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Managing non-point source pollution in China making the market work

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A B S T R A C T

This study explores the incentive instrument to avoid overuse of nitrogen, which causes Non-point source pollution (NPS), and discusses what the mechanism that results in this nitrogen over-use is. It asks how to introduce market tools that would provide the right incentives to stop its overuse. The paper compares the current water pollution management systems in the Chesapeake Bay, USA, where payments for capital costs at the farm and abatement programs of agricultural measures have been undertaken, with the current systems of Dianchi Lake in China. The methodology used involves a comprehensive review of the relevant definitions of terms used in Payment for Ecosystem Services (PES) by the Chinese and the international community, and discusses implementation of PES for managing farmers' use of fertilizer in China. The review of PES also includes the steps needed to determine compensation. It involves uses interviews conducted with farmers in Yunnan Province and an economic analysis of current subsidy policies, taxes, and grants used domestically and internationally. The main PES schemes that have been implemented in China for NPS processing are also discussed and reviewed in order to show how to successfully achieve PES projects that ensure poverty alleviation. The findings suggest that one of the main ways to reduce overuse of nitrogen and to reduce run-off pollution is to change the Chinese subsidy programs by creating new direct subsidies that will promote and reward behavior change. This will give incentives to farmers to curb their overuse of chemical fertilizers.

1. Introduction

Non-point source pollution (NPS) is identified as one of the prominent sources of water quality deterioration via the introduction of water pollution. NPS is caused by agricultural runoff (EPA, 2003). Agricultural runoff is caused by the overuse and dissemination of various fertilizers typically used in farming practices, including chemical fertilizer, nitrogen fertilizer, and pesticides. These chemicals are distributed via water sources and water operations and rain runoff, and are often carried to downstream rural and urban populations. This polluted water can then affect the quality of life and health of local communities. Thus, controlling agricultural NPS pollution source is a necessary priority.

However, effective work has yet to be done on how NPS can be mitigated, and what ecological compensation mechanisms could be effective. Though China has attempted to implement several ecological compensation mechanisms, most of the focus has been on curbing pollution identified from single localized sources, a.k.a. Point-source pollution. This study will show that many international governments and organizations, including the USA - which will be shown in the study, utilize environmental Payment for Eco-system Services (PES) and subsidies through central government grants and taxes that encourage better environmental practice by considering local watershed development cost. This study will examine and consider how such PES schemes implemented in the USA can also be used in China to mitigate the overuse of chemical fertilizers.

1.1. Background: general water resource situation

Three quarters of rivers in China suffer water pollution (China Daily, 2005). Agricultural NPS is considered to be a predominant source of this pollution. It results in health problems for citizens, soil erosion, and loss of land productivity. NPS modeling using Soil and Water Assessment Tools by Xiaoyan Zhai (2013) has shown that since 2001, NPS has been increasing in China. NPS sources of water pollution are those such as agricultural chemicals (fertilizers, pesticides, herbicides), and the discharge of wastewater from animals released via soil erosion and water runoff.

The main causes of NPS are overuse of chemical fertilizers as well as insect killing sprays known as pesticides (Sun, et al., 2012), and the yearly use of these toxins has risen to almost 120% (Norse, 2005). In fact, China is the main consumer as well as manufacturer of these fertilizers. The application of chemical fertilizers is typically over-used by up to 50% more than necessary, which is more than intensive vegetable production needs (Norse, 2005). Farms are the largest source of sewage runoff and nitrogen emissions, and intensive agriculture has been found to be the main source of phosphorus emissions. In fact, nitrogen and phosphorus have been found to directly contribute to the wide range of water quality problems in China (China Environmental Protection, 2010).

The main issues found in curbing the over-use of such fertilizers relate to high inefficiency in fertilizer application. Through this, ammonia and nitrogen found in these fertilizers is released unintentionally through rains, flood and general water loss. This then leads to high amounts of such chemicals in local waterways (Norse, 2005). Why farmers over-use these fertilizers is a difficult question to answer and involves various socio-economic factors, including yield losses, costs and profit margins, as well as climate discrepancies.

Thus, the behavior of small farmers is a main cause of agricultural runoff pollution (PRC, MEP, 2010). It is important to understand the farmers' choices and incentives, and to develop and implement sound measures that take their choices into consideration when adopting NPS mitigation policies. There are a number of tools to combat NPS pollution. These include direct regulation (such as censoring certain practices), economic incentives (such as taxes, subsidies, allowances), and promotional activities (such as educational campaigns, training workshops, and pamphlets) However, the long-term interests of the farmers need to be a priority before the implementation of any or all of the suggested above policies and measures.

1.2. Research question

This paper's' research question is the following: How to introduce market tools that would provide the right incentives to stop nitrogen and chemical fertilizer over-use in conjunction with legal, institutional and educational policies?

This study discusses why farmers currently over-use nitrogen fertilizer, which causes Non-point source pollution (NPS). It explores what economic incentive instruments can assist in curbing the over-use of nitrogen, when combined with additional legal, institutional, educational and social policies.

1.3. Literature review

The literature on NPS in China is divided into three categories: 1.) Causes of NPS, 2.) Underlying Factors for Agricultural NPS, and 3.) Policy Proposals and Examples. NPS is a major cause of water problems and of environmental quality in the water bodies of China, but research on and practices of NPS pollution control is rare (Cang, 2003; Smith, 1999; Wang, 2006). NPS pollutants contribute to a scarcity of surface and groundwater resources (Ren, 2009; Huang, 2010). Studies and interviews with farmers have shown that the over use of fertilizer by farmers revolves around the issue that the use of chemical fertilizer will result in more crops and higher productivity. Combined with the high opportunity cost associated with chemical fertilizer and the structure of the traditional extension system (a structure which aids farmers in improving their farming techniques via educational actions), nitrogen fertilizer is in high demand (Zhang, 2009; World Bank, 2006). Furthermore, costs also play a role in the use of fertilizers, and the low price of chemical fertilizer affects farmers' decisions, especially when no grants, subsidies or third-party capital is available for them to rely on (Zhou, 2010; Williams, 2005). However, surveys show that, with proper financial incentives, private farmers are willing to develop ground water, change cropping patterns and adapt water-saving technologies (Wang, 2006).

Control of pollution in China is also constrained by several other issues, including: unclear laws on water pollution, weak local commitment and lack of policy-based grants to reduce agricultural NPS pollution. (Bennett, 2009. Gill, 2007; Xie, 2009; Wang, 2003a, 2003b, 2004; Wei, 2001). In addition, mechanisms for ecological compensation in China are generally restricted to the "supply" side, meaning that the polluter pays principals. In addition, there is difficulty in measuring the amount of reduction for each specific farm household when it comes to NPS.

