Non-point pollution problem rooted in rural land: the case of Dianchi basin in China

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Abstract

While the issue of point source pollution has drawn a lot of political and academic attention, the problem of non-point source pollution has long been put between brackets in China due to its latency and complex nature and the difficulty to control. However, China can no longer ignore the fact that pollution arising from non-point sources accounts for a majority of the contaminants in streams and lakes. One of the major efforts of the Government to control non-point source pollution is a pilot project in Dianchi lake basin in Yunnan province. Although the original goal of this pilot project is to develop a technical package to non-point source pollution in the basin, it has led to the discovery of a more fundamental cause of the problem: the current rural land property rights based on the so-called Household Responsibility System. This paper analyses the relation between the rural land system and the non-point source pollution control based on the case study of Dianchi basin. One of the major conclusions is that the absence of rural land registration and unclear land tenure have largely contributed to the rural environmental degradation. The current rural land property rights arrangement has made it difficult to implement environmentally sound land use planning or to construct environmental facilities. This situation calls for major reform effort to clearly define rural land property rights and new government-farmers-environmental authorities relationship.

Key words: non-point source pollution, rural land property, environmental protection

I. Post-industrial-pollution-war: non-point source pollution in rural China

China's economic achievements over the past two decades have been accompanied with myriad environmental problems. In response, the Chinese Government has introduced various environmental laws, regulations and policies and has made considerable efforts to tackle environmental problems, in particular those most urgent and visible problems, such as urban air pollution, surface water pollution and industrial pollution. Despite the clear implementation gap between the ambitions of Chinese Agenda and the reality, it is an undeniable fact that China has made considerable progress in the control and prevention of point source pollution[1], especially in the area of industrial and urban pollution reduction (Zhang, 2002; SEPA, 2003).

While the issue of point source pollution has drawn a lot of political and academic attention, the problem of non-point source pollution has long been put between brackets due to its latency and complex nature and the difficulty to control. However, China can no longer ignore the fact that pollution arising from non-point sources accounts for a majority of the contaminants in streams and lakes. In the mid 1980s, many Chinese rivers and lakes gained national notoriety due to declining water quality. Rapid population growth and increased land use activities during the last two decades caused increased runoff to rivers and

[1] Point source pollution represents those activities where wastewater is routed directly into receiving water bodies by, for example, discharge pipes. In contrast, non-point source water pollution comes from many diffuse sources: a broad group of human activities for which the pollutants have no obvious point of entry into receiving watercourses. Non-point source pollution is typically classified into several categories: agriculture, forestry, rural sewage systems, urban runoff, mineral extraction, transportation, and liquid and solid waste disposal. Obviously, non-point source are more difficultly identified, measured and controlled than point sources (ADB, 2002).

lakes. For example, it was estimated that, in the three lakes (Dianchi, Taihu and Chaohu), which are singled out by the Central Government for an immediate clean-up[2], the total nitrogen, total phosphorous, and chemical oxygen demand (COD) loads from non-point sources would account for 60-70%, 50-60% and 30-40% of the total water pollution load by 2005, respectively (ADB, 2002). All these three lakes face severe eutrophication problems[3].

The current Chinese environmental policies that have been conceived to control industrial point source pollution fail to address the significant impacts of non-point sources pollution in rural China. In fact, after two decades war again environmental pollution in China, the government has realized that despite considerable investment in point source control measures, further point source control can not achieve major additional benefits in water quality without significant control over rural non-point sources. With forceful control measures and "Zero Hour Clean-up Action"[4] in the above mentioned three rivers and lakes basins, most of the industrial polluters have managed to meet the permitted discharge standards, while the water quality in the lakes remain heavily polluted with pollutants from non-point sources. For example, before the zero hour of 1999, it was reported that all the identified industrial polluters in Chaohu basin met the wastewater discharge standards. But, this effort only led to 10% reduction of the total load of total nitrogen and total phosphorous in the lake (Anhui EPB, 2003).

The Chinese Government is well aware of the severity of non-point source pollution. Its Tenth Five Year Plan (2001-2005) aims to manage water resources based on river and lake basin capacity and environmental protection; and balanced socioeconomic development. Rural environmental protection is one of the six main aspects addressed in the National Tenth Five Year Plan for Environmental Protection (SEPA, 2003). Among others, control and prevention of non-point source pollution caused by livestock production, agricultural wastes and pesticide and fertilizer uses are specified as priority tasks for environmental protection in rural areas.

