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Land Use and Water Resources Research

Educational, institutional and governmental obstacles to protecting water resources from improper agricultural practices in Lebanon

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Abstract
Agriculture is the biggest user of water in Lebanon, a relatively water-rich country in a mostly arid region. Pollution of water resources in Lebanon varies according to region but most is mainly due to sewage discharge and agricultural activities. As with intensive agricultural practices worldwide, the agricultural sector in Lebanon relies heavily on agrochemicals to protect crops and improve their yield. To ensure sustainable agricultural production, proper management of soil and water quality is required. This study aimed to identify obstacles (educational, institutional, regulatory, etc.) hindering the protection of water resources from inappropriate agricultural practices in Lebanon. First, a limited field survey was conducted to determine current farm practices with respect to the farmers' awareness of the environmental impact of their practices, specifically agrochemical use, and the role of best management practices (BMPs). Second, a review of studies on the impact of agriculture on water resources in Lebanon and a review of current regulations and legislation aimed at controlling environmental degradation were performed. Finally, key barriers to implementing water resources protection measures (e.g. BMPs) were identified and measures to overcome them recommended.

Introduction

As population increases, agricultural productivity has to be stepped up to meet the increasing demand for food and fibre. To achieve this goal in Lebanon, intensive agricultural practices have been taking over from traditional practices. Intensive farming is characterized by the extensive use of agrochemicals to protect crops and increase their yields. Soil and water pollution often arise when these chemicals are used in excess of crop requirements or in a manner not consistent with their intended use.

Literature Review

The problem of agrochemical pollution is a worldwide phenomenon. The many aspects of the problem include poverty, lack of awareness, absence of adequate and proper legislation, poor enforcement of laws, inadequate extension services, misguided assistance by developed countries to poorer countries, etc.

The increased awareness of the environmental damage caused by this type of pollution has prompted governmental and non-governmental agencies to seek prevention and mitigation measures. Several solutions have been elaborated and applied. These comprise, among others, the development of agricultural and environmental policies (Tomich *et al*., 2004; Piorr, 2003; Falconer and Hodge, 2001; Walls and Palmer, 2001); establishment of monitoring programmes using environmental and agricultural indicators and data (Piorr, 2003; Singh, 2000; Scoones and Toulmin, 1998); enactment of economic and other, namely legal, incentive programmes to encourage farmers to use less polluting methods and technologies (Yang *et al*., 2003; Stanley, 2000); and raising awareness through educational campaigns and out-reach programmes that targeted mostly farmers (Sidibe, 2005; Bhanti *et al*., 2004; and Rahman 2003). Two

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major themes that underlie most of the solutions proposed to reduce, mitigate and prevent pollution from agricultural practices are participatory approaches and institutional reforms. Participatory approaches emphasize the involvement of all stakeholders, especially farmers, in the development of solutions to environmental problems. Many case studies may be referred to that attribute successful efforts at curbing pollution from agriculture to farmers' participation (see Sidibe, 2005). In addition, some researchers have identified the participation of farmers as very important in pollution prevention efforts (Tanaka and Sato, 2005 and Bhanti *et al*., 2004). Reforms of institutions and the development of an adequate institutional framework were stressed by Yang *et al*. (2003) in their review of irrigated agriculture in Northern China. Tanaka and Sato (2005) emphasized the role of water user associations in the sustainability of agriculture in Japan. A study on the fertiliser market reforms in Benin found that these resulted in lower applications of fertilisers, thus reducing the potential for pollution (Kormawa *et al*., 2003).

Lebanon's climate

Lebanon's climate is typical of the Mediterranean region and is characterized by distinct seasons. It has a short rainy season followed by a relatively long dry period. The physiographic features of the country have a marked effect on water resources and their distribution. The country's distinct features are its two parallel mountain ranges running north to south: the Mount Lebanon on the west and the Anti-Lebanon on the east. The Mount Lebanon range is separated from the Mediterranean by a narrow coastal plain while the Beqa'a valley separates the Mount Lebanon from the Anti-Lebanon.