China has not yet established a direct link between ecosystem services providers and beneficiaries of ecosystem services, making policies financially unstable (Xie, 2009). One proposed solution to over-use includes the cancellation of the original funds on chemical fertilizers and pesticides. Other countries with different social and economic environments have advocated and implemented "green box" (government-funded, agricultural, non-trade distorting) subsidies (World Bank and Analytical Support Program Advisory, 2007).

What remains to be explored, however, is the question: what is the market mechanism through which this manifest abuse of nitrogen occurs, and what market system can become the right incentive for curbing its over-use? This paper plans to determine why nitrogen fertilizer overuse manifests, and what economic incentives could be used in conjunction with institutional, informational/education/community, and legal policy changes to curb this overuse. It will examine if the introduction of PES in the market system will make the economic market more effective in curbing overuse by providing financial incentives for farmers to curb its use through the saving of natural resources in the market.

Current Chinese subsidies of emission abatement, focus on point-source pollution and therefore do not provide emphasis and provide for a market-oriented system. In contrast, in the Bay, NY, there is the Conservation Enhancement Reserve Program, which pays landowners to curb nitrogen fertilizer use in specific areas. This paper will compare current this current system in the Chesapeake Bay to China's current systems in Dianchi Lake, using facts and evidence observed in these "similar" situations as evidence.

1.4. Methodology

This paper discusses current developments in Dianchi Lake in China with developments in the Chesapeake Bay, USA and provides suggestions for the watershed component of China's projects. It assesses the implementation of PES trials and successes in the USA, and studies the relevancy it may hold for China. Furthermore, the main water pollution schemes that have been implemented in China for NPS processing are discussed and reviewed in order to determine what the distinct characteristics PES needs are in China in order to achieve successful curbing of nitrogen over-use.

This methodology of using survey and analysis of secondary data, combined with the comparison of domestic and international case studies, will allow the assessment of both Chinese and US policy models and will allow discernment of gaps and deficiencies in current methods.

1.5. Case study

Since the 1990s, Dianchi Lake has been suffering from serious water pollution, NPS discharge of agricultural practices and a sharp increase in livestock production. Analysis of research, water analysis, and interviews conducted in Dianchi Lake will be undertaken in order to understand how effective PES can be in China. Documented interviews with farmers in these areas will also be incorporated into the analysis.

These interviews are secondary sources, derived from previously published reports. These established interviews will be used as part of the survey-research for determining if PES Subsidies could be a viable alternative based on the current beliefs and practices of farmers in the practical implementation of subsidies. This will provide the data necessary to make recommendations for the implementation of such subsidies, and allow for the mapping of the potential implementation scheme needed in water pollution management in China.

Information and data for Dianchi Lake is compiled from reports by the CCICED Task Force and Center for Agriculture in China.

1.5.1. International comparison

For an example of a successful case of PES implementation, the Chesapeake Bay, USA project will be analyzed. It will define and examine the steps taken in the Chesapeake Bay to curb NPS pollution and farmer participation. This international comparison will focus specially on the following: tradable pollution permits used, NPS pollution control in the area, nitrogen fertilizer use, farmer's perspective in past and current programs, and farmer's perspective on reforms in subsidy policies.

Project data, project information documents, implementation completion reports of PES and subsidy policies in New York are provided by the Chesapeake Bay Committee.

2. NPS pollution in china

There are two types of pollutants typically found in water. One is of the biological variety that includes microorganisms that can cause diseases. The other is that of chemical pollutants like those such as those found in chemical fertilizers. The main two are nitrogen and phosphorous. In China, only 5% of water is characterized under Grade I, which means that it is considered 'pristine 'water up in the mountains often untouched by humans (Huang, pg. 5). Grade II is at 27.6% of China's water, meaning that it is drinkable and sanitary for use.

As mentioned earlier, the use of chemical fertilizers results in agricultural run-off via storm water and watering operations, which leads to NPS. It is one of the main causes of China's water pollution. However, the use of chemical fertilizer in farming practices is both beneficial and harmful. For example, adequate nitrogen supply is also essential for high yields; it and has increased farmers' income, improved food consumption, and maintained national food security. It has also buttressed crop yields and agricultural business (Huang, pg. 5).

2.1. Classes of agricultural NPS sources – prevention and modification of land-use practices

All NPS sources of pollutants are derived from soil loss caused by water run-off. This water run-off usually is derived from rainfall, snow melt or over water-use and irrigation. These pollutants eventually reach water sources, and hurt the local ecosystems including animal and human populations (Ren, pg. 250).

NPS agricultural pollution is a result of excess use of fertilizers and pesticides, as well as the burning of straw, manure, and sewage in rural areas and solid waste emissions. It is transported through the leakage of run-off and soil (Ren, pg. 250).

Excessive nitrogen fertilizer in the production of grain and vegetables in China leads to the loss of 1,740,000 tons of nitrogen per year (Williams, p. 12) and is a direct source for pollution in China's water systems.

Fertilizers play a vital role in crop production. The production and consumption of fertilizers in China has grown to 41.24 million tones. At present, the use of fertilizers is about 400 kg / ha of fertilizer in China. Average use of fertilizer in China is only 30% to 35%. The remaining 60-70% of the fertilizer is absorbed and lost into the environment, thus polluting the soil and water (Ren, pg. 250).

Chemical fertilizers have polluted the rivers and lakes of China, such as in the Dianchi basin. Approximately 23% of nitrogen discharge in Taihu Lake is from fertilizer use, and throughout China, there has been the loss of 1,740,000 tons of nitrogen per year due to the production of grain and vegetables (Williams, page 12).

In China, the largest organic pollution is from the increased use of pesticides. China produces 76.7 million tons of pesticides, and there are over 250 varieties of pesticides currently in use (Ren, pg. 250).

Use of these chemical contaminants is detrimental to long-term health. Chinese pollution studies have found a correlation between NPS pollution and increased occurrences in liver cancer and stomach cancer due to the consumption of chemicals and heavy metals via water and produce (Ediger, pg. 6). China has the highest mortality from cancer of the liver and stomach in the world. This is 4-8 times higher than the world average (Facts and Details, 2010).

3. Dianchi lake case study

Agricultural run-off, an important part of the NPS, is caused largely by small farmers' choices and behavior. If no policy intervention takes place, farmers will typically conduct their farm practices in the most cost-effective way for themselves. In China this has resulted in an increase in dependence on chemical fertilizers and on low-priced single ingredient fertilizer. This has also been the case in Dianchi Lake.

