PART II G 2

REGIONAL CASE STUDY ON ECOSYSTEM SERVICES AND POVERTY ALLEVIATION – DESAKOTA ASSESSMENT MIYUN RESERVOIR WATERSHED

Liu[1] Jing, Wilko Schweers[2], Liang[1] Shumin, ,Zhu[1] Lizhi, Cai[2] Dianxiong, Zheng[3] Haixia
[1]Institute of Agricultural Economics and Development,
[2]Institute of Agricultural Resources and Regional Planning
CAAS - Chinese Academy of Agricultural Sciences
[3]College of Management, Beijing Union University

1 THE DESAKOTA CONTEXT

Desakota characteristics (Annex 1) in this case are rather apparent from a reaction against negative consequences of such development on ecosystem services, i.e. shutting down of water resource intensive and polluting industrial enterprises and abolishing access to natural resources for the sake of conserving water, the most limiting resource for economic growth and sustainable development of the capital city of China.

It is suggested that the case of transformation of a region which is peri-urban to rural along its geographic scale, needs to be investigated further, precisely because the available information indicates, that the necessities of nature conservation condition a reduction of access to natural resources and disincentives to some development activities that contribute to keeping more population inside this region or attracting more population into it.

This case demonstrates why the ESPA program is not simply focusing on environmental services, but takes poverty alleviation into account, based on global knowledge, that in the long term sustainability of ecosystem management cannot be achieved without addressing the needs of poor population groups that depend on such services. The disparities between urban stakeholders benefiting from ecosystem services and the agricultural population requested to provide them, is an example of the conflict in desakota regions between affluent and pauper with competing interests between provisioning services (ecosystem managers) and regulating services (urban residents) along the desakota scale.

As evident from the proceedings and deliberations taking place during the recent Chinese People's Political Consultative Conference (CPPCC), the Chinese government is trying to enhance income equality also by payment for environmental services. Alone, the speed of finding solutions is - amongst a range of issues - limited by the complexities of ecosystem management and the difficulties of valuating and monitoring ecosystem services. Ill-devised regulations at a local or regional scale could easily raise false expectations elsewhere, which, given the extent of the potential target group, would be undesirable. Despite significant achievements, poverty alleviation in China remains an urgent and challenging task.

2 WATER SCARCITY IN BEIJING

Beijing has experienced a nearly uninterrupted drought since 1999. Shortage of water resources has become one of the most important factors limiting its economic and social development. The top priority task at present is to ensure the capital's water supply before the completion of the first phase of the project "diverting water from the south to the north" (Nanshui Beidiao) in 2010, which will transfer tens of billion m^3 (Berkoff 2003) from the Yangtze. Based on the exploration results in Beijing, a plan for the construction of 6 well fields as emergency water supply is proposed (Li et al. 2005). Figure 1 illustrates the case described by Lohmar et al (2006), that cities in North China are lowering the water table, thereby affecting groundwater accessibility in peri-urban areas, although these, as we will see further below, are also contributiong their share of groundwater depletion. The argument that cities need not necessarily waste more water than rural areas is put forward by Kendy et al. (2007), chiefly on the grounds of less actual evapotranspiration. However, this debatable 'advantage' in cities, which create more heat and evaporation, can only be transformed into a benefit, if runoff inside the urban areas is directly used or recharged into the groundwater and not transported straight out of the area with the drainage system.

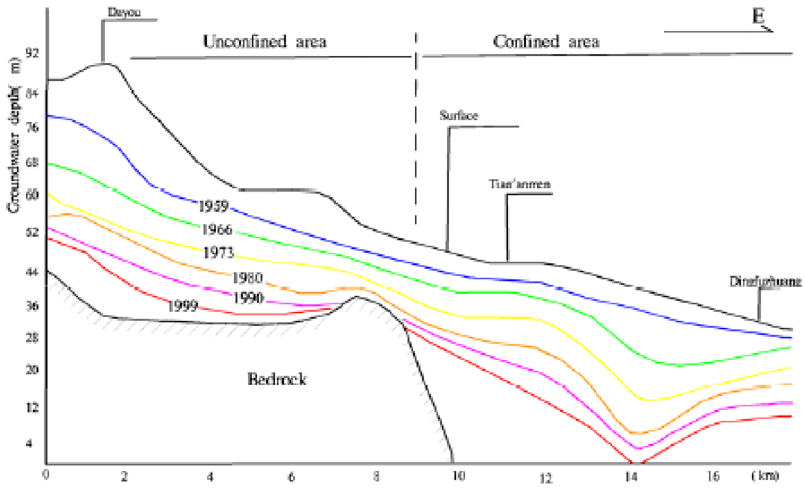

Figure 1 Groundwater exploration in Beijing (Li et al. 2005)

The need to over-abstract groundwater is explained by the negative water balance of the metropolis as shown in Table 1. Beijing managed to achieve GDP growth of nearly 50% between 1988 and 2005, while reducing its water use by nearly 10%. This was largely achieved by closing down or moving high water consumption industries out of Beijing. In draught years, Bejing relies on additional inflows from neighboring provinces, where it has also stocked up emergency reservoir supplies for the 2008 Olympic Games, in case the share of 80% of average precipitation of 600 mm (less in recent years) between June and September (60% in July and August) might turn out much lower in 2008.