To seek solutions, the Government has carried out several studies and demonstration projects in the selected areas with valuable supports from international donors, including FAO, GTZ and USDA. However, these studies and projects mainly focused on experimenting certain techniques for the control of non-point source pollution. These small-scale technical successes could hardly be extended to other areas without project supports and have not generated an effective management systems for non-point source pollution control. Given the complexity of the issue and the lack of nation-wide database and monitoring system on rural non-point source pollution, many questions remain unsolved before one can suggest any specific policy innovations or institutional reforms. This fact calls for a more holistic view and more integrated approaches that can generate fundamental solutions.

One of the major efforts of the Government to control non-point source pollution is a pilot project in Dianchi lake basin in Yunnan province of southwest China. Dianchi lake is the most eutrophicated lake among the above mentioned "Three Lakes". In 2000, the Ministry of Science and Technology and the Yunnan Provincial Government jointly launched a project "Non-point Source Pollution Control in

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[2] China Trans-Century Green Project Plan is an important component part of the National Ninth Five-Year Plan (1996-2000) for Environmental Protection and the Long-Range Objectives for the Year 2010. It is a concrete plan with specific projects and key areas, designed to organize the relevant departments, localities and enterprises and pool financial and material resources in carrying out a series of project measures with regard to some key areas, major basins and vital environmental problems. "Three Lakes and Three Rivers" were identified as the most pressing regions in 1996 (Zhang, 2002; SEPA, 2003).

[3] Eutrophication is one of the major forms of water ecosystem degradation. It refers to the phenomenon in which nitrogen, phosphorous and other nutrients flow into enclosed water bodies, causing algae and other organisms to propagate and resulting in decline in the aesthetic appearance and foul-smelling water of lakes and reservoirs, and "red tides" in ocean regions (ADB, 2002).

[4] "Zero Hour Clean-up Action" is a forceful action to support "Total Control, Two Target", which is the most important national environmental targets set by the State. It was first stated in "State Council's resolution Regarding Several Environmental Protection Issues (State Council Document No. 31, 1996)" that total pollution load must be controlled, all industrial polluters must meet the national or local pollution discharge standards by 2000, water and air qualities in key cities must satisfy function-based standards. During the "Zero Hour Clean-up Action", all the industrial polluters on the list are checked at zero hour of the year (Zhang, 2002).

Dianchi Lake". The Department of Environmental Science and Engineering of Tsinghua University won the bid (Liu, et al., 2002). This project aims to develop a technical package to control different types of non-point sources in the basin and to develop management systems required for the application and extension of these techniques. Although the original goal of this pilot project focuses on developing a technical package to non-point source pollution in the basin, it has led to the discovery of a more fundamental cause of the problem: the current rural land property rights based on the so-called Household Production Responsibility Contract System (HPRCS). The following sections are devoted to introducing non-point source pollution in Dianchi basin, presenting the main findings of this pilot project and analyzing how the current rural land institutions contribute to non-point source pollution in the basin.

II. Dianchi: a national focus for non-point source pollution control

2.1 Facts about Dianchi

Dianchi Lake, a famous scenic spot on Yun-Gui plateau of China covering 307 square kilometers, is China's sixth-largest freshwater lake, and plays a key role in balancing the ecological environment in Kunming, the capital city of Yunnan province (Figure 1). The basin area covers 2,920 square kilometers and has a total population of 2.1 million people. More than 20 rivers flow into the lake. Dianchi lake serves as the direct water source for Kunming municipality and towns and villages around the lake.

Figure 1 Dianchi Basin in the People's Republic of China

(Source: http://www.chinacp.com/eng/cpmaps/)

Dianchi basin has been one of the most dynamic economic areas in Yunnan province. The annual growth rate of gross value of agricultural and industrial production has been above 10% since 1980. The population and urbanization have been increasing at an annual average rate of 1.55% and 2.54%, respectively (Hu, 2001).