Since the 1990s, Dianchi Lake has been suffering from serious water pollution and NPS discharge of agricultural practices due to an increase in the intensification of livestock production. Therefore this analysis addresses pesticide and chemical fertilizer use in Dianchi Lake. It will show how new policy suggestions are beneficial to locals. The comparison focuses on key farmer fertilizer use and their reasons for chemical fertilizer dependency. It also focuses on the farmer's perspective in past and current programs and the farmer's perspective on potential reforms in subsidization policies.

In studying Dianchi Lake and its farmers' overuse of nitrogen fertilizer, the following questions are considered: 1.) Are farmers in China overusing fertilizer due to cheap cost and increased profits (economic reasons). 2.) What determines their level of fertilizer use? 3.) Has education or information programs had any implications on their fertilizer experience? 4.) Are there any measures or policies that can curb this overuse? 5.) Can technical extension services assist?

3.1. Dianchi lake background

Dianchi Lake is the main water resource of Yunnan's Kunming,. The lake is used for industry, irrigation, and even provides drinking water (Huang, pg. 2).

Dianchi Lake received nearly 240 million cubic meters of wastewater in the year 2000, including industrial wastewater of about 50 million cubic meters and urban wastewater of about 190 million cubic meters. These are the sources of pollution. It also received large amounts of rural waste NPS pollution. According to the 2002 statistics, more than 30% of the water pollution in Dianchi Lake originates from agricultural NPS pollution now (Huang, pg. 3).

3.2. NPS in dianchi lake

Surveying and testing in the towns around Dianchi Lake has focused on the use of phosphorus and nitrogen in the area. It has revealed that farmers, urban dwellers in the city, and the chicken factory are the main source of the chemicals. The contribution of phosphorus and nitrogen from NPS in the Dianchi Lake region has been studied with farming being shown to cause 38% of phosphorous levels and 48% of nitrogen levels (Guo, pp. 147-156). NPS makes 68% of the phosphorous and 74% of nitrogen in the lake, exceeding Point-source pollution. The amount of nitrogen fertilizer and phosphate, and the usefulness of pesticides on per unit of land, in the Dianchi Lake basin have grown rapidly since 1990. However, it has also been assessed that by reducing fertilizer operation in crops by half, total nitrogen and phosphorus could be reduced by 7%, which allows the reutilization of approximately ¼ of current farming land (Yanfeng, pp. 250 – 254).

These tests have shown that there has been inefficient use of agricultural chemicals, which is directly caused by the excessive use of chemicals and a large loss of nutrients in the water. According to the statistics, a large proportion of nutrient loads from agricultural chemicals have caused gross nutrient pollution in Dianchi Lake. The low efficiency of the effectiveness of agricultural chemicals by local farmers is caused by a variety of factors - the most important factor is that in the current system, there is a distorted agricultural economic policy and lack of specific provisions for the protection of environment in rural areas (Huang, pg. 3). This seems to be one of the main causal mechanisms for the overuse of nitrogen fertilizer.

The reason for this is that for the last 20 years, environmental protection in rural areas has been neglected. Thus, the current agricultural policies and laws of environmental protection in China have not internalized externalities supported by the production activities of farmers. Rather, some of the institutions and policies have existed only to promote farmers to make production decisions based on short-term benefits and to engage in environmentally-unfriendly production ways. For example, the price of subsidized fertilizer and pesticides, leads to lower prices of these chemicals on the market, and provides negative incentives for farmers to reduce pesticide use and fertilizer. As a result, they acquire short-term, high yields, but neglect environmentally sustainable tools and outcomes.

3.2.1. The farmer's perspective

As mentioned earlier, the key questions to ask are, firstly, whether farmers are overusing fertilizer from an economic point of view and, if so, to what extent? Secondly, what have been the factors determining the level of fertilizer use? In particular, what is the role of information in this process?

These questions are the most important aspect in developing a NPS policy to convince the farmer. Any policy, regulation, system of incentives, or outreach programs to change the application of fertilizer should consider how the farmer makes his decision on what type of fertilizer he choose to use. Williams interviewed farmers in Yunnan regarding their farming policies, and found that nitrogen and phosphorous were used heavily. Some farmers also admitted to considering the experience of other farmers, and their advice on agricultural services when making a choice (Williams, pg. 8).

The reason for limiting the use of or over-using of chemical fertilizers includes the purchase prices of fertilizers, and the effect the fertilizer has on the taste and quality of their fruits and vegetable products. The inefficiency of chemical fertilizer and how it affects crops was also considered, especially whether or not there were weak reactions of some crops to the fertilizer (Williams, pg. 19). These seemed to be the reasons s for the overuse of nitrogen fertilizer.

Williams' empirical data and survey shows that farmers who used chemical fertilizers did so because they believed in the efficiency of these fertilizers. The efficiency counterbalanced the cost of purchase. In addition, chemical fertilizers were readily available whereas manure access was limited (Williams, pg. 19).

As evidenced above, fertilizer use is determined by a variety of factors, and varies from farmer to farmer. One of the causal mechanisms appears to be price and affordability of chemical fertilizer. However, for many, the decision to use or not use is also influenced by technical service extension agencies and by irrigation restrictions (Williams, pg. 19). For any policy, farmers' demand for agricultural economic development needs to be considered and policy makers need to recognize this crucial fact (Williams, pg. 19).

In summary, fertilizer overuse is an issue; farmers in China appear to be systematically overusing fertilizer. The reason is this may due to a lack of financial resources coupled by the low price of chemical fertilizers, and low productivity and lack of irrigation systems. Reasons for such high demand for chemical fertilizer are complicated. Part of reason may be related to the high opportunity cost of labor. Furthermore, the traditional extension system encourages overuse, and does not educate on alternative farming practices, and the poor control on the quality of fertilizer induces farmers to use more fertilizer.

3.3. Current policy developments

Besides, the low price of purchasing chemical fertilizer, much limited work has also been done on developing any integrated framework for NPS and water management. In 2011, the State Council established a Chao Lake Management Authority whose mandates cover all water matters such as land use planning and water quality and quantity. The Chao Lake Management Authority also incorporates Dianchi Lake and with assistance from the Asian Development Bank, this watershed region is developing a water quality trading scheme, and eco-compensation mechanisms for clarifying rights and response for these lakes. However, it still is in the planning processes (Shang, 2006). Other financial watershed infrastructure investments that are in the development stages include a pilot eco-compensation project and funds to subsidize livestock operations, funds to produce organic fertilizer and subsidies to pay farmers to use commercial organic fertilizers. It will be paid from water user fees and government funds (Shang, 2006).