Table 1 Water balance of Beijing in an 'average year' (Diepen et al. 2003)

Supply		Demand	
Precipitation	9.55	Evapotranspiration	6.76
Inflow	1.2	Outflow	1.8
Deficit	0.11	Consumption	2.3
Total	10.86	Total	10.86

Total water use of Beijing peaked in 1992 at 4.64 billion m^3 in 1992 and then declined gradually to 3.45 billion m^3 in 2005. The share of water used by agriculture has diminished to 38.7% in 2005 from 44.5% still in 2002. The changes in agricultural production systems mentioned by Diepen at al. (2003) were partially a reaction to declining water resources: (1) loss of arable land areas due to conversion to urban areas; (2) rapid reduction in arable land areas and increase in orchards; (3) reduction in grain crop area and strong growth of vegetable crop area; (4) rapid increase in fertilizer use per hectare; (5) sharp reduction in total water use for irrigation; (6) shift in livestock from the near-suburbs to the outer suburbs and counties; (7) increase in livestock numbers, in particular cattle, sheep and poultry.

Table 2 Composition and changes of water use in Beijing

Sectors	**2002** million m^3	**%**	**2005** million m^3	**%**
Agriculture	1545	44.6	1322	38.7
Industry	754	21.8	680	19.9
Municipal and residents	1083	31.3	1338	39.1
Environment	80	2.3	80	2.3
Total	3462	100.0	3420	100.0

A comprehensive account of the complexities and the history of water resource management in Beijing and the Hai Basin has been given by Peisert and Sternfeld (2005). The authors describe efforts to make better use of upstream water resources, which are collected in the Miyun and the Guanting reservoirs, that complement the water transfer project and enhance water security in the capital.

While looking at the case of the Miyun reservoir it is worth considering also the situation of the Guanting reservoir west of Beijing. It was built in the 1950ies, earlier than the Miyun to supply Beijing with drinking water. Originally the storage capacity of Guanting reservoir was nearly as high as Miyun's. However, much of that has been lost to sedimentation. The watershed is more industrialized and more densely populated than the Miyun watershed. While its water quality improved in the meantime, the Guanting reservoir could still not be reconverted to supply drinking water. It was shut down in the 1980ies because of pollution problems related to heavy metals, phenol and cyanide (Wang 1986). Pollution from diffuse sources in agriculture (fertilizers, pesticides) also contributed to the deterioration of its water quality. In part, this was due to lack of training and extension (Zhang and Lu 2007). Water for agriculture came mostly from surface water in the 70s. However, in the 1990s 80% of agricultural irrigation water has been extracted from groundwater. Due to the excessive extraction of groundwater and its insufficient protection, the quality of groundwater has deteriorated since the 1980s.

It can be expected that climate change is going to further augment water scarcity in the Hai river basin. Using PRECIS, Xu at al. (2006) predicted that the temperature in Northeast China, North China, and Northwest China would increase, while the precipitation would only slightly increase under B2 scenario in 2071-2100. The climate would obviously become warmer and drier over these three regions in the northern part of China. Average annual rainfall in Beijing from 1988-2005 showed a declining trend (Figure 2).

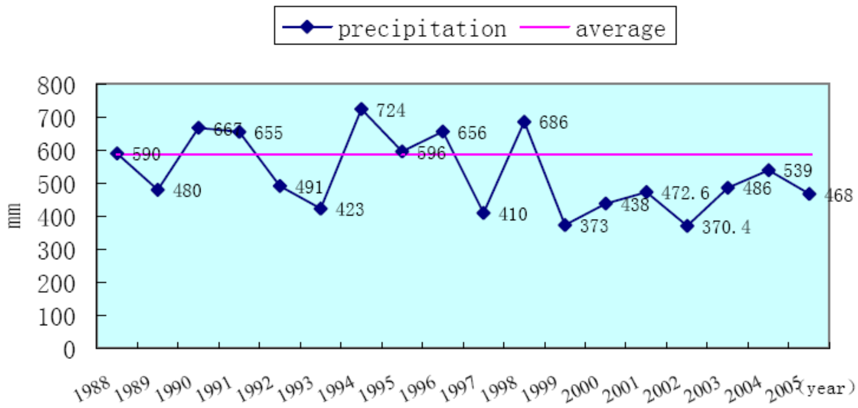

Figure 2 Annual precipitation in Beijing 1988-2005

3 THE SITUATION IN THE MIYUN WATERSHED

4.1 CHARACTERISTICS OF THE MIYUN RESERVOIR

Miyun county is famous for the Miyun Reservoir which is the main drinking water source of Beijing, accounting for more than 50 percentage of Beijing water supply, which makes the reservoir and the watershed above it (Fig. 3) one of the most important water protection areas in the world (Peisert and Sternfeld, 2005). Lacking major auxiliary water sources, Beijing is vulnerable to any form of development that could reduce the capacity or quality of the Miyun.