However, the lake's water has become murky from the large amount of industrial and domestic waste discharged into it over the last 20 years rapid industrialization and urbanization processes, and fast-increasing algae, the growth of which is encouraged by the chemicals and warm waters from sewage and factories, is also clogging it up. The pollution levels in the upper Dianchi exceed the fifth (worst) level on China's five-level water quality scale. Level five is defined as suitable for agricultural use but not fishable or swimmable. The deteriorating water quality and eutrophication has threatened the water security of Kunming municipality and become a major constraint for local economic development, including tourism, which is a mainstay of the Yunnan economy. The current target is to improve water quality throughout the lake to no worse then the level-four standard by 2010 (SEPA, 2003).

Apart from industrial and urban pollution sources, rural non-point source pollution is regarded as one of the major source of pollution in Dianchi. The Kunming Environmental Protection Bureau estimated that about 53% of the total nitrogen and 42% of the total phosphorus that flow into Dianchi are from the non-point sources in the surrounding areas, of which 27% of the total nitrogen and 37% of the total phosphorus are from agricultural production (Table 1).

Table 1 Agricultural non-point source pollution contribution in Dianchi lake in 1999 (Unit: tons)

Pollutants	Village sewage	Solid waste	Fertilizers	Soil erosion	Total
Total Nitrogen	327.85	1167.28	1328.8	626.07	3450.00
Total Phosphorus	19.37	426.64	194.5	5.2.37	1142.83

Source: Kunming Agricultural Bureau, Kunming Agricultural Association (1999).

2.2 Battle against lake pollution

In the 1980s, Yunnan province began to carry out a series of projects and measures to protect and revive polluted lakes. “Regulation for Dianchi Lake Protection” has been put in effect since 1988 and amended in 2002 (Yunnan People’s Representatives Congress, 2002). “The Outline on Dianchi Lake Comprehensive Ecological Improvement” was issued by Kunming Municipal Government in 1989. “Dianchi Lake Protection Committee” was established in 1991 and “Dianchi Lake Protection Management Bureau” was reorganized in 2002 as a part of Kunming Municipal Government (Liu, et al., 2002). The sale and use of the detergent containing phosphorous has been banned in the basin too.

In 1997, the Chinese government listed Dianchi Lake a key part of the "Three Rivers, Three Lakes" clean-up project. Since then, more than US $ 2 billion – much of it financed through World Bank and Japanese Government loans - has been spent over the years to clean up the lake. Most of the funds were used to build sewage treatment plants for Kunming. But the investments have produced little if any payoff, because they have not addressed non-point source pollution (US Embassy Beijing, 2000). In 2000, Yunnan delegates lobbied hard at the national People’s Congress plenary for additional funds to clean up the Dianchi. Specifically, they sought to reprogram US $ 11 million in undisbursed funds from a 1993 World Bank environmental technical assistance loan to improve monitoring of Dianchi pollution. However, they did not succeed due to no significant achievements made in the past. The clean-up measures to date have failed to stem the pollution because they have focused almost exclusively on point sources around the lake’s periphery. They have not addressed agricultural runoff or pollution of the lake’s tributaries.

Shortly after the National People’s Congress plenary adjourned, the Ministry of Science and Technology announced that it has awarded contracts to Tsinghua University and the Institute of Aquatic Organisms of the Chinese Academy of Sciences to develop and implement projects to control agricultural runoff and algae growth in Dianchi. The Ministry and the Yunnan provincial government provide 50 million (US $ 6 million) to fund the projects (US Embassy, 2002). Tsinghua University is mainly responsible for developing technical options to various types of non-point source pollution in rural areas around the lake.

The following possible control strategies were identified by Tsinghua experts:

- Control nitrogen and phosphorous in household wastewater in towns and village;
- Environmentally sound treatment and utilization methods for rural solid waste;
- Control water and soil erosion and lose of nitrogen and phosphorous from tableland;
- Control nitrogen and phosphorous in farm fields by promoting precise fertilizer application;
- Recycling of drainage water with high nitrogen and phosphorous contents;
- Improvement of ditch and cannel networks for wastewater collection in villages;
- Separation of storm runoff and nitrogen and phosphorous pollution;
- Artificial wetland techniques for nitrogen and phosphorous control.

Apart from this technical solutions, another two sub-projects were added to do baseline survey in the pilot project areas and to develop management systems that will enable the operation and extension of these technical options in the whole basin.

