Payments for watershed ecosystem services: mechanism, progress and challenges

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\begin{abstract}
\textbf{Introduction:} Payment for watershed ecosystem services (PWES), a policy instrument for compensating for the externality of watershed ecosystem/environmental services, has gained in policy importance in China over the past two decades. Many scholars and researchers have contributed to the conceptualization of this policy framework by developing operational mechanisms as well as compensation standards for PWES.

\textbf{Outcomes:} This article reviews 27 PWES schemes piloted in China and in 10 other countries, with a particular emphasis on successful cases of land-use conversion programs, such as the Paddy Land to Dry Land Program and Sloping Land Conversion Program that have been implemented in China.

\textbf{Discussion:} By comparing different cases, the authors attempt to answer the following questions: what were the ecological and institutional contexts in which these schemes were established and how did they work? What were the actual efficiencies and impacts of these piloted schemes? Which scheme worked better in certain ecological, socio-economic, and institutional contexts?

\textbf{Conclusion:} Based on case studies, the authors draw the following conclusions about Chinese PWES: (1) to establish an acceptable standard for a PWES program, it is necessary to estimate the economic and social costs regarding the livelihoods of households; (2) multi-stakeholder negotiation mechanism for PWES, including intermediaries, such as the local government, NGO/NPOs, village committees, and user associations, should be used; (3) ES, non-market services, should acquire positive externalities to accomplish an optimal win–win pattern concerning both environmental goals and the livelihoods of local resource users.

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\textbf{Introduction}

To combat ecosystem deterioration caused by the over-use of ecological resources, China is constructing its regulatory and institutional framework to effectively implement eco-compensation schemes. In the past 20 years, supported by the government, Chinese scholars have developed and piloted a conceptual framework, mechanism for implementation, and technical standards for eco-compensation. At the same time, case studies and comparative analysis were carried out, and the study results have already had practical implications. The Chinese government has implemented a number of land-use conversion programs that provide environmental services to relevant stakeholders. Eco-compensation or payments for ecosystem/environmental services (PES) have seen exponential growth in academic articles. Implementation, rather than the development of a theoretical framework, is more concerned with the livelihood impacts on local resource users and with the government’s goal of created shared ecosystem conservation benefits and externalities with stakeholders outside of a watershed. The existing studies of PES are predominantly focused on how a PES mechanism works, how to assess environmental and social impacts of implemented PES schemes, and particularly, how they are applied in a watershed eco-service compensation scheme. Landell-Mills and Porras (2002) did pioneering work in PES markets and payment mechanisms and modality classification and emphasized the role of global governance as well as emerging markets. Porras, Grieg-Gran, and Neves (2008) further reviewed the payments for watershed services (PWS) in developing countries and pursued answers to the question of how and to what extent these schemes can be designed to be economically and environmentally efficient. The above valuable reviews of PES were supported by the International Institute for Environment and Development (IIED). Li et al. (2007) reviewed a series of PWS schemes in China and focused on the roles and functions of the government and the market in PWS; they present the findings and conclusions in their book. In this article, the authors adopt the definition of payment for watershed ecosystem services (PWES), and mainly reviewed 27 successful PWES schemes piloted in China and in other countries to compare their mechanisms and to make policy recommendations.
Review of studies and research on PWES

PES definitions

Ecosystem services (ES) have garnered attention from researchers for decades. Scholar and researchers suggested the definitions from different points of view; for example, in the introduction to her book Nature’s Services, Gretchen C. Daily defined ES as “the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life” (Daily 1997). Costanza et al. (1997) defined ES as including ecosystem goods and services because these are “the benefits human populations derive, directly or indirectly, from ecosystem functions.” The Millennium Ecosystem Assessment initiated by the United Nations defines ES as “the benefits that people obtain from ecosystems” (MA 2003, 2005).

Wunder (2005, 2015), Wunder and Albán (2008), Wunder, Engel, and Pagiola (2008), The Forest Trends, Katoomba Group and the UNEP (2008), Corbera, Kosoy, and Martinez-Tuna (2007), Vatn (2010), Asquith and Wunder (2008) provided their own understandings about PES, of which the definition by Wunder in 2005 has become widely accepted, who defined PES as “a voluntary transaction where a well-defined ES (or a land use likely to secure that service) is being ‘bought’ by a (minimum one) ES buyer from a (minimum one) ES provider if and only if the ES provider secures ES provision (conditionality)” (Wunder 2005). Wunder’s procedural concept was applied to PWES, which is illustrated in the following figure (Figure 1).