Figure 3 Map of the Miyun catchment

The Miyun Reservoir with its total storage of 4.375 billion m^3 and approximately 188 km^2 of surface area, is located in a hilly landscape to the north of Beijing. The Chao and the Bai rivers are its main tributaries. The watershed area of Chao river and Bai river is 6,960.59 km^2 and 8,827.41 km^2 respectively, out of which 88%, i.e. 15,788 km2, drain into the reservoir. The Chao river system originates from Halawan, Liangui town, Fengning county, Hebei province, runs through Fengning, Luanping, Chengteh and Gubeikou of Miyun county into Miyun. The main system of the Bai river originates from the mountainous range of Guyuan county and Chongli county of Zhangjiakou city, Hebei province. It runs through Guyuan, Chongli and Chicheng counties in Zhangjiakou city, Xuanhua district, Yanqing county, Huairou district and Shihetang town in Beijing into the Minyun reservoir..Two thirds of the watershed areas upstream of the reservoir are within the regions of Chengde and Zhangjiakou cities of Hebei province, and one third is under the administration of Beijing municipality. Of the total 11406.33 km2 watershed area in Hebei, the upstream Chicheng county occupies 46.4%, while Fengning occupies 36.7% (Figure 4). At present, the daily water intake from Miyun reservoir is around 1.17×10^6 m^3. After 1999 the water in the reservoir decreased due to continuous droughts for 6 years, dropping by 40% of its previous storage.

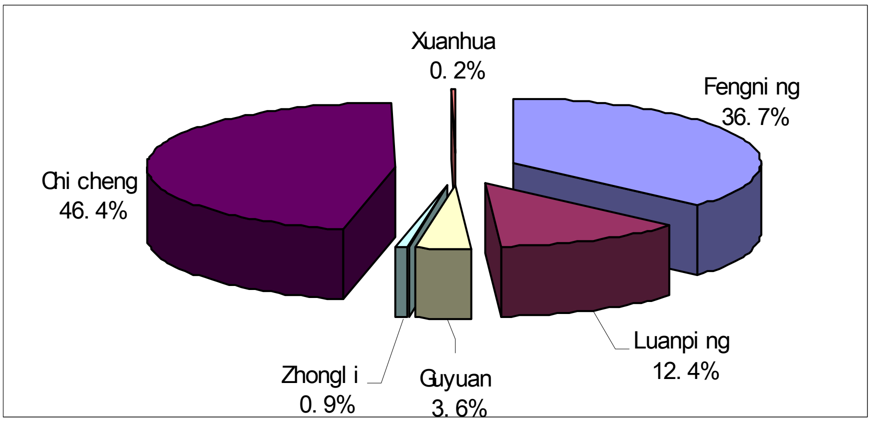

Figure 4 Watershed area percentages in upstream Hebei counties of Miyun Reservoir

It is interesting to note that as opposed to the general trend, which saw a decrease in agricultural land by 72,000 ha from 29% (1991) to 24% (2001), Miyun county was the only administrative constituency of Beijing, where agricultural land actually increased (by 3000 ha or 1%). In 2001, Miyun County shared 14% of Beijing's territory and 11% of its agricultural land. Within the county, agricultural land use was 19%, similar to the entire watershed (Figure 5).

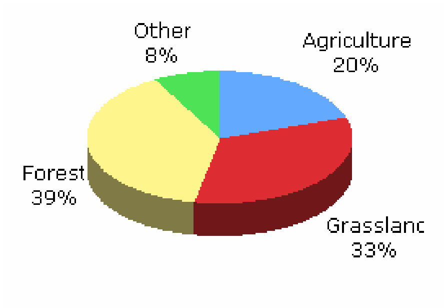

Figure 5 Land use distribution in Miyun County (Wang 2002)

In 2001, Miyun County had 422,000 inhabitants (3.3% of Beijing), and behind Huairou and Yanqing the third lowest population density (181 inhabitants/km^2; all Beijing: 760, Inner City: 30574). Compared to its low overall share of the population, Miyun County represented 9% of the city's agricultural population, having the highest ratio of agricultural population (75%) together with Yanqing county. Given that Miyun has a lower share of agricultural land than the Beijing average, as mentioned, it has quite a low size of agricultural land per inhabitant (0.14 ha, less than 1 mu = 0.167 ha). This indicates that the majority of the population derives a base income from agriculture, but that there is a necessity to seek additional income from non-agricultural activities. In a small-scale study by Enders (2005), such tendencies are reflected in the responses of 5 households in Maoshigou village of of Fengjiayu township. All but one derived substantial income proportions from non-agricultural activities. The one household which depended only on agriculture was not satisfied with the income situation. There were only 7000 non-permanent residents (1.6%) in Miyun County in 2001, whereas Beijing had 1,705,000 (13.3%). This shows that Miyun county is not an area where migrants are typically settling in the quest of employment opportunities. Besides, the county is also a bit far from the city for daily commuting.