At the early stage of Tsinghua's project plan, the importance and complexity of developing effective management systems were underestimated. It was assumed that once the technologies are proved successful in pilot areas it will be relatively simple to give policy recommendations for widespread of these technologies in the whole basin. However, during the experimental phase of the proposed technologies, problems already occurred regarding access to farmers' land, gaining support from the local communities, over-fragmented and dynamic land use, lack of information on land, lack of financing mechanism for public facilities, lack of cooperation between different agencies, and sustainability of the demonstration projects. The technical teams complained about the difficulties in carrying out their experiments in selected villages and asked for more effective overall coordination for project activities.

This question was posed to the team that worked on management systems for non-point source pollution control. After one year implementation of the pilot project, Tsinghua researchers realized that technological solutions could rarely succeed without major changes on the institutions in relation to land. Therefore, a large survey on socio-economic situation in Dianchi basin was conducted by Tsinghua in July of 2001. In total, 1,024 households in more than 100 villages were interviewed to generate data on farming activities, fertilizer application, municipal waste and agricultural solid waste disposal, environmental protection in villages and towns, and willingness of the residents to pay for environmental protection. Tsinghua researchers concluded that, among other causes, the current land use and administration has contributed to the deterioration of Dianchi water quality and the failures in implementing environmental plans.

Coincidentally, the researchers in the Environmental Policy Group of Wageningen University, which has been cooperating with the Department of Environmental Science and Engineering of Tsinghua University for another environmental education and research project, have done some studies on China's land registration issue from environmental perspective. Not surprisingly, both sides found it a common interest to conduct further research to examine the relation between land registration and spatial planning required by effective control of non-point source pollution. This research might be the first of its kind regarding its effort to analyse the environmental dimension of land administration in a more systematic manner.

The common interest and timely communication between Wageningen and Tsinghua led to an agreement on a joint research in the project areas of the Dianchi basin during the summer of 2002. The two co-authors of this paper are the principle researchers from both sides and they conducted field work together in Dianchi basin from June 23 to July 12. The next sections describe the content of this research and major findings.

III. Joint research focusing on rural land institutions

The overall objective of this joint mission is to identify constraints in non-point source pollution control in relation to spatial planning and land registration. To this end, this research aims to find answers to the following questions:

- what are target groups/stake holders involved?
- What are the current local regulations/policies on this topic? Are there any at all, in other words is the local government aware of this problem?
- What is the current view of the government towards this issue?
- What are exact problems that Tsinghua has encountered during its pilot project?
- What are possible solutions?

Three kinds of activities have been conducted in Beijing and Yunnan, namely, collection of relevant documents and literature, face-to-face interviews of governmental officials in different organisations and questionnaire-based large-scale survey at farmer household level in the Dianchi basin.