Payments for Watershed Services (PWS) programs are also currently under development. PWS is another example of a water quality trading market. Under normal circumstances, the water can create the high-quality market where there is a clear economic driving force, such as regulatory objectives (Shang, 2006). Transaction costs between given pollutants can be integral for a polluter to effectively reach his or her target level. Further, farmers who diminish their nutrient run-off can make credits at a lesser cost and sell them to others who have complications in dropping their own pollution level at a practical cost. However, this is also still in the development phase and has not yet been implemented.

3.3.1. Current policy issues and difficulties

Current Chinese agricultural policies and environmental protection laws do not curb chemical use, and only encourage farmers to make production decisions based on short-term benefits and to engage in production of environmentally-unfriendly ways. For example, the price of subsidized fertilizer and pesticides leads to lower prices of these chemicals on the market, and encourages farmers to increase pesticide use and fertilizer use (Huang, pg. 4). In addition, there are no subsidies for agricultural production of ecological agriculture, but only for circulation of agricultural products. A series of "green box" subsidies that are non-trade impeding government sponsored funds have not yet been implemented in China (Huang, pg. 5), and local policies and schools have not been able to make the external costs of agricultural production successfully internalized to encourage sustainable use because of a lack of specific regulations or penalties (Huang, pg. 4). Current water laws (as mentioned in Chapter 2) leave water rights and polluting penalties vague and make enforcement difficult. In addition, local governments do not encourage educational training programs or lectures on NPS management (CCICED Working Group, 2004).

It is important to implement policies, both economic and social, that can persuade farmers to adjust their model of soil employment, reduce agricultural chemicals and improve farming techniques, thereby dropping nutrient concentrations of nitrogen and phosphorus in the lake. However it is also important to note that any eco-compensation practice in China must manage agricultural pollution while dealing with the distinctive societal features of the country's agriculture. This includes taking into consideration the low farmer income and very small farm size. A holistic, integrated approach must be used.

Given the current characteristics of the NPS and the institutional context of the watershed of Dianchi Lake, one of the most important tasks to achieve the objectives of the fight against agricultural NPS, is to implement policies that can encourage farmers to change their pattern of land use, reduce inputs of agricultural chemicals and to improve agricultural production techniques, thereby reducing nutrient concentrations of nitrogen and phosphorus in the lake.

Policy makers should take more care of the farmers' demand for agricultural economic development, and a policy instrument cannot be set down solely for attaining an environmental protection target. Rather, each factor of the local economic development and institutional backgrounds should be considered in order for the policy instruments of controlling agricultural NPS water pollution in Dianchi Lake area to be practical and effective.

3.4. Policy options

Based on the above analysis, economic based policies for agricultural NPS pollution control in Dianchi Lake need to include reforms in agricultural taxation and fees (Williams, pg. 13), as well as new payment systems. There will also need to be reforms in the current subsidy policies. To ensure subsidy reform, China needs to withdraw the original subsidies on chemical fertilizers and pesticides, and instead implement "green box" subsidies. These "green box" subsidies should include subsidies for technological improvement, and stopping the use of pesticides and chemical fertilizers. Below is a more detailed explanation of the types of taxes, fees and subsidies that could be effective specifically for Dianchi Lake.

3.4.1. Polluters pays principle in agricultural NPS control

Pollution fees or taxes are a specific application of the "Polluters pays principle" (PPP) in environmental management. This mandatory fee on polluters encourages them to reduce their pollution and find alternative practices, subsequently improving the local ecosystem (Huang, pg. 4). This policy instrument is hard to apply to NPS because pollutant emissions of farmer's crop-land are too difficult to monitor or identify since the discharge is discrete and scattered.

However, since nutrient pollution of nitrogen and phosphorus comes from agricultural production causing water deterioration of Dianchi Lake, and since a main strategy for reducing these toxins from farm land is to decrease the application rate of agricultural chemicals, PPP can be an effective way to restrict the amount of fertilization and pesticide utility of the local farmers for controlling agricultural NPS in the Dianchi Lake area. In this case, adopting a transformation form of pollution fees, i.e. agricultural chemicals over-use fee, which is levied upon the over-use of fertilizers and pesticides (Huang, pg. 4) could be successful. This however must ensure that cropland yield is in direct proportion to the agricultural chemicals utility amount. The nutrient loads discharged from the same cropland must also be in direct proportion to the agricultural chemicals utility amount. This is necessary because the social cost is more than the private cost of the farmer's in this case. If the local government implements a regulation on agricultural chemicals utility amount per unit of cropland, and stipulates a specific and high-enough penalty rates upon the farmer's overuse of agricultural chemicals, then the farmer will reduce his agricultural chemical input level to make his/her private marginal cost equal to the social marginal cost. In other words, the farmer will reduce the input to the optimal level.

3.4.2. Reforms in subsidization policies

Using only PPP as the NPS policy scheme would be unfeasible as one of the most important criterions in choosing an effective environmental policy or policies is that no extra burden is imposed on farmers as a result. Hence, to ensure attainment of water pollution control targets, subsidies to farmers to reduce NPS pollution must be a necessary component.

A potential subsidy would be a yield reduction subsidy. Subsidizing yield reduction caused by the reduction of agricultural fertilizers and pesticides utilities, would offset profit losses and operation costs of the farmers. There should also be subsidies and payments that encourage farmers to buy bio-scientific or commercial organic fertilizers with less hazardous ingredients. The government could also encourage the abandonment of tillage with a subsidy that promotes the use of ecological forestry.

For farmers who view the use of these chemical fertilizers as crucial to their livelihood, these subsidies would ensure the development of an agricultural economy while also protecting environmental resources. Therefore, if the subsidy is high or large enough, the farmer will maintain the lower yield caused by lower input of agricultural chemicals. Otherwise, the farmer will be likely to increase input of agricultural chemicals again to get more private financial benefits.

3.4.3. Tradable pollution permits

Implementing tradable pollution permits could also be an effective way to control agricultural NPS under some certain preconditions. Since agricultural NPS is mainly caused by nutrient discharges from the use of fertilizers and pesticides, tradable pollution permits could become marketable agricultural chemical use permits. These may be traded between at least two NPS sources, or between a point-source and NPS source to restrain the total deterioration of the water pollution in Dianchi Lake.

However, the prerequisite of implementing tradable pollution permits is that a gross pollution control system must be set up in the local water environmental management office, which Dianchi Lake has not done. Further, equitable distribution of starting emission permits among the local polluters is another critical factor to effectively implement this policy. Finally, calculations of the transaction costs for emission permit trading must be undertaken, and these can be hard to determine (Huang, pg. 5). Despite this, tradable emission permits in pollution control can be more efficient compared with conventional policy instruments.