Rainfall in Lebanon is also greatly influenced by the country's physiographic features. The coastal plain and the western slopes of the Mount Lebanon mountain range receive the highest rainfall. Next is the southern section of the Beqa'a. The plain's middle and northern portions have less rainfall and the Anti-Lebanon receives the least amount of rain. Annual precipitation on the coastal plain ranges between 600 mm and 1000 mm. Mount Lebanon may get precipitation up to 2000 mm annually but a typical range is 1000 mm to 1400 mm. Rainfall in the central and northern Beqa'a is approximately 200 mm to 600 mm annually, while in the southern portions of the plain it is 600 mm to 1000 mm annually. No consistent data are available for rainfall on the Anti-Lebanon Range (Ministry of the Environment, 2001). In all regions, rainfall is concentrated in a very short period between November and April. Typically, January is the wettest month followed by December and February. The highest evaporation rate occurs in the months of July, August and September (Ministry of the Environment, 2001).

Water resources in Lebanon

Lebanon is drained by 17 perennial and several seasonal rivers. Flow data are sporadic and were nearly non-existent during the war period (1975–1990). Almost all of the perennial rivers are coastal, with only three found in the interior of the country: Litani, Assi, and Hasbani. Furthermore, Lebanon shares three rivers with neighbouring countries: the Kebir and Assi with Syria and the Hasbani with Israel. Flow from perennial and seasonal streams and rivers is estimated at around 3900 million m^3 (MCM) per year (Ministry of Environment, 2001).

Fissured karstic limestone covers more than 65% of Lebanon (Hajjar, 1997), which has allowed for the formation of a substantial number of high yield aquifers. Sustainable development of groundwater may yield between 400 and 1000 MCM per year (Abdulrazzak and Kobeissi, 2002). A 1970 report by the UN estimates the potential maximum exploitable amount of groundwater to be around 3000 MCM per year (Hajjar, 1997).

Agriculture is the biggest user of water in Lebanon (Ministry of Environment, 2001). It is estimated that between 75% and 80% of available water is used in agricultural practices. Abdulrazzak and Kobeissi (2002) estimated that agricultural water demand was 875 MCM in 1990, 950 MCM in 2000 and projected it to be 2300 MCM in 2025. This is compared to domestic water demand of 271 MCM in 1990, 550 MCM in 2000 and 1110 MCM in 2025. Irrigated lands make up approximately 44% of the total agricultural lands. Surface and groundwater sources are used in irrigation, with nearly 489 MCM per year from surface waters and 411 MCM per year from groundwater (Khalifeh, 2002). The dominant irrigation technique in Lebanon is surface irrigation followed by sprinkler irrigation and then drip or trickle irrigation.

Agriculture in Lebanon

Agriculture is a major component of Lebanon's economy. It employs 12% of the labour force and represents 10.4% of the country's gross domestic product (Salloum, 2002). The Ministry of Agriculture (MoA), reported that in 2001, agricultural land covered about 24% of the country – approximately 253 000 ha (MoA, 2002). The Beqa'a muhafaza (county) has the highest percentage of land dedicated to agricultural use followed by the North muhafaza and then the South muhafaza (see Fig. 1).

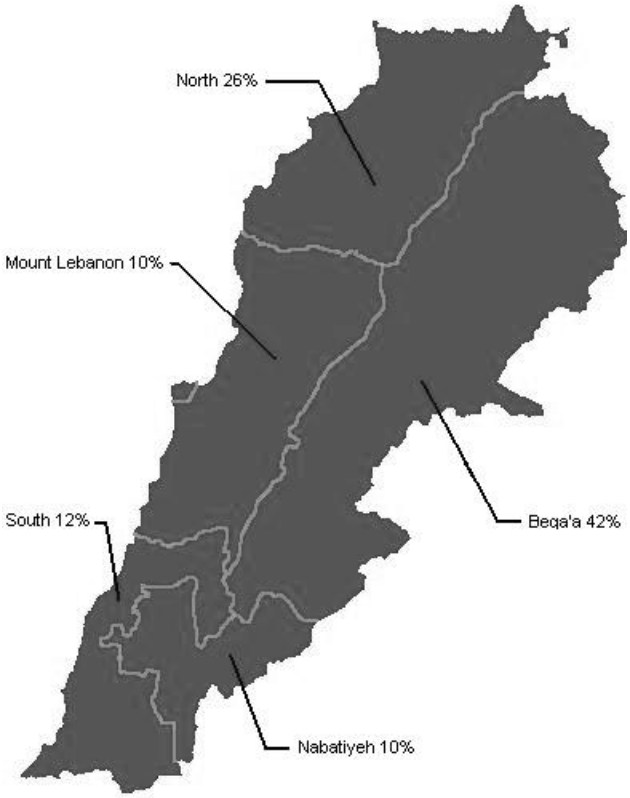

Figure 1. Distribution of agricultural land in Lebanon

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According to agricultural censuses conducted by the Ministry of Agriculture in collaboration with the United Nation's Food and Agricultural Organization (FAO), over the past five years land dedicated to agriculture has fluctuated, increasing in the first three years and then decreasing. However, during that time, revenue from agriculture decreased steadily (MoA, 2000 and 2002).