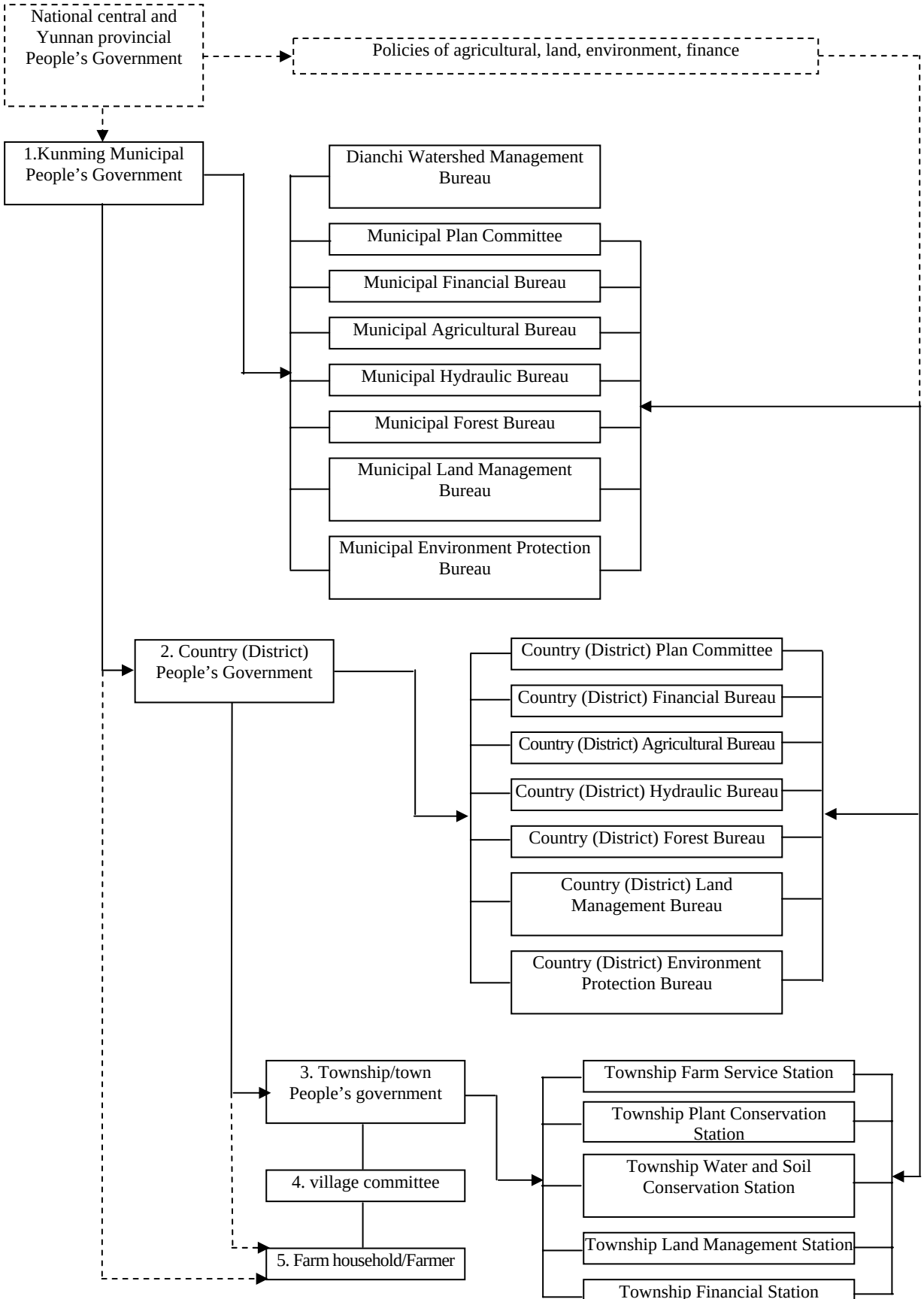
In order to gain insight into the complexity of the issue, the authors have conducted face-to-face interviews with governmental officials from a broad range of governmental agencies in the basin from municipal, county, town to village level. The interviewed institutions and governmental agencies at each of these levels include: Agricultural Bureau, Forestry Bureau, Land Administration Bureau, Environmental Protection Bureau, Environmental Research Institute, Planning Commission, Financial Bureau, Rural Economics Research Institute of Yunnan Academy of Social Sciences, Township government and village committee, and Farm Service Station, Plant Protection Station, Water and Soil Conservation Station and Financial Station in Dayu town of Chenggong County.

A series of structured and open questions were asked, including: the agency's primary functions; current central works; works done in relation to non-point source pollution; relevant policies and the implementation effectiveness; future planning. At the same time, considerable amount of secondary data was collected.

We also joined some farmer household interviews. In total, 498 farmers households in 84 natural villages around Dianchi lake were interviewed with the help of local university students. Farmers were mainly questioned about their knowledge and opinions towards the following issues:

- land use and land policy in the village
- land use planning and decision making process
- construction and maintenance of public infrastructure in villages
- fertilizer application and cost
- livestock farming and manure disposal
- various fees imposed on farmers
- access to micro-credit
- agricultural subsidy
- willingness to pay for agricultural non-point source pollution control facilities

These interviews and studies have generated adequate knowledge about the current actors involved in the studied issue and about the relationship between them. Figure 2 shows the governmental agencies that are involved in implementing policies affecting agricultural non-point source pollution. Although there is no single integrated environmental policy that addresses specifically agricultural non-point source pollution, there are a number of laws, ordinances, regulations and policies that encourage the abatement of these agricultural pollution. For example, at the national level, there are Land Administration Law (1985, 1998), Forest Law (1994, 1998), Water and Soil Conservation Law (1991), Agricultural Law (1996) and policy on returning farm land to forest. In accordance with these national laws, Yunnan provincial government and corresponding departments have made local regulations to enforce and implement national policies and laws. However, it is observed that, in practice, local governments tend to interpret the national and provincial policies with discretion.


