costs, increase competitiveness of the crops and create new job opportunities. Also, new export markets could be created to supply these alternatives to other countries.

Local companies could be encouraged to take advantage of the emerging business opportunities in terms of importing the methyl bromide alternatives or producing them locally. Technical and financial assistance could be provided to these companies such as a list of the alternatives that are most commonly used in Lebanon and the approximate number of farmers using them (approximate market size for each product).

In order to encourage farmers to switch from methyl bromide to alternatives, awareness campaigns on the direct and indirect hazards of methyl bromide on the environment and human health should be organized. The aim of these campaigns would be to inform the users of methyl bromide (i.e. the worker who carries out the fumigation) and the consumers of products grown using methyl bromide. These campaigns could be in the form of lectures or sessions in schools and universities, leaflets to be distributed in supermarkets and grocery stores, billboards, TV shots, etc. Local environmental NGOs should assume the main responsibility for implementing these awareness campaigns.

The awareness campaigns addressed to farmers should include information on the hazards of using methyl bromide and the availability of potential export markets once alternatives are adopted. Farmers should be aware that methyl bromide is already banned in several countries.

One additional task that could promote the use of methyl bromide alternatives is the establishment and marketing of the concept of eco-labels (environmental labels) for products where methyl bromide was not used. These labels would inform consumers about the non-utilization of methyl bromide throughout the growing process allowing them to choose such products.

Alternatively, a reverse policy could be used to limit the marketing of products for which methyl bromide was used in the production process. The Government could oblige farmers who still use methyl bromide to indicate it on the product labels.

The farmers could be further convinced to adopt organic production methods and thus gain competitiveness in local and international markets. This would be more effective and reliable with Government certification issuance. Eco-organic labels could be used, and premium prices should be sought for ecological and eco-organic products to compensate for the lower yields compared to conventional production systems. Financial incentives could also be used to promote the best alternatives and demote the least preferred ones.

8.2.2 Phase II (2007 – 2012): new challenges faced by Lebanese farmers

Financial incentives from the MLF through UNDP will cease at the end of Phase I. Hence, the second phase is characterized by increased farmers' autonomy in terms of financial needs for the alternatives. By this time, farmers should have built their own capacity to face new challenges on local and international markets in order to maintain competitiveness and maximize their profits.

Once subsidies or financial incentives have ceased they should be replaced by well-established European and other export markets identified in Phase I. This could be done with the help of exporters, middlemen, and IDAL.

During the second phase, imports from EU countries would still be subject to tariff barriers while most Lebanese products will be exempted from any tariff upon entering European markets. This could be capitalized on to expand the export markets and make use of local markets (since local products would still be more competitive). The help of local associations or organisms could be sought to assist in implementing the expansion into both local and international markets.

Farmers could be encouraged and convinced to switch to chemical-free production once markets are identified. This would increase their profits since these products would enjoy higher premium prices in both local and international markets compared to conventional products. Certification plays a significant role in these chemical-free products. An efficient and reliable certification system within an institutionalised quality infrastructure would pave the way for more potential markets.

Training campaigns should continue during this phase to ensure farmers are aware of the consequences of using any other chemical if organic production was supposed to be followed. The farmer should be aware that product quality is currently the key to export success and any change in product quality would have significant negative impacts on Lebanese exports as well as Lebanon's image in international markets. A reduction in exports would occur, generating over-supply in local markets and bringing about a decrease in product prices. For this reason, farmers should be trained to work within an auto-control system at the farm level (irrespective of the presence of any Governmental control or monitoring system), and would thus participate in their own long-term sustainability in the agricultural business. This auto-control system could be more effective if agricultural cooperatives in each area were to manage and direct the process.

By the end of the second phase (i.e. removal of taxes on EU products), farmers should be prepared for high competition resulting from the free-trade zone between Lebanon and the EU countries, but also at the local market level since rival products from countries enjoying economies of scale may load local markets with products having more competitive prices. Thus, concerned ministries (Ministry of Economy and Trade and Ministry of Foreign Affairs) and export associations should inform farmers about the expected rival volumes of each crop in both the local and international markets so that farmers can identify the best crops to produce and their respective quantities.

8.3 Cost-benefit analysis of the suggested policies

The policy and action plan suggested above has numerous direct and indirect benefits, such as increased competitiveness in the local and international markets. Another important benefit is the saving in relation to workers' health problems resulting directly from the use of methyl bromide since medical bills and sick leave will be reduced and productivity will increase. Savings in human health in general is also a benefit since Lebanon will be contributing to minimizing ozone depletion and thus decreasing the indirect effects from the sun's UV radiations. Minimizing environmental damage brings about additional and significant benefits that will be further increased if chemicals other than methyl bromide are also regulated and controlled.