Current crop production in Lebanon

The general type of planted crops and their distribution has not changed significantly over the period 1997 to 2001 (MoA, 2000 and 2002). Agricultural activities are, and historically have been, based mainly in the Beqa'a county, with 42% of agricultural production, followed by the North and the South counties (26% and 12 % respectively). The Ministry of Agriculture (MoA, 2000 and 2002) reported that the most commonly grown crops in Lebanon are fruit, olives, cereals, vegetables, legumes and forage crops. Fruit tree production constitutes the largest portion of agricultural land followed by oleaginous trees and cereals; the highest revenues are generated by fruit trees followed by vegetables with fruits, oleaginous trees and vegetables.

Use of agrochemicals in Lebanon

As with intensive agricultural practices worldwide, the agricultural sector in Lebanon relies heavily on agrochemicals to protect crops and improve their yield. As such, synthetic chemicals are used abundantly and in some cases abused. Most farmers in Lebanon rely on synthetic fertilisers rather than the more environmentally friendly organic fertilisers by a ratio of nearly 6:1 (Port of Beirut Customs, 2003). According to Customs data, synthetic fertilisers are purchased primarily during the first half of the year (Port of Beirut Customs, 2003), during which time most are applied, indicating that most probably no stockpiling of fertilisers occurs. This information would support the premise that most pollution due to fertilisers is from fertiliser application rather than from leaks from vendor stockpiles or on-farm storage. A similar pattern is observed for pesticides in which the reliance by Lebanese farmers is mainly on synthetic products that are applied directly upon purchase, with limited to no on-farm storage (Pharmaceutical Division, MoA, 2003). This last point is important when considering sources of agrochemical pollution in that it rules out leaks from on-farm storage facilities.

This study aims to identify obstacles (educational, institutional, regulatory, etc.) hindering the protection of Lebanon's water resources from inappropriate agricultural practices, namely improper agrochemical use, and to propose measures and programmes to overcome these obstacles. The major steps to reach the study objectives are:

(i) a review of current regulations and legislation;
(ii) a review of studies of the impact of agriculture on water resources in Lebanon;
(iii) a survey of current agrochemical use amongst farmers;
(iv) the identification of key obstacles or barriers that hinder the implementation of BMPs; and
(v) a proposal of measures to overcome the barriers.

Methods and Results

A review of relevant Lebanese legislation and regulations was carried out, together with a limited survey of current farming practices focusing on the use and disposal of agrochemicals. A brief review of studies addressing the impact of agriculture on water quality and quantity preceded the survey. The following sections summarise the results of these two tasks.

Administrative set-up for the Lebanese water sector

The national administrative set-up for the water sector consists of line ministries and water authorities. The main ministries involved are the Ministry of the Environment which is concerned with the quality of water resources and the Ministry of Energy and Water (MoEW) which handles the planning, development and exploitation of water resources. Water authorities are affiliated to the MoEW and are responsible for regional and local implementation of applicable policies, as well as the development and operation of relevant infrastructure. However, the Ministry of Public Works and the Ministry of Interior and Municipalities are also involved in the development and operation of water-related infrastructure. The Ministry of Public Health is also concerned with water quality issues as related to public health. There are no clear demarcation lines as to where one ministry's jurisdiction begins and another ends. This is further confused by the poor coordination that is typical of a strongly centralised government.

Relevant Lebanese legislation and regulations

There are several laws, decrees and decisions that pertain to agricultural practices and water use, the most pertinent of which are listed in Table 1. None of the laws, decrees and decisions directly addresses the issue of agrochemical pollutants. Decision No. 8/1 by the Ministry of the Environment focuses nearly entirely on point source discharges. It does not address the issue of non-point source pollution. This is especially critical because most of the pollution generated from agricultural activities is non-point source pollution. Moreover there are no laws, decrees or decisions that give incentives, financial or otherwise, for farmers not to pollute. None or very few clearly state what the penalty would be for non-compliance. The agency responsible for enforcement is often not clearly described nor is the process of enforcement. In addition, there is no dedicated judiciary with a clear mandate to follow up on environmental laws.