3.4.4. Non-economic policies

Economic incentive instruments can assist in curbing the overuse of nitrogen, but only when combined with additional legal, institutional, educational and social policies. This will be discussed in greater detail in the subsequent chapters, but will also be touched upon briefly below.

Technical assistance services should be increased and should include expert guidance, such as water quality maintenance, soil erosion management, inorganic and organic fertilizer management, proper and efficient use of fertilizers, agricultural transition, and the application of new technologies. These plans are vital for agricultural productivity and environmental protection.

The development of a composting facility and waste treatment site could also improve NPS dispersion. Demonstrations of this in the Dianchi Lake of sewage treatment and recycling has shown to prevent as much as 32.2t nitrogen and 3.9t phosphorous from entering the water, when 92 of solid waste was collected and approximately 88% was recycled (Lu, pg. 19).

3.5. Summary and dianchi lake NPS policy analysis

As of now, Dianchi Lake's watershed programs are only in the initial stages of development, with planned subsidies for organic fertilizer use and better agricultural operations. Currently, there are no subsidies for production of ecological agriculture, but only for circulation of agricultural products. A series of "green box" subsidies that are non-trade impeding government sponsored funds have not yet been implemented. The current agricultural policies and environmental protection laws of China induce farmers to make production decisions from views of short-term benefits and engage in production activities in environmental-unfriendly ways. Current production subsidies for chemicals and pesticide manufacturers results in lower prices of these fertilizers. Thus current economic-incentives in fact make chemical fertilizer cheap to use and encouraged. This is why current PES schemes for NPS in Dianchi Lake have not been effective. Further, Dianchi Lake watershed management is still only beginning to implement pilot programs for economic-incentive schemes. Coupled with the corruption and bureaucratic infighting of the MEP, MWR, and RBOs, mentioned in earlier chapters and their lack of information-sharing, this prevents PES programs from taking root.

In the following chapter, methods for curbing NPS in the USA will be analyzed to see if and how they can be adopted by China.

4. International comparison: the chesapeake bay

Just like in Dianchi Lake, the Chesapeake Bay, USA, has also faced NPS issues, particularly NPS caused by farming practices. Given the current characteristics of NPS and the institutional context of the watershed of Dianchi Lake, one of the most important tasks to achieve the objectives of the fight against agricultural NPS, is to implement some policies that can encourage farmers to change their pattern of land use, reduce inputs of agricultural chemicals, improve agricultural production techniques, thereby reducing nutrient concentrations of nitrogen and phosphorus in the lake. The Chesapeake gives an example of the steps China can take for curbing farmers' practices.

4.1. The chesapeake bay project

Located in the United States, the Chesapeake Bay watershed includes encompasses a total of six different US states, and also includes Washington D.C, the capital of the US. The Bay's "total area is 64,000 miles", and includes "150 major rivers and streams" (Cestti, pg. 3). Agricultural chemicals, animal waste and food dispersal has resulted in high levels of toxic chemicals in the Bay. This has caused an increase in turbidity, reduced sediment, and the death of fish and shellfish due to disease. This began in the late 1970s. Agricultural NPS is chiefly to blame for this, and is caused by the manufacturing industry and factories along the Bay, as well as from agricultural practices and urban NPS pollution caused by residential construction (Cestti, pg. 3). The food services industry has also been found responsible as high-toxic chemicals from food service plants have also contributed to NPS. NPS has accounted for 68% of nitrogen 77% of the phosphorus, with agricultural run-off being the single biggest polluter (Chesapeake Bay Program, 1997).

Common strategies for curbing water pollution include land management and water use management, the establishment of best management practices (BMPS), training programs for farmers, and financial aid and cost splitting for monitoring, enforcement, and implementation of projects. Furthermore, in the US, there has been government agency funding for market-based water quality trading, and subsidy grants for targeted watersheds. There also has been financial support for technological development from the federal government as well as financial support from states (ADB 2011, pg. 1). In addition, there have been established quotas for nutrient discharges with the Clean Water Act that has established maximum daily loads, thereby allowing for the nutrient discharge permits to be adopted and the subsequent trading of them (ADB 2011, pg. 13).

The Chesapeake Bay has various BMPs for agricultural management. They include: pesticide management, waste management, tillage and irrigation policies, soil erosion prevention methods, nutrient organization and budgeting, technical regulation, crop rotation, and covering crops in winter (Cestti, pg. 9). Soil erosion prevention involves managing surface waters' run-off. This allows for the soil to stay in place and also reduces NPS through this. Nutrient and pesticide conservation involves reducing pesticide use and taking steps to maintain nutrients in the soil, while also curbing NPS. Till aging involves reducing animal grazing and irrigation allows for more efficient water use on farms. Both of these improve water quality. Crop rotation also helps keep soil in place and cover crops (specific crops planted to manage water and soil quality) in winter. This allows for less use of fertilizer in spring. Finally, waste management involves better disposal of animal waste and feces, ensuring it does not enter waterways.

There are also monetary incentives and technical facilities and programs that encourage the adoption of the BMPs mentioned above. The Agricultural Water Quality Cost-Share Program pays for 88% of the cost of BMP installation in the state of Maryland. There is also cost-shared assistance for animal waste control and handling. Each farm receives a maximum of fifty thousand dollars. However, they receive sixty-five thousand dollars if they combine the treatment/containment program with other BMPs (Cestti, pg. 9). Each other BMP program can entitle a farm to receive ten thousand dollars to thirty-five thousand dollars, depending on the farm and program. Virginia's program pays for 75% of BMP installation, and tax credits of 25% for agricultural BMPs also support farmers to set up management practices (Cestti, pg. 9).

Finally, there are now upstream and downstream payment systems, where farmers upstream are given payments for the services they provide in environmentally friendly ways. An example is that farmers along waterways in the Catskills and in Delaware are given monetary compensation from New York City which uses the water from upstream for drinking. In addition, new water regulations have allowed for public participation by local communities, state and federal government funding for programs, well-developed quotas and standards for measuring program success and water quality, and guaranteed accountability and transparency by having both local enterprises and local community members serve on monitoring and policy committees (ADB 2011, pg. 13).

4.2. Previous fertilizer practices

Chesapeake Bay farmers, however, did not always conserve their fertilizer application. They used to apply both manure and commercial fertilizer on top of one another even though the manure was sufficient in providing nutrients to their crops (Cestti, pg. 4).