The usage of the term “ecological compensation” was first adopted when Vinogradov (1965) republished his research in English. In China, PES is gradually accepted by scholars and applied in different fields (Zhang 1987; Ouyang, Wang, and Zhao 1999; Wang 2014). Sun and Xie (2006) found that the first practice of ecological compensation in China was conducted in 1983. Wang, Wan, and Zhang (2006) distinguished the definition of ecological compensation from different perspectives.

Review of related institutional economic theories

As a policy instrument, PWES was developed based on a number of theories of institutional economics, particularly theories that address externalities of the resource and environmental costs. After Alfred Marshall first proposed the concept of an external economy in 1890, Arthur C. Pigou introduced it in the Economics of Welfare in 1920 as a distinguished external economy and external diseconomy.

Ronald H. Coase (1960) did not agree with the idea that simply considered the problem of externality as a market failure. He asserted that the essence of an externality was the unclear clarification of property rights of different resource users, which led to uncertainty in the power and benefit interface. Mao, Zhong, and Zhang (2002) suggested that the basis of PWES implementation is to clarify the property rights of resource users in the upstream watersheds, whereas the standard of compensation amount should be quantified based on the opportunity cost of resource property rights transfer.

Review of studies and policies

A large number of PWES fundamental researches and case studies have been performed by different researchers and scholars. Frélichová and Fanta (2015) found that long-term land-use changes in forests could create more ES than other types of land-use change, such as those on arable land during the same period. Lin et al. (2012a; 2012b), Brouwer, Tesfaye, and Pauw (2011), Huang et al. (2009), Southgate and Wunder (2009), and Grima et al. (2016) conducted case studies on PWES in Asia and Latin American countries. Schomers and Matzdorf (2013) compared the schemes in developing and industrialized countries, particularly between Latin America and the United States and Europe, and examined those schemes in terms of both impediments and achievements. In China, Liu, Liu, and Lu (2013) gave an overview of research into eco-compensation in China from 1987 to 2012 and concluded that there was a transition from qualitative research to quantitative research, and from fundamental research to technological guidance and policy. Jin and Zhen (2008), Qiao, Yang, and Yang (2012), and Zhang et al. (2012) focused on the mechanism, theoretical basis, compensation standard, and technologies of watershed schemes. Xu, Zheng, and Liu (2008), D. W. Xu et al. (2012) measured ecological compensation cases on the basis of calculation and model analysis.
In 2005, the principle of “Developer protects” and “Beneficiary pays (BPP)” were first presented in the Eleventh Five-Year Plan of China. The principles guiding the opinions “Developer protects; Saboteur rehabilitates; Beneficiary compensates; Polluter pays (PPP)” were affirmed by the State Environmental Protection Administration of China in 2007 in establishing PES pilot projects. This includes “PPP” and “BPP,” which were considered to be the core of ecological compensation policies in China (Wang, Wan, and Zhang 2006). Although a special national law for PES has not been established, the single laws of the Forest Act, Environmental Protection Act, Law of Water Pollution Prevention and Control, and Law of Soil and Water Conservation all mentioned eco-compensation. In 2011, the National Development and Reform Commission drafted a document for the Twelfth Five-Year Plan that outlined sound mechanisms for eco-compensation and another draft of its regulations. In doing so, the policy measures for PES mechanisms were preliminarily established. In 2014, “compensation for ecological protection” was first written into the new Environmental Protection Law of China. Some provinces also have their own regulations and practices, such as Zhejiang and Jiangsu. The PES regulation in Suzhou City, which involves three-quarters of the watershed areas of Tai Lake, mainly comprised of paddy land, forest, and water sources, first went into effect in 2014. The BPP is reemphasized by the regulation of the Opinion on Strengthening the Compensation Mechanism for Eco-Protection that was published by the State Council in May of 2016. The Opinion also indicated that the ecological red line should be strictly observed and that the key ecological functional area should be entirely covered (Wang, Liu, et al. 2016). Among the PES cases, the ones in watersheds and on agricultural lands are in their initial states. The Agriculture Act and Law of Solid Waste Pollution Prevention and Control also play a guiding role in carrying out the agricultural PES policies (Jin 2015).