Some of the laws/decrees/decisions listed in Table 1 date back between 30 and 80 years while others are fairly recent. More importantly, there is no coherent national water or environmental policy to guide legislators in drafting the required laws and regulations. Thus they lack proper focus or direction for enforcement. There is therefore a dire need to update and revamp some of the existing laws and formulate these under a policy for both the water and environment sectors.

Impact of agriculture on water resources

The direct impact of agricultural practices on the quality and quantity of water resources in Lebanon has not been well documented. Many well owners in the Beqa'a have noticed a steady decline in the level of water in their wells over the past decade or more. Nitrates and chloride

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Table 1. Relevant Lebanese legislation

Laws/Decrees/Decisions	*Summary of Legislation*	*Date*
Decision No.320:	Sets conditions for the practices and activities affecting water bodies (Rivers, Canals, Public Springs, etc.)	26/5/1926
Law No. 6/68	Targets all the practices dealing with the production, import, packaging, selling and buying of agrochemicals	
Decision No.341395	Requires to have a pedigree for compound fertilizers from the country of manufacture and to perform a local test in an approved laboratory showing the authenticity of the pedigree and the extent of the activity of the fertilizer	11/5/1995
Decision No.94/1	Presents a list of banned agrochemicals (pesticides)	20/5/1997
Decision No.254/1	• Import of agrochemicals is subject to a preliminary authorisation by the minister of agriculture • Monitors the quantity and quality of imported of agrochemicals, and the use of the chemical	30/5/1997
Decision No. 92/1	Requires labeling of specification and directives as set by the WHO and the FAO	1/1/1999
Amendments to Decision No. 92/1	Sets regulations for obtaining a licence to: • Import agrochemicals. • Load, unload and transport agrochemicals. • Market agrochemicals for the public. • Package agrochemicals. • Formulate agrochemicals. • Produce agrochemicals. • Become a contractor dealing with agrochemicals	27/4/1999
Decision No. 8/1	National Environmental Quality Standards for air pollutants and liquid wastes discharge in the sea, sewer networks and surface waters	1/3/2001
Decision No. 262/1	Banning the use and import of some pesticides.	26/9/2001
Law No. 444 (Environmental Code)	This law specifies legal framework for implementing the national environmental protection policy, in order to prevent and control environmental degradation and pollution and enhance sustainable natural resources exploitation.	2002

concentrations were particularly high in coastal wells while phosphates, sulphates and heavy metals (Cr, Mn, Ni, Cu, Fe, Zn, As, Cd, Pb, and Hg) concentrations were within acceptable ranges (El Fadel *et al.,* 2000a). A study of groundwater in the Litani basin determined that heavy metal concentrations were very low in all sampled wells (MVM Konsult, 2000).Very few studies addressed the issue of surface water quality. Furthermore, very few if any of these studies separated point source pollutants from non-point source pollutants. A study carried out on nine perennial rivers attributed most of the pollutants to the discharge of untreated sewage (El Fadel *et al.,* 2000b). Farajalla and Abou Mosleh (2005) found no heavy metal pollution in the ten perennial coastal rivers. Another study (MVM Konsult, 2000) concluded that the Litani River (the major inland river of the country) is severely polluted by domestic sewerage and some industrial sewerage. The study also indicated that the extent of pollution from agriculture needs to be further studied due to the lack of data. Finally, a study targeting the southern part of Lebanon determined that farmers in the area of study applied on average 170% more water on their fields than was required. (MoE/ARD, 2003) This applied to all irrigation methods, with over- application in surface irrigation ranging from 110% to 300%, in sprinkler irrigation from 70% to 100% and nearly 130% in drip irrigation. The same study showed that some water sources in the area covered had high nitrate and phosphorous concentrations that may be attributed to agricultural practices.

In summary, pollution of water resources in Lebanon has not yet reached a critical level. Stress on water bodies in Lebanon varies according to regions. Along the coast, where population densities are high, the primary source of water pollution is sewage followed by agriculture practices. In the Beqa'a, agricultural practices are the prime sources of pollution (Abou Mosleh, 2005).