In 2003, the farmer's income per capita of the upstream Chicheng, Fengning and Luanping counties of Hebei was 144.8, 121.5 and 182.5 dollars respectively, while the farmer's income per capita of Huairou district, Miyun county and Yuanqing county of Beijing was 726.8, 735.6 and 707.3 dollars respectively (Hebei Statistical Yearbook, 2004). Being the direct beneficiaries, the citizens in Beijing had a disposable income per capita of 1735.3 dollars in 2003, more than 2 times that in the upstream Beijing counties. The average water fee in Beijing was 0.46 RMB/m³ (in 2008, the water price was already above 2 RMB), while the high water-consuming enterprises like bathing, car-washing and bottle water companies were charged high fees of 7.7 RMB/m3 and 5.2 RMB/m3.

4.2 DRIVERS OF CHANGE AND STAKEHOLDER OPINIONS

The self-perceived opinions of several hundred farmers interviewed in the watershed, about what were the primary factors that lead to an environmental degradation of the reservoir are depicted in Figure 6. Economic growth was seen as the most important driver, followed by policy failures and 'decline in moral values'.

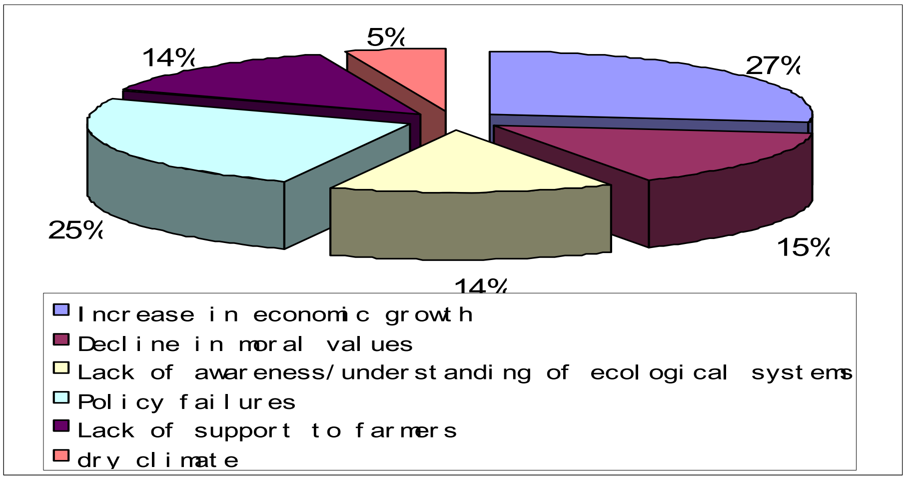

Figure 6 The causes of environmental degradation in Miyun reservoir

When asked about the most effective strategies to reduce environmental degradation, the farmers replied: (1) village coercion ('laws & rules' 44.4%), (2) joint effort and community participation (26.3%), (3) taxes and fees with (16.3%), (4) engaging in off-farm employment (12.5%), and (5) technical training (10.6%). This leads to the conclusion, that legislation and regulations for PWS (Payment for Water Services) and the involvement of stakeholders at the grassroots level are very important to implement the policy. How the interviewees viewed the effectiveness of PWS measures is shown in Table 3 (Zheng 2008): 60% thought of the implementation of PWS policies as being successful (19%), while 12% people did not agree, thinking it was very bad. As for the impact on family income of PWS, the percentage of those who thought it increases very much was 15%, while those who thought it decreases very much were 24%. Taxes were generally not viewed as a good and equitable way to pay for watershed services.

Table 3 The effectiveness of PWS in Miyun reservoir (from Zheng 2008)

	3	2	1	0	-1	-2	-3	-4

Effect of PWS policy(N)	30	32	34	23	3	11	19	7
Percent (%)	19	20	21	14	2	7	12	4
Impact on family income(N)	24	21	14	30	9	10	38	11
Percent (%)	15	13	9	19	6	6	24	7
Equality on taxes for PWS(N)	14	24	29	40	5	9	27	11
Percent (%)	9	15	18	25	3	6	17	7

* +3=strong agreement,0=neutral,-3= strong disagreement, -4=don’t know

4.3 POLICIES AND METHODS FOR WATER PROTECTION IN MIYUN RESERVOIR

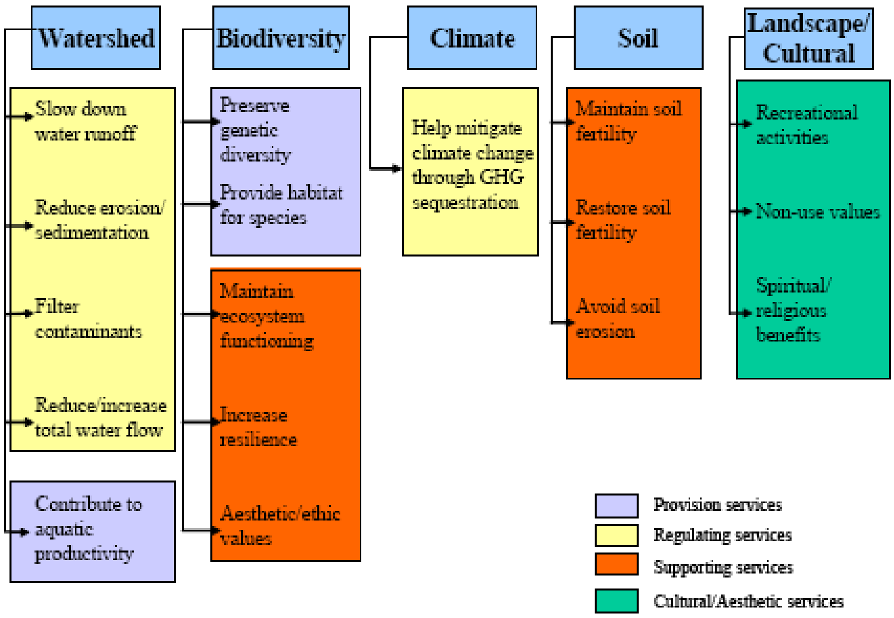

Fig. 7 Main ecological and environmental services by type of service (FEEM 2006)