National central and Yunnan provincial People's Government
Policies of agricultural, land, environment, finance
1.Kunming Municipal People's Government
Dianchi Watershed Management Bureau
Municipal Plan Committee
Municipal Financial Bureau
Municipal Agricultural Bureau
Municipal Hydraulic Bureau
Municipal Forest Bureau
Municipal Land Management Bureau
Municipal Environment Protection Bureau
2. Country (District) People's Government
Country (District) Plan Committee
Country (District) Financial Bureau
Country (District) Agricultural Bureau
Country (District) Hydraulic Bureau
Country (District) Forest Bureau
Country (District) Land Management Bureau
Country (District) Environment Protection Bureau
3. Township/town People's government
4. village committee
5. Farm household/Farmer
Township Farm Service Station
Township Plant Conservation Station
Township Water and Soil Conservation Station
Township Land Management Station
Township Financial Station

These policies are enforced and implemented by different governmental agencies along a vertical hierarchical line as shown in Figure 2. The main problem with this kind of top-down system for policy making and implementation is the lack of cooperation at horizontal level and creation of abundant rules with little effectiveness. However, the issue of non-point source pollution control requires overall planning and coordination. Natural resources like water and land ignore these administrative demarcations. To control agricultural non-point source pollution in the basin, measures must be taken to control nutrient flows into the eco-system and to treat and keep the nutrients onsite before they flow into the lake. These measures involve changes in current land use, cropping patterns, farming activities, people's behaviours, spatial planning, compensation policy for land use, etc. Success depends on cooperation between different governmental departments and agencies and the integration of their policies, which, unfortunately, does not exist. For example, local Environmental Protection Bureaux used to focus on industrial point source pollution control. For non-point source pollution control, they are mainly supervising the buffering zone of one kilometres wide around the lake. It is the responsibilities of the Agricultural Department and Bureaux to ask farmers to return their farm lands to forest, but the funds for planting trees go to the Forestry Department and Bureaux. In this case, the Agricultural Department and Bureaux are not motivated. Similar problems can be observed everywhere. And all these problems are related to the rural land institutions in one way or another.

Researches on land ownership structure in rural China shows that what is largely ignored in the Chinese approach to solving environmental problems is their relation with spatial planning (Zhang, 2002; Liu, 2002; Wang, 2002). And at this point we touch on upon of China's most fundamental, yet, sensitive issues: the reform of land tenure.

The current rural land ownership arrangement is mainly based on the Land Administration Law, which was promulgated in 1986[5]. Apart from the state-owned land in urban areas, rural lands are collectively owned by farmers collectives. Rural land here refers to arable land, forest land, grassland, and other types of land used for agriculture, which are owned by farmer collectives or owned by the State but used by farmer collectives in accordance with the Law[6]. With the introduction of the so-called Household Responsibility System[7] since late 1970s, the majority of arable land was contracted out to farmers households on the basis of family size. The decisions on how to divide the collective land to households were made internally within each village. Based on these contracts, farmers have the right to use the contracted land for 15 years during the first contracted period (late 1970s to late 1990s). These contracts are extended to 30 years by the Central Government in 1993 and was written in the amended Land Management Ordinance in 1998 (Liu, 2002).

This Household Responsibility System has played a critical role in reshaping the social, economic and environmental landscapes of the rural China. It is the important background of the rapid development of rural industries and small towns (Zhang, 2002). Despite apparent overwhelming benefit, implementation of the Household Responsibility System contains a number of flaws. One consequence of this change has been the accentuation of an existing trend of land fragmentation and degradation. Recent debates focusing on the connections between economic development and environmental change in rural China have been marked by an increasing awareness of environmental crisis that threatens to limit rural economic development (McElror, et al., 1998). However, relatively little research has been directed towards the relationship between the evolution of farmland institution and its practices and rural environmental

[5] In the 1986 Land Administration Law, Article 5 provides the legal base for the establishment of Land Administrative Department at central and local levels. According to Article 9, it is the function of the local governments to carry out registration of land rights (Wang, 2002).