Survey of current farming practices

A limited survey was conducted throughout four counties (or muhafazat) in Lebanon that have the highest percentage of land dedicated to agriculture – Beqa'a, South, North and Mount Lebanon. The survey was conducted through personal

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interviews with farmers by members of the survey team. The target population was farmers in the designated areas, some of whom owned their farms while others only rented them. All were males and heads of households. Typical family size was around seven. This figure, however, includes only parents and children and does not cover the extended family (grand-parents, in-laws, cousins, etc.) that may be dependent on the interviewed farmers. The survey itself was made up of 16 questions which covered the following:

- Personal information (name, location of home, ability to read, etc.);
- Land size holding and location;
- Use of agro-chemicals including (separate entries for fertilizers and pesticides):
  - sources
  - storage,
  - method, rate and number of applications,
  - source information for the above,
  - disposal, and
  - targeted crop and area planted
- Irrigation including:
  - if irrigation is practised, then the method/type followed,
  - rate and number of applications per season and length of each application
  - source of information for above
  - targeted crop and area planted
- Knowledge of the effect of agricultural activities on the environment; and
- Best management practices that might be implemented (i.e. terracing, tillage practices, use of windbreaks, etc.) and whether these had negative impact on crop yield or productivity and the financial cost of such practices.

The responses to questions were noted by interviewers and the response rate to the survey was 100%.

The total farm land area covered in this survey was about 1000 hectares and the crops grown included grains and orchards and the most commonly grown crops in Lebanon. It was noted that some kind of crop rotation does take place; farmers lease land for farming and would then grow crops that had not been grown on it during the previous season.

Nearly all (95%) of the farmers surveyed applied fertilisers and pesticides to improve the productivity and yield of their crops, while the remainder practised organic farming. Among the farmers who use chemicals in their cultural practices, nearly 60% rely on the chemical vendor for application rate information; the rest rely on label information, on advice from agronomists, or personal experience. The farmers that relied on vendors for information indicated that most agrochemical vendors recommended that applications be made at 20% to 30% in excess of the rates indicated on the labels.

Many agrochemicals are used in the survey area. Fertilisers used include the common compound fertilisers and the more unique foliar fertilisers. Over the survey area, fertiliser application rates varied widely, with some farmers under-fertilising while others over-fertilise. The reason for this variation is that vegetable farmers tend to apply more fertilisers than other farmers. Only 5% of the farmers surveyed tested their soils for nutrients and those that did, did not take the results into consideration when planning their fertilisation programme. Pesticide spraying also varied within the survey area in a manner similar to that of fertilisers. Significantly, none of the pest control chemicals used was found to be on the banned chemical list issued by the Lebanese Government. No farmers conducted field surveys to detect pests and none applied integrated pest management. More than 60% of farmers store their agrochemicals on their property and all either burn their unused and empty containers or dispose them in fields or dumpsters. Fertiliser bags are either burned or washed and reused for some other purpose.

More than 95% of surveyed farmers irrigate their crops. The method of irrigation used is dependent on the crop grown. Nearly 68% of the farmers in the south use drip systems. A larger number of orchard growers in Mount Lebanon are also now using drip systems, with nearly 60% of those surveyed having such systems installed. The Beqa'a and the North had the lowest number of drip system users, 57% and 42% respectively. However, 42% of the farmers in the Beqa'a are using sprinkler systems but only 14% of those in the North have such systems installed.

It was found that water application rates are determined mostly through personal experience, even for the drip and sprinkler systems. Furthermore, no farmers know the exact flow rate in their conveyance and application network.

Most of the surveyed farmers (70%) believed that their agricultural practices had no negative impact on the environment. However, this awareness varied by region. Farmers in the South seemed to have higher awareness, with nearly half of those surveyed indicating knowledge of the impact of their practices on the environment. The Beqa'a and the North had the lowest awareness, 16% and 33% respectively. The probable reason for the high awareness in the South is the high level of non-governmental organizations (NGOs) activities in that area. Most of these activities are centred on sustainable development which involves sustainable agricultural practices. Some farmers do implement BMPs, though most do not knowingly do so. The BMPs implemented are terracing (farmers in the North, South and Mount Lebanon only); safe/proper disposal of agrochemicals; proper applications of agrochemicals (timing, rate, frequency); use of trees as wind-breaks. Most farmers believe that the soil acts as a filter that traps and neutralises chemicals. No farmers are aware of vegetative buffer strips, irrigation water recycling and other similar practices.