Figure 7 lists a wide variety of ecosystem services that are potentially amenable to PES schemes (FEEM 2006). Payments for environmental services are categorized into voluntary contractual agreements (VCA), public payment schemes (PS), and trading schemes (TS) (Table 4). Some of these have been described by SEPA (2006), Zheng and Lubiao (2006) and Zheng (2008). What has been done so far in the Miyun reservoir watershed mainly falls into the category of PS in the form of remittances between governments. Unfortunately, the methods and extent to which these have reached poor ecosystem users who have few other options of income generation in an area geared towards conservation of water resources rather than economic development, is not known.

Table 4 Main types of PWS schemes (source: FEEM 2006)

Type of PES	Participants	Type of EES	Requirements
Voluntary contractual agreements VCS	- Private to private. Role of government limited to enforcement of property rights.	- High-value EES, related to private good. - Low cost of provision of EES. - Small scale.	- Clear and enforceable property rights. - Negotiable contracts. - Limited number of providers and beneficiaries.
Public payment schemes PS	- Government to private, government to government, or government to other organizations (e.g. NGOs, CBOs)	- Public good, significant externalities involved. - High value of EES, but high cost of provision.	- Generation of funds for government (e.g. taxes, user fees,…) - Transparent institutions. - Public participation.
Trading schemes TS	- Private to private, with government setting initial standards and allocation of rights.	- High value of EES, variable costs of provision. - EES related to private good. - Services provided by different providers must be perfectly substitutable.	- Strong institutional setting. - Strong monitoring and compliance mechanisms. - Initial allocation of rights.

Some of the measures taken by the Beijing administration and public institutions in Hebei reflected in the literature are summarized below:

(1) To ensure water quality in Bai river, Chicheng county has shut down more than 20 small enterprises in mining and paper-making, and strictly set limits to the development of mining along the Bai river. It is estimated that this action caused revenue cut by 250 million dollars and a loss of nearly 50,000 employment opportunities which restricted the local people income generation capacity, especially of poor people. At the same time, the Chicheng county invested 10 million dollars and an accumulated total area of 3.19 million m^2 of soil erosion in the watershed has been controlled, greatly reducing sediment flow into Bai river. The latest testing results show that 6 main indices of the Bai river running out of Chicheng all reach the national water standard of Class II.

(2) While, to ensure the water quality of Chao river, the development of metallurgy and mining industries, key industries in Chengde, were restricted there due to the pollution and high water use. In 1996, the local government shut down 70 smaller polluting enterprises, and another 138 mining enterprises along the riversides from 1999-2004. These enterprises had hired large amounts of local people. In order to conserve water and soil, in 2002, Chengde city released a document which prohibited grazing along the Chao river banks, and only captive breeding of cattle and sheep were still allowed. This decree caused the number of sheep to decrease by 50%. Later there were less than 1 million left. Therefore, local people suffered from water protection.

(3) The Beijing municipality made payments to the upstream Chengteh and Zhangjiakou cities of Hebei province, to protect watershed environment, so as to increase water quantity and improve water quality in Miyun reservoir. From 1995 onwards, Beijing started paying Zhangjiakou and Chengteh an annual fee of 250,000 dollars for protection of water conservation forests, and increased the payment to 2.25 million dollars, among which 1 million dollars goes to Zhangjiakou. Ecological payment funds were used only for specified purposes, in this case for the protection of water resources in Luanping and Fengning counties. A large portion of the special funds is used for converting rice growing areas locally, i.e. reducing or even totally replacing rice paddies for other grains, to reduce water consumption for the benefit of Beijing.

(4) In the context of a Sino-German project for the protection of the Miyun reservoir, farmers received payments (400 RMB/person/month) for the protection of near natural reforestation areas from the Bejing Forestry Bureau under the Forest Warden Program. Water warden receive slightly more (500 RMB/person/month) and also more training to protect the reservoir and report pollution incidents. This was welcomed by the local population as a complementary income. The job was done mostly by elderly men who have few other possibilities of income generation (Peisert 2007). These measures were described in more details by Enders (2005).

(5) As a special local variation of the nationwide “land conversion program,” in 2001 the government of Miyun county announced it would completely abandon growing cereals, and instead develop perennial cultures, mainly fruit trees. While this land conversion program eventually could help to reduce the agricultural water demand in the county, it would probably raise the input of chemicals for plant protection (Peisert and Sternfeld 2005).