[6] Rural Land Contracting Law of People's Republic of China, Article 1, August 2002 (Ye, 2002).

[7] This system was first introduced during the 3rd Plenary Meeting of the 11th Party Congress in 1978. For the first time in the history, this system enabled the separation between the ownership and the use right over the land, and farmers were given the right to use the collectively owned land based on contracts. This reform on the land use is the prelude of the whole economic system reforms in China (Qu, et al., 1997).

governance, although the land tenure reforms and their impacts have been subjected to considerable scrutiny (Liu, 2002).

Some negative consequences of this Household Responsibility System can be observed in Dianchi Basin. First, it was not difficult to find out the current situation of land registration in the Dianchi basin because that no land registration as we expected existed. The county Land Management Bureaux are responsible for land use registration, but only register the rural land on village level. More detailed information about the plots contracted by each household in terms of area, location, crops, yields, rights and so on remains in the hands of the village committees. It is an open secret that village leaders tend to report to the upper levels less land areas than they actually have because larger areas will lead to increased agricultural taxes. According to the former Kunming Municipal Land Administration Bureau director[8], a detailed survey conducted in 1986 concluded that the actual arable land area could be the double of the registered area. However, there was lots of resistance from the counties and towns to re-register. Only after 1999, satellite pictures are used to measure the land, but still not possible to have the information at the household level.

The reason behind this is the ill-defined land property rights in rural areas. One distinctive feature of the current rural land tenure system is that the household responsibility contracts manages to separate the land use right and ownership of the land. Farmers can possess land use right through land contracts with the village committees, whereas the right to dispose of land associated with ownership remains with the collective. Although in theory the land belongs to the collectives, the specific content of land property right is not precisely defined by the law (Wei, 1999). At present, the 'virtual' collective ownership represented by township, village committees or villagers groups make it very difficult to say which specific collective organization should be the real owner of rural land. Consequently, whenever environmental projects and facilities require changes of land use or rural land requisition, one is running into trouble.

Second, when spatial planning is not based on a reliable and complete land registration system, its feasibility is in question. It is common that many land use plans only remain on the wall and have never been implemented due to various reasons. Although the land planning bureaux send their draft planning to relevant bureaux for comments, other bureaux just take it as a formality. At the end, nobody will be responsible for the consequences of implementing the plans. The often-used expression "eat your own rice" refers to the attitude of "minding your own business" (Luijkx, 2002). Similarly to the clear status within traditional Chinese families, the status of all institutions within the government is also well defined and this leads to a hierarchical way of government. Cooperation between equal administrative levels can be difficult. Horizontally, authorities are not defined and the "minding your own business" attitude does not encourage cooperative thinking and behaviour. Vertically, the higher level is able to decide upon differences of opinion. This could for example lead to the policy that villages within one county were ordered by the county government to produce only certain kind of vegetable or flowers. In Dianchi basin, a model of intensive agriculture based on more profitable crops like vegetable and flowers were followed by more and more villages and counties since early 1990s with a hope to increase farmers' incomes and to show career achievements of some leaders. The impact of this model in terms of increased input of nutrients into the system was not checked. This change of land use is not based on studies on market demand and can lead to disasters to growers due to overproduction in some cases. This is not only environmentally unfriendly, but also economically inefficient.

Third, when economic goals prevail among governmental officers and farmers, environmental facilities and other public facilities are not taken into their considerations concerning land allocation. In Dianchi basin, the total area of land resource available for development of agriculture, industry, towns and cities is 700 square kilometres. Arable land per capita is only 0.45 – 1.0 mu[9], which is less than the national average of 1.35 mu. There is severe competition between urban, industrial development and agricultural land use in the basin. When the economic benefit of environmental facilities can not be seen directly, it is difficult to convince the village committees and farmers to allocate their limited land for the construction

[8] Interview with Mr. Huang, the current vice director of Kunming Municipal Environmental Protection Bureau, July 5, 2002.
[9] 1 mu = 0.1644 acre = 0.0667 ha

of environmental facilities, such as artificial wetland engineering, solid waste/wastewater treatment plants, plantation of trees, etc. Although Tsinghua researchers managed to establish some environmental facilities with the funding of the project (by renting farmers' lands for project period), the sustainable operation and maintenance are not guaranteed after the project. The success of Tsinghua's pilot project and its future extension to other counties in the basin are rather doubtful.