Despite the various benefits, the policy suggested above has several direct costs:

- Training farmers on methyl bromide alternatives and awareness on using methyl bromide represents significant costs to be considered:

  - costs will be paid by the party conducting the training, international donations or local Government
  - costs can be estimated by multiplying the total number of farmers to be trained by the approximate cost for each trainee (depending on the cost of the trainer, the material required and the number of training sessions needed).
- Subsidies given to farmers if these were to be continued.
- Cost of establishing networks among the different stakeholders.
- Cost of conducting the market surveys inside Lebanon and abroad for setting up a market information system to be disseminated to the farmers.

8.4 Sanitary and phytosanitary measures related to trade in Lebanon

Although this study on the effects of trade liberalization on agriculture in Lebanon focuses on the use of methyl bromide, this is just one of numerous chemicals that are used in agricultural production in Lebanon. Therefore, banning methyl bromide alone would only have partial positive impacts on the environment and human health if other chemicals continue to be used in an uncontrolled manner. In addition to the impacts on the environment and on human health, agro-chemicals are currently barriers to trade since more countries are using them as a means to regulate their trade, particularly imports, as well as to ensure that their consumers are being supplied with safe foods.

Measures have been taken in relation to food, animals and plants to ensure consumer safety. These are known as the sanitary and phytosanitary (SPS) measures, and are considered to be the most important obstacle for developing countries to export agricultural products to the developed world. Hence, if Lebanon wishes to export its agricultural products to other countries, particularly European countries, it will have to abide by the SPS measures imposed by trading partners.

The SPS agreement allows countries to define their own standards although these must be based on science and should be applied only to the extent necessary to protect human, animal or plant life or health. They should not arbitrarily or unjustifiably discriminate between countries where identical or similar conditions prevail. The SPS agreement includes provisions on control, inspection and approval procedures. It also acknowledges the special needs of developing countries in the preparation and application of SPS measures.

In Lebanon, LIBNOR is the institution responsible for issuing standards. In terms of MRLs for pesticides, and within the context of applying SPS measures to agricultural products, a technical committee was created to set the national standards for pesticide residues. The national standards were based on the Codex Alimentarus. Certain pesticides that are not mentioned in the Codex Alimentarus but are included in the EEC guidelines were also accounted for. The initial committee consisted of representatives from the Ministries of Agriculture, Industry, Health, Economy and Trade and Defence in addition to representatives from various concerned syndicates, laboratories and universities.

A smaller, more focused committee was then established to follow up on the standards. This committee consisted of representatives of the MOA (Plant Protection Department and the Pesticide Committee), LARI, the Industrial Research Institute (IRI), and the American University of Beirut (AUB). The technical committee approved the standards on 14 August 2002.

In order for the above-mentioned standards to become a technical regulation, LIBNOR, through the Ministry of Industry, should request the Council of Ministers to issue a decree on this issue. However, for the time being mandatory technical regulations cannot be applied without:

- improving the dissemination of information and technical assistance to the private sector
- designating laboratories officially responsible for testing pesticide residues for local and imported products
- designing and implementing an efficient administrative and technical support system to adopt and apply the technical regulation that would allow imported products to be tested rapidly enough, taking into consideration that they are perishable products.

Currently, the IRI provides the following services regarding chemical products:

- control of pesticide, insecticide, and herbicide contaminants in food products, soil and water
- control of polyaromatic hydrocarbons contaminating food products, soil and water
- control of polychlorine of biphenyl (PCBs) contaminating food products, soil and water
- detection of traces of metal in food products, soil and water
- nutrition labels for food products
- conformity to specifications.

The above-mentioned services can range from testing a single sample to conducting any kind of statistical sampling or methodology proposed to the IRI. The cost of testing one sample is LBP 128,000 (US$ 85.30). However, considerable discounts are made depending on the quantity tested. IRI can also provide labels once the products are tested. The cost of the whole eco-labelling programme again depends on the quantity of samples and the agreement made with the IRI.

The IRI is currently working with the "Export Plus" programme – a programme helping exporters of agricultural products to reduce transportation costs – to test some exports before they are shipped through the Export Plus programme. While the IRI is equipped to handle all technical testing required by exporters or importers of Lebanese products, the main problem remains the cost incurred by the farmer and/or exporter to obtain this kind of certification, which can be an additional financial burden they cannot afford.