(6) Beijing has adopted new environmental programs aimed at reducing the pollutants accumulating in the Miyun. During the mid-1990s, the Beijing government established three “environmental protective zones” around the Miyun Reservoir. The innermost zone, covering the land located within approximately 300 meters of the reservoir restricts all agricultural and residential activities. The second zone allows limited agricultural activity, while the third and outermost zone limits mining and industrial activity (Peisert, personal communication, July 2007, cited by Langton and Regele 2007). The Environmental protection zones have been moderately effective at reducing the most overt and extreme pollution sources. However, the zones largely fail to address the causes of subtler forms of pollution. While point source pollution has been effectively regulated and removed from the watershed, non-point source pollution - primarily in the form of agricultural runoff - continues to contaminate the Miyun’s water (Wang et al., 2001).

(7) Grazing was thoroughly prohibited from December 1, 2002, causing the number of sheep to fall from 560,000 to 110,000.

(8) In addition to regulations limiting many different types of economic activities in the Miyun reservoir—mining, aquaculture, and agriculture—there has also been a broad resettlement of residents away from the reservoir’s banks since 1999. Little information is available on the scope and impact of this resettlement policy, but lowering population pressures around the reservoir was seen by the Beijing leadership as a difficult, yet crucial policy to protect water quality.

In 1985, non-point source pollution accounted for 53% of the total phosphorus entering the Miyun. By 1997, that number had risen to 86% (Wang et al, 2001). Today the number is estimated at 94% (Wang et al., 2006). While the reservoir is currently still at the mesotroph stage, accumulation of nutrients, especially phosphorus can gradually cause eutrophication of the Miyun reservoir. The release of phosphorus from the sediment may be supported by rising temperatures due to global warming and less runoff may reduce phosphorus dilution. Eutrophication can lead to higher treatment costs for the drinking water facilities that treat Miyun’s water. The processes for raw water treatment are ineffective under high densities of algal growth and need to be repeated several times whereby treatment costs increase significantly. The cost calculation for such treatment processes can be taken as an indicator of how much money the municipality of Beijing could pay to subsidize farmers for using less fertilizer. The amount should compensate the loss of yield and income resulting from less intensive fertilization (Figure 8).

Empirically based equations, like that of Vollenweider (1968) can be applied to determine the concentration of phosphorus in the reservoir from defined nutrient loads. Reversely they can also be used to calculate the permissible loads without reaching phosphorus levels in the reservoir, that entail eutrophication. Naturally such procedures require sufficient monitoring infrastructure and data to identify areas of non-compliance with agreed management practices. Another possibility consists of the establishment of buffer strips, which could quite effectively filter out phosphorus and prevent it from entering river courses. In that case, which could be considered the most important initial and comparatively easily controllable step, farmers would have to be compensated for giving up cultivation along rivercourses.

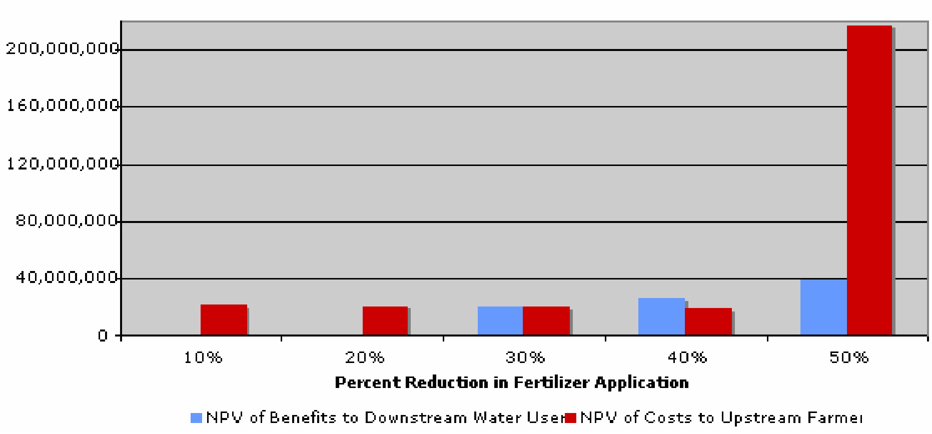

Figure 8 Comparison of benefits and costs of fertilizer reductions (Langton and Regele 2007)

A PWS scheme can create benefits for downstream communities in the form of reduced water treatment costs and reduction of the risk of a catastrophic eutrophication event. Providing ecological services creates costs for upstream communities. Most of these costs come in the form of lost or avoided agricultural production or expenses for environmental activities, like erosion control and land use conversion. In addition to the already existing payments for local forest keepers, such payments could be extended to include fertilizer reductions particularly of phosphorus, the main eutrophication agent in the reservoir. (Langton and Regele, 2007)

A more critical view of the potential of PES in the Miyun watershed is shared by Zheng (2008): “At the moment, the government still plays a role of buyer and facilitator in the PES. When the PWS in Miyun reservoir is analyzed as a case study, we find that it is difficult to implement the PES policy very well in China, due to the imperfectness of the relevant legislation, ambiguous water rights, undefined payers and suppliers, indistinct duties and rights in the PES, which leads to some problems: high transaction costs, inconsistent payments, a low level of implementation of PWS, which could provide experiences and lessons for PWS also in other watersheds.”