Even though the survey was limited in scope, it corroborated the findings of other studies (El Fadel *et al*., 2000a; MoE/ARD, 2003). On the water quality aspect, the study highlighted the lack of awareness among farmers of the impact of agricultural practices on the environment. For example, nearly all farmers surveyed improperly disposed of their empty or unused chemical containers. Farmers were found to use 20 to 30% more agrochemicals than recommended on the labels which reflects both the farmers' lack of confidence in the quality of the product used, the common belief being that more is better, and also the lack of proper guidance. This takes on special significance when considering the cost of agrochemicals and the poor financial conditions of farmers. Similarly, with respect to water quantity issues, farmers were found to be uninformed on how much irrigation water is required by crops. This reflects a similar finding by MoE/ARD (2003) which

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indicated that farmers in some parts of southern Lebanon over-irrigated their crops. Farmers in general were found to be not well informed of the impact of their cultural practices on the environment, especially on water resources.

Conclusions and recommendations

Lack of farmer awareness and knowledge of the impact of agricultural practices on the environment in general and water resources in particular is the primary barrier to implementing best management practices in Lebanon. Secondary barriers exist and may be grouped into the following four major categories: economic/financial, technical, legal and incentives. The economic/financial barrier mainly revolves around the farmer's inability to afford the costs involved in implementing BMPs. The technical barrier relates to the farmer's lack of practical know-how. Typically, there are no financial incentives for farmers to implement BMPs. In addition, there are no legal consequences or constraints on the polluting activities of farmers.

Knowledge and awareness are at the core of the problem. They come into play along each secondary barrier. For example, a farmer must know or be aware that there are incentive programmes for implementing BMPs. Similarly, a farmer must know or be aware of the material that should be used to have the least impact on the environment and water resources, and so on. The most effective method to overcome the knowledge/awareness barrier is through education. Educating farmers is not sufficient, however: decision-makers and the general public must also be informed of the impact of agrochemicals on the environment. The best education tool is awareness campaigns coupled with demonstration projects to tangibly prove that BMPs would be effective and eventually financially rewarding if properly implemented. Awareness campaigns must target farmers, decision-makers and other stakeholders (e.g. schools, professionals and the general public). The financial/economic barrier should be addressed through the perspective that both farmers and society must share the cost of BMPs. If the implementation of the BMP is too costly for a farmer in terms of forgone profit, then farmers will not change their practices. However, if BMPs are not implemented, then water supplies are threatened by pollution from agrochemicals and the community pays. Therefore, government programmes must be created which off-set the costs borne by farmers in implementing BMPs. Some of these programmes are cost-share programmes in which the government pays for part of the cost of implementing BMPs. The technical barrier may be readily overcome through extensive extension work by the government and NGOs. Cooperatives may also aid in making information and required material available to farmers at cheaper rates. The legal and incentives barriers represent the carrot and the stick with the latter being the carrot. A good incentive programme that involves financial and material rewards would help convince farmers to adopt and implement BMPs. Such programmes may include admission into export or marketing cooperatives that will help market the produce of farmers who implement BMPs. At the same time, hefty fines would serve to deter farmers from practices that have been outlawed. Table 2 lists examples of the approaches that could be used in overcoming barriers.

Once the awareness barrier is overcome, economic analysis will invariably guide farmers. Therefore, it is with this in mind that all approaches to overcoming barriers must be designed. In addition, a national policy aimed at preserving the quantity and quality of water bodies must be developed. Part of this policy would be the establishment of institutions and services throughout the country, but particularly in the rural communities, that provide key services especially for farmers. These institutions and services would address critical issues such as security of land tenure, adequate markets and transportation to these markets, and easy access to technical assistance. New laws and regulations must be drafted and old ones modernised to meet this need for a flexible forward-looking policy that would support the sustainable development of the agricultural sector while at the same time protecting the environment. Of particular importance within this framework would be to draft laws or regulations that address all aspects of non-point source pollution and promote the use of incentives. Of special importance though is the inclusion of a 'polluter-pays' clause to ensure proper compliance.

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Table 2. Barriers and examples of approaches to overcome them

Barrier	Approach	
Knowledge/Awareness	• Awareness campaigns	• Extension programmes
Economic/Financial	• Assistance programmes • Tariff removal	• Tax reduction • Low interest, long term loans
Technical	• Research and extension work	• Private sector involvement
Legal	• Enforcement of laws	• Updating of Laws
Incentives	• Financial: e.g. marketing assistance for farmers implementing BMPs	

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