Fourth, the ambiguous rural land property rights are also blamed for underdeveloped rural land market. When individual's right to the land is not secured, paid transfer of land to others has no legal base. It is also very difficult to decide the value of a piece of land if it is not registered. When a piece of farm land is taken over for non-agricultural construction, it is very time consuming and costly to reach an agreement with all the stakeholders on the compensations. Since rural land serves as social security for farmers when alternative income sources are limited, it is highly sensitive to touch on their land. For the Tsinghua pilot project, it is more difficult for the researchers, as outsiders, to bargain with farmer households one by one. High transaction cost also discourages the attempt of both village committees and farmers to enlarge the operation scale through land exchange. Our survey shows that only about 10% of the respondents have ever exchanged land with others and this exchanges mostly take place within a small circle of relatives, friends and fellow villagers.

Last, excessive fragmentation of farmland and the shrinking trend of farm size are also important problems associated with existing farmland institution. Although the Household Responsibility System increased the productivity of farmers at early stage, its disadvantages in terms of environmental protection, optimal use of resources and large-scale application of high effient technologies are increasingly recognized. In Dianchi basin, the size of an arable land plot is from 0.03 ha to 0.04 ha, and this fragmentation trend tend to continue (Liu, 2002). This will increase the cost of negotiation with all land holders for any changes in their land use and land exchange in future.

IV. Conclusions

All of the world, non-point source pollution problems can be observed in densely populated areas with intensive land use practices. Researches to non-point source pollution in the past have generated lots of knowledge and understanding of the physical processes of the problems (Carpenter, et al., 1998). One common conclusion from these researches is that the obstacles to address non-point sources are not only physical, but also include the socio-economic and institutional environment. The physical processes of discharge of (agricultural) non-point sources are related to physical, socio-economic and institutional factors (Fischer and Sun, 2001; Verburg and Chen, 2000; Verburg and Veldkamp, 2001). Adjustments to the processes in agriculture will have to be perceived in the context of these factors.

Non-point source pollution control in Dianchi basin is a typical example of the conflicts between administrative demarcation, sectoral hierarchy and the holistic nature of the problem. Dianchi is not alone in this sense. For example, one similar research done in Taihu basin found that the lack of coordination between various government departments involved in environmental protection and pollution control in the basin result in inefficient management practices (Grontmij and SEPA, 2001). In Chaohu lake basin, another key lake for clean-up, similar measures have been undertaken in the Chaohu basin, such as: demarcate protected zone around the lake, encourage precise fertilizer application and eco-farming, ban on the use of detergents containing phosphorus, return some cultivated land to forest, restructure of the rural energy consumption, build solid waste treatment plants, etc. However, the social and institutional consequences of these measures remained under studied. The implementation effectiveness remain limited. This observation confirmed again the importance of this research (ADB, 1999; Anhui Planning Commission, 2002); Anhui EPB, 1998).

Property rights and collective action issues are important constraints to the adoption of improved technologies and natural resource management practices that can help poor people and reduce environmental degradation. Many improved natural resource management practices require long-term investments, and farmers will only make these investments if they have sufficiently secure and long-term rights to their land so that they know they will reap the benefits of their investment. Unfortunately,

unclear property rights over rural land and other natural resources have caused lots of disputes in Dianchi basin and become a major institutional barrier for effective non-point source pollution control.

Many natural resource management practices have to be undertaken by groups of farmers working together or they require effective community management of common property resources. Ineffective collective action at the local level becomes a constraint on the adoption of these types of natural resource management practices. Given the current socio-economic conditions and low level of public environmental awareness, any black and white policies, such as enforcement of standard fees for taking over farmers' land or introduction of penalty on malpractice of waste disposal, will be doomed to fail. However, there are cases in the basin prove that more community-based and –motivated projects work better. This fact calls for deeper studies on alternative pollution control approaches and necessary institutional arrangements.

We must be aware that the existing property rights and management institutions typically have their roots in local indigenous arrangements. Future policy reforms should aim at coordinating different interests and objectives, involving stakeholders, increasing the transparency of decision making, building up the local self-organizing capacity and environmental awareness. A lake is the product of its watershed and the people who care for it.

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