9. Main conclusions and recommendations

9.1 Main conclusions

This study on the effects of trade liberalization on agriculture with special focus on products where methyl bromide is used has shed light on the main alternatives to methyl bromide that are currently being used in Lebanon. The study was based on the Demonstration Project on Methyl Bromide Alternatives in Soil Fumigation – Lebanon 2001 (Lebanese Ministry of Environment and UNDP, 2001). The major conclusions of this study are summarized below.

1. The analysis on annual NRs indicated the financial feasibility of almost all alternatives that were tested on the four considered crops (except for cucumbers under 1,3-Dichloropropene, Dazomet, soil solarization, and bio-fumigation using Sudan grass). However, although feasible, several of the alternatives yielded lower annual NRs than methyl bromide (except for eggplants).
2. The analysis of the impact of methyl bromide alternatives on the production of crops has shown that several alternatives produce lower yields than methyl bromide (except for Cadusafos on cucumber, grafting on tomato and bio-fumigation on eggplant).
3. The financial CBA indicated that most of the alternatives tested on cucumber, strawberry and tomato were infeasible when based on the average market prices for 2000 and 2001. However, these alternatives become feasible (except for cucumbers in which only some alternatives become feasible) when the crops enjoy premium prices as eco-labelled products and when it is taken into account that farmers do not actually pay for all costs, in particular the cost of labour (i.e. not considering the opportunity cost of family members involved in the production process). The CBA also indicated that all alternatives tested on eggplants were feasible based on the market prices for 2000 and 2001, while methyl bromide was not feasible under these prices.
4. The impact assessment of trade liberalization and methyl bromide use on the environment in Lebanon indicated that methyl bromide alternatives have no known effect on the ozone layer and on human health, but might result in groundwater contamination, possible pesticide residues in the case of chemical alternatives and waste generation (plastic residues).
5. The socio-economic impact assessment of trade liberalization and methyl bromide use in Lebanon indicated that methyl bromide alternatives might be ineffective against certain pests, but may result in more revenue for the farmers compared to some other alternatives, and more employment opportunities with the boom in exports (particularly with non-chemical alternatives). Rural-urban migration would eventually be limited as a result of farmers being better off.
6. The impact assessment of trade liberalization and methyl bromide use on the import/export of agricultural products in Lebanon indicated that, although methyl bromide alternatives produced lower

yields per dunum compared to methyl bromide, using these alternatives enables the farmers to test, adapt and adopt alternatives in due time before the supply of methyl bromide decreases and eventually ceases. Increased marketable volumes will occur as a result of new markets, leading to an overall increase in crop production (though not an increase in production per area of land) and eventually to an increase in overall farm incomes.

7. The impact assessment of trade liberalization and methyl bromide use on the import/export of agricultural products in Lebanon indicated that the use of methyl bromide alternatives could lead to a potential increase in export volumes specifically with the use of non-chemical alternatives (i.e. crops enjoying higher premium prices). However, the assessment also indicated that potential losses in local and international market competitiveness could occur once trade is liberalized due to the advantage of developed countries' economies of scale.

8. The study has suggested a two-phase policy plan to ensure the efficiency and sustainability of the methyl bromide phase-out in Lebanon. The main processes in this policy include motivating farmers to switch to methyl bromide alternatives, establishing networks between production and marketing stakeholders, exploring and identifying potential export markets, guiding the farmers through the newly explored markets, and establishing a database that could be accessible to the network of stakeholders. These measures will render farmers ready to compete in free-trade markets.

9.2 Recommendations and areas for future studies

This study constitutes one minor step towards analysing the effects of trade liberalization on agriculture in Lebanon. Several additional studies should be conducted in order to achieve a complete and comprehensive assessment of the effects of trade liberalization on agriculture in Lebanon.

The main recommendations and areas of future studies suggested by this project are as follows.

1. Conducting experiments on methyl bromide alternatives on a wider range of crops and using specific experimental designs that would reduce variability in conditions between one experiment site and another in terms of soil structures, crop variety, management practices, geographical locations, etc.
2. Conducting studies that would take into consideration the various pesticides and the quality of water used in the production of crops in Lebanon since these constitute a significant barrier to trade in terms of SPS measures.
3. Exploring new alternatives that might be more profitable than the ones currently being tested.
4. Establishing a database on factors regarding greenhouse production in Lebanon (an example would be the yield of various crops from greenhouses).
5. Conducting studies on trade liberalization in Lebanon, particularly on the agricultural sector.
6. Assessing quantitatively the decrease in medical costs as a result of switching to methyl bromide alternatives.
7. Assessing quantitatively the environmental benefits resulting from a switch to methyl bromide alternatives.

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