Recently, through education and training programs, the attitude of farmers on the use of chemical fertilizers and manure value has changed because the Chesapeake Bay program combined educational programs and economic incentives with assessment of the local watershed. Nutrient budgets and management programs considered the establishment of realistic performance targets for crop and quotas for nutrient levels, testing the soil to assess needed amounts of nitrogen and phosphorous and how much manure could replace chemical fertilizer in application, and assessing the best time of adding these additional nutrients to ensure strong crop growth (EPA 1993, pp. 2-60).

These programs allowed farmers to decrease their NPS, thus cleaning up the local waterways impacted by their operations. However, it also improved their farming practices and operation management systems. This resulted in better crop quality and quantity while reducing their operational costs (Pease, 1998), with an annual saving of approximately fifty-five dollars per every hectare (EPA 1993, pp. 2-60).

In fact, the Division of Soil Conservation and Water in 2003 assessed several Virginian farms, and found that with these new operations policies nitrogen fertilizer use decreased by 106 kilos per hectare and resulted in a decrease in dissipated/diffused nitrogen by 45%. Meanwhile, profits rose approximately by four hundred to seven thousand dollars per hectare (Cestti, pg 20).

4.3. Financial incentives and educational services for farmers

The Chesapeake Bay Area offers financial incentives for farmers to reduce nitrogen use. Taxes, subsidies and Best Management Practices have been organized by the local and state governments (Cestti, pg. 8). These assist farmers in implementing better practices, and especially ease costs of farmers by compensating them for initial product and profit losses. For example, Maryland gives tax credits to farmers to change their fertilizer brand. However, in states like Virginia, farmers are given tax breaks when they participate in their best management schemes (Cestti, pg. 10). Farmers need to buy nutrient management plan accredited technology that applies nutrient qualification testing. The state pays for 25% of this cost via tax break (Faverno, 1997).

However, the program also encourages education and technical assistance. The program has a partnership with numerous agencies, research and development boards, and technical extension services that aim to educate farmers on new BMPS. For example, the Virginia Cooperative Extension helps agricultural producers improve the efficiency and profitability of Virginia farms. The Farm Manure to Energy Initiative identifies alternatives to land application of manure and fertilizer, giving farmers the tools and knowledge they need to make their management decisions (Cestti, pg. 13).

4.3.1. Factors influencing farmer involvement and implementation of BMPS

The Department of Agriculture in the U.S. (Feather and Cooper, 1995) has shown that, much like in Dianchi Lake, the profitability of the farm is the most important factor to influence farmers' decisions. Any management approach that is adopted by the views of farmers, and its impact on profitability, and farmers' knowledge and familiar practices affects their desire to implement BMPs. Successful BMPs promote inexpensive changes in existing agricultural practices. As mentioned earlier, the Chesapeake Bay program uses various monetary incentives, including tax breaks, payments and government funding, as well as training programs to promote BMP implementation. The use of BMPs and financial incentives improve environmentally-friendly agriculture, and incentives to off-set the initial cost of the additional use of BMPs are crucial for successful implementation. All the BMPs used in the Cheesecake Bay have required some sort of incentive system (Cestti, pg. 20). Of course this must be combined with educational policies to ensure successful BMP implementation. It is shown by the program that certain types of financial assistance are essential for agricultural NPS control, and cost-benefit analysis, including the use and implementation of technology, has to be considered for any financial incentive plan to be effective and efficient (Cestti, pg. 20).

4.4. Lessons to be learned from chesapeake bay

As evidenced in the Chesapeake Bay, a successful program must have the participation of the local community. BMPs in the Bay could not have been implemented without educational programs and environmental campaigns. These educated farmers on the effects of the practices, and changed their perspective towards alternative management practices. In addition, the Chesapeake Bay project used federal/central government legislation, such as the Clean Water Act, and regulations to ensure compliance as well as to provide financial incentives for new BMPs. Finally, they used local technical assistance to train farmers in new BMPs. Thus a successful NPS and nitrogen over-use mitigation scheme needs to include multiple policy instruments including monitoring and enforcement mechanisms, legislation, economic policy, and education.

Firstly, it is important to emphasize that community participation is crucial to the success of PES and BMPs. In the Chesapeake Bay program, local communities were willing participants. They used their own personal time to implement these programs. They had a desire to fix their community. Indeed, the Adopt-a-Stream program in Virginia, where communities 'adopted' and cleaned specific rivers, showed that community groups were willing to improve their own waterways. Thus, community spirit is needed to ensure lasting monitoring and action of the water pollution. The Chesapeake Bay program encouraged community participation through the development of Watershed websites where locals could learn about the situation, communicate with each other and plan events, and keep up to date with the programs being implemented.

The successful NPS reduction results of the Chesapeake Bay Program are due to BMPs. However, the Chesapeake Bay program also shows how crucial it is to design a system of cost-sharing. All BMPs in the program were given the same level of state support, and the cost-sharing allowed mitigation of the cost of agricultural operations following the adoption of BMPs. This ensured effectiveness of programs. The Chesapeake Bay project gives examples of what would occur without such financial aid. In Virginia, BMPs were adopted when government funding was provided, but when funding ceased, BMP use also ceased (Cestti, pg. 21).

Therefore sustained or continuing financial assistance is crucial to control and curb agricultural NPS (Cestti, pg. 22). Tax incentives and subsidies are needed to make farm practice changes feasible and economically non-damaging to the farmers. A survey of New York Catskill farmers within the Chesapeake Bay participating in the Water Agricultural Program found that 44.3% of surveyed farmers believe monetary payments maintain or improve their income level. Extra income has also allowed for development of infrastructure and allowed them to focus on marketing their enterprises too. These added bonuses have also improved their overall profits and management systems (Pagiola et al. 2003; Rosa et al. 2003; Orrego 2003). They represent a level of financial stability for tenants and as a result the tenants can make informed investment decisions for the future, while also continuing their farming as their main source of income. Nevertheless, economic incentives would not have been successful without the educational campaigns and community participation mentioned above, nor without the BMP training programs they offered to participants.

4.5. Implications for dianchi lake

Based on the above, several lessons from the Chesapeake Bay may be applied to Dianchi Lake's treatment of NPS. Firstly, training programs and lectures should be launched for farmers in order to change the behavior of farmers in their agricultural operations and to educate them in sustainable practices. However, a key part of the training program is the availability of cost share assistance for these volunteer projects and its personnel. Also subsidy programs encouraging adoption of BMPs are needed to offset loss of profits from lower yield. Finally, environmental regulations or regulatory threats such as fines and fees may be an incentive to the producers involved in agricultural projects to curb nitrogen overuse.