Without going into further detail, Scherr et al. (2006) mention the Miyun watershed as being one of the better documented 'instances', reiterating the opinion of Peisert and Sternfeld (2005) that in the case of the Miyun reservoir, a well-designed PES scheme could do much to reconcile Miyun county's goal of improving local livelihoods with Beijing's need to ensure a stable, long-term source of clean water. In the development of PES systems the World Bank (2007) is looking for "low hanging fruit" – examples where a system can be easily and quickly implemented. Such a situation would exist when the following conditions are met:

- The cause and effect link between providers of ecosystem services and the beneficiaries is clear and relatively close,
- The beneficiaries realize the importance and value of the ecosystem services,
- Mechanisms exist (both institutional and legal) to efficiently collect payments for the ecosystem service from the beneficiaries and make transfer (payments) to the service providers,
- The institutional structure to collect payments and make transfers is in place,
- The numbers of service providers is manageable and the number of beneficiaries is clearly defined and not too large (or at least clearly defined as in the case of municipal water consumers),
- There is public and private support (e.g. on the part of both Government and individuals) for establishing a PES system.

Whether there are any fruit that hang so low and if the Miyun watershed is one of them remains to be questioned. However, these or similar criteria could certainly be of use in the context of further studies on the characteristics of PES schemes in the area with regard to possibilities for their improvement and expansion.

Looking at poverty in a wider sense, we realize that income poverty is not the only issue at stake, but also resource poverty, i.e. access to water, land, mineral resources etc., which are curtailed in this case, and service poverty, i.e. lack of education, health and other facilities, less likely to be promoted in economically weak, but strategically most important areas to the continued economic development and prosperization of the Chinese capital.

5 REFERENCES

Berkoff, J. 2003. China: The South–North Water Transfer Project — is it justified? Water Policy 5 (2003) 1–28.

Diepen C.A., van Wijk, M.S, Cheng Xu, Roetter R., Jongbloed A.W. Hu Yanxia, Lu Changhe, van Keulen, and C. Wolf. Urban and Peri-Urban Agricultural production in Bejing Minicipality and its impact on water quality. Alterra Repart 757: 62 p.

Enders, S. (2005). Miyun - Integrated watershed management for the protection of Beijing's drinking water. P.R.E.M.I.U.M. 2005 Research Experience for Undergraduates. Sponsored by the National Science Foundation and Michigan State University: 23 p.

FEEM - Fondazione Eni Enrico Mattei Servizi (2006). Best Practices Approaches on PES (part of the Study on Payment for Ecological and Environmental Services in China). Milan, FEEM Servzi

Kendy, E. , Wang JinXia , Molden, D. J. , Zheng, C. M. , Liu ChangMing , Steenhuis, T. S. 2007. Can urbanization solve inter-sector water conflicts? Insight from a case study in Hebei Province, North China Plain. Water Policy, 2007, Vol. 9, No. Supplement 1, pp. 75-93, many ref.

Langton A. and Regele A. 2007. Room for a Deal: Using Payment for Environmental Services to Protect Beijing'S Miyun Reservoir. Masters Thesis. University of California, Berkeley: 36 p.

Li Wenpeng, Hao Aibing, Ye Chao, and Zheng Yuejun. 2005. Emergency Plan for Water Supply in Consecutive Drought and Sustainable Water Resources Management in Beijing. China Institute for Geo-environmental Monitoring (CIGEM), Beijng: 10 p.

Lohmar B., Wang Jinxia, Rozelle S., Huang Jikun, and Dawe D. 2004. Market and Trade Economics Division, Economic China's Agricultural Water Policy Reforms: Increasing Investment, Resolving Conflicts, and Revising Incentives. Research Service, U.S. Department of Agriculture. Agriculture Information Bulletin Number 782: 27 p.

Peisert, C., and Sternfeld, P. 2005. Quenching Beijing's Thirst: The need for integrated management for the endangered Miyun Reservoir. China Environment Series (7) 33-46.

Peisert C. 2007. Personal Communication.

Scherr S.J., Bennett M.T., Loughney M., and Canby K. 2006. Developing future ecosystem service payments in China: lessons learned from international experience. A Report Prepared for the China Council for International Cooperation on Environment and Development (CCICED) Taskforce on Ecocompensation. Forest Trends (http://www.forest-trends.org)

SEPA - State Environmental Protection Administration, 2006. PES: an urgent demand for sustainable development: Exploration and practice on PES mechanism in Zhejiang and Fujian provinces, http://www.zhb.gov.cn/eic/649096689457561600/20060629/19194.shtml

Vollenweider, R.A. 1968. Scientific fundamentals of the eutrophication of lakes and flowing waters, with particular reference to nitrogen and phosphorus as factors in eutrophication. Technical Report DAS/CSI/68.27, Environmental Directorate, OECD, Paris.

Wang, Jing, Xiu-juan Liang, Tian-xing Yang, Xiao-lu Meng, Xiao-duan Liu, 2006. "Miyun Reservoir Total Phosphor Sediment Regularities of Distribution Transportation Control. The distribution, migration and control for Total Phosphorus in Miyun Reservoir." (in Chinese).

Wang Jinghua. 1986. Water quality in Guanting reservoir. Water, Air, and Soil Pollution 29 (1986) 149-154.

Wang, X., T. Li, Q.Xu, W. He. 2001. "Study of the distribution of non-point source pollution in the watershed of the Miyun Reservoir." Water Science and Technology, Vol. 44 No. 7, page 35-40.

Wang, Xiaoyan, et. al, 2002. "Characteristics of Non-Point Source Pollution in the Watershed of Miyun Reservoir" Chinese Journal of Geochemistry, Vol., 21, No. 1

World Bank 2007. Promoting Market-oriented Ecological Compensation Mechanisms: Payment for Ecosystem Services in China. World Bank Analytical and Advisory Assistance (AAA) Program China: Addressing Water Scarcity - From Analysis to Action Policy Note. IBRD, Washington D.C.: 28 p.

Xu Yinlong, Huang Xiaoying, Zhang Yong, Lin Wantao, and Lin Erda. 2006. Statistical Analyses of Climate Change Scenarios over China in the 21st Century. Adv. Clim. Change Res., 2006, 2 (Suppl. 1): 50-53.

Zhang Hong and Lu Yonglong. 2007. End-users' knowledge, attitude, and behavior towards safe use of pesticides: a case study in the Guanting Reservoir area, China. Environ Geochem Health (2007) 29:513–520

Zheng, Haixia and Zhang Lubiao (2006). Chinese Practices of Ecological Compensation and Payments for Ecological and Environmental Services and its Policies in River Basins.

Zheng Haixia (2008). Chinese Practices of Ecological Compensation and Payments for Ecological and Environmental Services in River Basins —Case study of Miyun Reservoir Basin, China.

ANNEX DESAKOTA CRITERIA IN THE CONTEXT OF THE STUDY

Desakota Criteria	**Water-based Ecosystem Services**	**Poverty**
1. Greater Connectivity—physical, electronic and cultural.	The effects of better access to the reservoir in form of new roads are two-fold: On the one hand, the improved transportation network can increase the pressure on the reservoir (e.g. illegal waste dumps, illegal fishing activities, transportation of agricultural inputs and produce to and away from sites close to the reservoir); on the other hand, these roads can also be used for better supervision. The same can be said about access to forestry resources.	Greater connectivity in the form of infrastructural development is taking place everywhere in China, the watershed areas near the capital being no exception. For poor land users and fishers, the benefits are restricted to better marketing options of produce near the capital. Limited tourism has profited from modern media to attract customers. Poor people can benefit indirectly from employment opportunities in tourism or better information about opportunities of migrant labour.
2. Greater penetration of cash economy, with remnants of exchange and reciprocity mechanisms on the decline.	The sloped land conversion program (agriculture is prohibited in areas with more than 25% slope, conversion to forestry or grassland) implemented in parts of the Miyun watershed has elements of exchange and reciprocity (‘grain for green’). This could be viewed as a step back and away from such mechanisms. However, generally, cash economy is clearly having the upper hand, even in economic relations between farmers.	In the individual case, this might bear disadvantages for poor farmers with little land and few income opportunities. On the other hand, the cash economy facilitates support by migrant family members who can send remittances through the banking system.
3. Mixed livelihoods drawing upon local as well as non-local service, and manufacturing sector opportunities.	In an interview of stakeholders, economic growth was given as the most powerful reason for environmental degradation of the Miyun reservoir, behind policy failures and ‘decline in moral values’. PES as an alternative option of income generation has been implemented at a very limited scale (Forest and Water Warden program). On the whole, employment opportunities in the primary sector are rather getting restricted, which applies to fisheries, agriculture, and forestry, which contributed to improve runoff, reduced pollution from diffuse sources, and sedimentation.	Economic cooperation projects have been cancelled that may cause water pollution, and 21 enterprises were either shut down or scaled down along the Bai river. It is estimated that this action caused revenue cuts by 250 million dollars and a loss of nearly 50,000 employment opportunities which damaged the local peoples’ income generation capacity, especially of poor people.

Desakota Criteria	**Water-based Ecosystem Services**	**Poverty**
4. Greater diffusion of modern production and resource extractive technologies.	Along the Chao river, Chengteh city shut down 70 small polluting enterprises in 1996, and another 138 mining enterprises along the riversides from 1999-2004.small enterprises (TVE's) in mining and paper-making were closed down, which benefited the water quality of tributaries,	..but at the same time, withdrew income opportunities for poor residents
5. Greater penetration of formal institutions existing in a transformational tension with traditional informal institutions.	Naturally, there must be tensions between the EPB's (Environmental Protection Bureaus), the WRB (Water Resource Bureaus), the police and local farmers, which are based on the abolition of traditional land and water use. The fact that new rules are in part not strictly implemented indicates that there is a lack of clear regulations or clear mandate for their implementation, possibly also that some officials either take bribes or have sympathy for the plight of poor ES users who have few alternative income generating options.	Informal regulation of water distribution are disrupted or become subordinate to new priorities of water-saving and pollution control.