Comparing Dianchi Lake and the Chesapeake Bay reveals two different approaches to NPS management. The Chesapeake Bay has active central/federal government and local government participation in regulating, financing, and managing NPS control. The program encourages strong community participation by local citizens and enterprises. This is done through website platforms for public information sharing, allowing for outreach, education, and citizen involvement. Dianchi Lake has not developed such community participatory platforms yet, and the technical extension services available are limited in size and scope.

Dianchi Lake in contrast has a fragmented government management structure, typical of most watersheds areas, with MWR, RBOs and the MEP fighting over jurisdiction, roles and duties. Monitoring and regulating is not strongly enforced and inconsistent. There is also weak community participation with local farmers not having access to education and training.

In terms of economic policy, Chesapeake Bay uses subsidies and grants to encourage farmers to adopt new BMPs and to curb fertilizer use. Dianchi Lake does not currently use such schemes to off-set the costs of adopting new BMPs. In general, NPS management needs more participation in Dianchi Lake by the local community.

Finally, the Chesapeake Bay program has a regional regulator body that uses monitored data and has training programs for encouraging the adoption of BMPs. In Dianchi Lake, this is not yet the case, though the regional government is starting to develop PES and BMP programs for future use. In summary, though Chesapeake Bay shows how new subsidies and economic policies can assist in curbing NPS; the Chesapeake Bay program also shows that educational/training programs, government monitoring and enforcement, as well as legal policies are needed to effectively change the behavior of farmers.

Based on the above analysis, economic policies for agricultural NPS control in Dianchi Lake should include carrying out reforms in agricultural taxation and fees. There should be an exemption on the original agricultural taxes on special products. The government should also stipulate the max allotment of chemicals that can be put on each farmland unit based on the crop being planted. The government needs to also develop a standard set of penalties for those who overuse fertilizers and pesticides. Reforms on the subsidy policies should also be carried out. The original subsidies on chemical fertilizers and pesticides ought to be canceled, and "Green Box" subsidies must be implemented. One of these green subsidies can include a yield decrease caused by reducing agricultural fertilizers and pesticides utility. A second could be a subsidy for technological improvement while a third could be a subsidy for giving up tillage and instead for planting ecological forestry, etc.

The government ought to also set up a gross water pollution control system and needs to create conditions for implementing tradable pollution permits. In addition, there needs to be the establishment of a centralized plant-scale composting system. Finally, the government must set up a waste treatment facilities.

5. Conclusions

This study has attempted to explain how to introduce economic market toll and what economic incentive instruments would work best to avoid and curb the overuse of nitrogen, which causes NPS, when used in conjunction with institutional/legal/education policies. It has also attempted to identify the market mechanism through which this nitrogen use over-develops, and suggest what market system would provide the right incentives to lessen this current over-use.

Various economic incentive instruments could assist in curbing the overuse of nitrogen, when combined with additional legal, institutional, educational and social policies have been studied and explored. This has been achieved by assessing the experiences of the Chesapeake Bay program and theorizing if the use of PES in the market would make the market more efficient, and if it would provide financial incentives for farmers to limit its use of the conservation of natural resources on the market. The paper also compared the current systems of the

Chesapeake Bay, where payments for capital costs at the farm / abatement of agricultural measures have been undertaken, with the current systems of Dianchi Lake of China.

5.1. Main findings correlation between nitrogen overuse and economic incentives

A survey of reports on the environment of Dianchi Lake has shown that chemical fertilizer is over-used and has resulted in NPS for the area. It was established that farmers were generally over-using fertilizers for largely economic reasons and then specific factors were identified which led to fertilizer over-use and why it was still continuing. The key questions were if farmers were overusing fertilizer for economic reasons and what specific factors have caused this overuse. The reasons for this overuse include an imprecise agricultural economic policy. This seems to be one of the main causal mechanisms for the over-use of nitrogen fertilizer. Indeed, the current price of subsidized fertilizer and pesticides, leads to lower prices of these chemicals, and provides negative incentives for farmers to reduce pesticide use and fertilizer. As a result, they acquire short-term high yields, but neglect environmentally sustainable tools and outcomes. Therefore, one of the major economic causal mechanisms appears to be price and affordability of chemical fertilizer when compared to their income.

5.1.1. Other reasons for overuse

Agricultural practices in Dianchi Lake have shown that fertilizer over-use is an issue; and that farmers in China generally appear to be systematically overusing fertilizer. Reasons for the high demand of chemical fertilizer are complicated and include issues over production efficiency, income and costs for alternative practices, and lack of education on BMPs. The traditional extension system also encourages over-use by not providing information on alternative practices or encouraging their adoption of BMPs. It is likely that poor control of the quality of fertilizer has induced farmers to use more fertilizer in an effort to provide adequate yields of acceptable quality.

Furthermore, the reason for the use of chemical fertilizers also included the relative affordability of fertilizer, and its beneficial effects on the taste and quality of fruit and vegetable products. Farmers who used chemical fertilizers did so because they also believed in the effectiveness of these fertilizers, and that efficiency offset the cost of purchase. In addition, chemical fertilizers were readily available while access to more environmentally acceptable fertilizers such as manure was limited (Williams, pg. 19). As a result, any policy for curbing fertilizer over-use needs to consider the farmers' demand for agricultural economic development and improvement in order to ensure adoption of new BMPs.

5.1.2. Problems with china's water enforcement and legislation

Because of the many sources of NPS, China has no overall management strategy. A Department of Agricultural Management of NPS does not exist, and therefore no one is responsible when pollutants are generated in agricultural production. China needs to build a complete system for managing NPS.

In addition, there is a lack of defined roles and duties in the water laws (Wang, 2007, pg. 403). The "Water Law" (2002) approves the MWR to supervise water management. However, the MWR also considers water quality protection as one of its main tasks, even though SEPA views water quality monitoring as its main duty, resulting in strife over the scope of authority. The two agencies do not share data, do not have a common set of data, and do not work together in data analysis of quantitative and qualitative tests of water (Wang, 2007, pg. 403). This undermines the value of any analysis of current water quality in China, or enforcement of environmental policies for local and regional areas.

5.1.3. Steps to curb overuse

For any policy to succeed, the farmers' demand for agricultural economic development must be taken into account. It is evident that there will need to be reforms in the current subsidy policies. To ensure the subsidy reform, China needs to remove subsidies on initial chemical fertilizers and pesticides, and instead implement "green" subsidies. These green grants should include subsidies for technological improvement, and the commitment to stop the use of pesticides and chemical fertilizers. Therefore, pollution markets are an effective way to reduce diffuse pollution, while at the same time using only the marginal costs. Input and process objectives also provide practical solutions and they may be more practical rather than developing policies to reduce the average load of nitrogen.

Using the Chesapeake Bay program as a model, while factoring in profit costs for farmers, policy changes could include structural and technological change, as well as institutional reform that include the formulation of laws, policies and regulations. These policies should include a ban on wastewater/sewage discharge and the establishment and management of water rights. There must also be the formation of a water-saving type of society (in order to encourage community participation including water-use associations. For example, specific water-associations for root vegetable farmers for continuing education and training should be considered as a priority. Capacity building at all levels, and public participation must be encouraged. In addition, there should be coordination and negotiation with neighbour provinces/state on common water sources. Finally, the government should incorporate the use of economic tools such as payments for ecosystems services, as well as private sector involvement (economic aspects and sharing of good practices).

5.1.4. Problems with current subsidies

Current Chinese agricultural policies and laws on the protection of the environment do not curb consumption of chemicals, and only encourage farmers to make production decisions based on short-term benefits and to engage in production in environmentally hostile ways. For example, the price of subsidized fertilizer and pesticides leads to lower prices of these chemicals on the market, and encourages farmers to increase the use of pesticides and fertilizers. In addition, there are no subsidies for agricultural production to organic farming, but only for the movement of agricultural products (Huang, pg. 3). Local policies have not been able to encourage sustainable use of land and water and fertilizer due to a lack of specific regulations or penalties (Huang, pg. 4).

5.2. Recommendations

The various agricultural sources of agricultural NPS inhibit the ability to use only one individual policy in managing NPS. Rather, the characteristics of NPS mean that several policy instruments need to be used in tandem (Braden and Segerson, 1993). In addition, any policy program must be established on a case basis, and determined by the specific area and the characteristics of the polluters, victims, and the body of land and water.

A variety of tools can be used to reduce NPS agricultural pollution. Tools include educating farmers, taxes, subsidies, tax efficiency and governmental research of BMP prospects. Each tool has its own strengths and weaknesses but is strongest when combined. For example, taxation can be highly successful in curbing NPS and changing behavior patterns thus improving water features, but can result in higher costs for pollution producers/farmers. Therefore, in addition to taxes, a combination of subsidies is needed so that farmers can adopt new technologies and consulting services (Wei, pg. 11).

Taking this into consideration, the best program is likely to include a mixed permit and trade scheme system combined with taxation for polluters to curb their chemical use, and subsidies/grants encouraging alternative practices/technologies. This system does not need to factor in costs of agricultural profits, losses or gains, and off-site damage information. However, continuous water rate increases could easily impact on low-income households, which is why subsidies and grants are crucial.

5.2.1. Institutional reform, education and public participation

Partnerships with the NGOs to provide the public and private sectors with agricultural extension services can be useful to encourage farmers to adopt agricultural BMPs. Through the provision of training and certification programs (Xie, pg. 53), the government can promote better agricultural BMPs for farmers, while also maintaining low costs for administration. Hence, new funding policies are needed to provide these additional programs for farmers. Agricultural extension services can be utilized to implement these information meetings, give advice on programs, and provide demonstrations.

These programs need to focus on three key lessons: enhanced rural policy, superior compost policy, and general water and ecological policy knowledge. This is very important for farmers developing greater land and water resource knowledge and understanding of and desire for sustainable development. The government must also develop effective pollution control programs by factoring special circumstances of a region and its water issues. Public involvement is needed to ensure effectiveness as it encourages technological progress and BMP adaptation since the farmers are involved in the process.

Other issues that need to be looked into include the capability of government bodies and their financial investment means, as well as coordination between sectors/activities that could prevent their in-fighting. Furthermore, the function of water user associations has not been adequately explored and developed and water laws and water rights also needs clarification.

5.2.2. PES incentive schemes

One key step is to revoke the existing subsidy policies and in their place establish subsidies that promote the cutback of pesticide and chemical fertilizer use. In addition, an effective subsidy needs to include compensation mechanisms for the beneficiaries and the eco-service providers especially if loss of income is involved with the adoption of new policies, and rehabilitation costs or educational training costs (Force, 2006 pp. 15-23).

PES would encourage market forces to be more efficient and sustainable thus improving environmental services. Through the development of national standards, market transactions should begin to protect the use of new technologies which will reduce the cost of protection and support environmental defense (Force, 2006 pp. 15-23).

This can be done through: Regulation, Agricultural Taxes and Fees, Environmental Cross-Compliance (farmers must achieve certain pollutant quotas for acceptance into certain subsidy programs), Water Quality Trading Programs (polluters purchase credits from other polluters to offset their pollution discharge) and Green Payments to Farmers (PES and conservation practice subsidies).

5.2.3. Conclusion and summary

In summary, a variety of methods are available for improving watershed ecological compensation. This would include taxes, funds, and concessional loans for project support. Payment can be in the form of direct agreements between companies or farmers with those communities or cities affected downstream by their pollution. It can also be through trade permits that assist polluters in reaching environmental quotas or through permit credits to be able to carry out certain practices, or through direct compensation. In this plan, the downstream communities, such as industry or government help pay for safeguard measures. Upstream communities pay the water fee on regional market prices, and those supplying water and wastewater treatment downstream would be compensated at a competitive price.

Overall, this study recommends a framework for curbing NPS that include the following items below.

There must be a tax that corresponds to approximately the cost of 50% of the nitrogen fertilizer. Fertilizer use should also only be allowed in the spring season, when growth yields are at their highest due to spring's temperature and rain level. This makes fertilizer use most efficient. In addition, the government should force or encourage the use of alternative fertilizers including slow organic fertilizer.

With the introduction of new fertilizer policies, the government needs to provide subsidies that will encourage the use of compost. The government must also provide subsidies for recycling manure, and a PES system of environmental trading units/permits between upstream and downstream users must be established.

In addition, there should be a system for the local community, for farmers and for environmental advisers to share information and water management techniques and BMPs experiences among one another. Training programs and networking events that offer courses for farmers by experts in water management should be developed by local agencies as well as overseen by the provincial and municipal agencies. Consumer-oriented activities are also needed so that the public is aware of water quality, causes of water pollution and ways to combat it.

Research is equally important, and a program of research to improve the treatment of water pollutants is required. Grants for research to develop farm product innovation are needed. This will reduce emissions of pollutants. Research and testing of any new farming technologies must also be a priority.

Finally, water assessment and monitoring by a team that includes local residents, farmers, businesses and communities is crucial. The use of surveys by local governments to understand current water and health perceptions is necessary to ensure full program effectiveness. There must also be a full public exposé of environmental information so they too can monitor the agencies activities.

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