A land-use proxy is a characteristic of PWES, including improved land-use practices, such as agricultural and ranching practices, agroforestry, and sustainable forest management. It also addresses the conservation and protection of existing ecosystems, reforestation, and rehabilitation of degraded ecosystems (Porras, Grieg-Gran, and Neves 2008). Such examples include a New York City program (Rosa, Kandel, and Dimas 2003) in the United States, the Munich-Mangfalltal program in Germany (Escobar, Hollaender, and Weffer 2013), the Vittel water company program in France (Perrot-Maitre 2006), and other typical developing country cases, such as in Costa Rica, Ecuador, and El Salvador. The land-use proxy has also been used in a number of case studies in China, such as in the national program of Sloping Land Conversion Program (SLCP) (Uchida, Xu, and Rozelle 2005; Bennett 2008; Groom et al. 2010) that is also regarded as an ecological construction in the source of Yellow River and Yangtze River (Li et al. 2007), and the municipal program of Paddy Land to Dry Land (PLDL) (Zheng Haixia 2013; Zheng Hua et al. 2013) that is conducted in the upstream of Miyun Reservoir. Experiences abroad were used for comparison, whereas both the practices in China and in other countries could represent their individual characteristics, progresses, and challenges.

The 27 schemes selected below are from 11 different countries, which were conducted successfully and seen as good examples in PWES cases. Some of them are from the IIEF watershed markets. There were similarities and differences between the approaches in China and those used in other countries. The government and market play a crucial role in government-driven schemes to achieve environmental goals as well as to improve household livelihoods. Intermediaries have different meanings in China and in other countries. Unlike other countries, the role of NGOs in China is extremely weak and has not been accepted by the government or the marketplace.

**PWES case studies**

**Chinese cases**

In China, there are ongoing typical cases of converting croplands to forests, grasses, or other types of land to achieve ecological benefits. Since the end of the twentieth century, the State Council of China permitted six large forest projects, including the Natural Forest Compensation Program, the Forest Ecological Compensation Program (FECP), the SLCP, the Constructing Protective Forest Shelter in Northern, Northwestern and Northeastern (Three Norths) China, and the Jing-Jin Sandstorm Source Control Project (Sun and Chen 2006; Li et al. 2007). In contrast to most other countries, China has a state-owned and collective land tenure system, wherein local farmers only have land-use rights, which greatly promotes the implementation of government-initiated PES schemes. Some national and local governments have initiated projects that are considered to be successful examples that fulfill the expected goals of land conversion. Other PES cases often maintain close ties with the rehabilitation of the forest or grasslands, the conservation of soil and water, and so on.

From the perspective of international PWES definition, China fulfilled several transactions around the country. Since the beginning of 2000, PWES has attracted widespread attention in China. Several local case studies have shown rapid development, such as the Dongjiang headwaters case (Guo et al. 2013) and the
Meijiang watershed case (Jin, Li, and Zuo 2005) in Jiangxi; as well as the Jinhua River case in Zhejiang (Zheng, Zhang, and Feng 2006), the Xin’an River case between Anhui and Zhejiang (Ma and Du 2015; Wang, Wang, et al. 2016), and three watershed cases in Fujian Province, including the Jin River (J. C. Xu et al. 2012), Min River (Rao et al. 2013), and Jiulong River cases (Yu and Ren 2007). The South-to-North Water Diversion Project was another national program of watershed diversion, with a payment scheme that is still under discussion (Yu and Ren 2007). Furthermore, the Deqing case in Zhejiang developed a protection fund for water and the environment (Huo 2010). Before the market’s role received more attention, the government often played a leading role (Table 1).

The SLCP program was implemented in 25 provinces, which is more than half of them. The pilot project started in 1999, and the government investment ratio was more than 90%. The program was taken as a typical PES case study due to its large range and efficiency, and also an example of PWES cases. As government purchasing is a characteristic mechanism of PES services, the government always plays a substitute role for the local community and households. Bennett (2008) evaluated the improvement of household autonomy in participation choice. In terms of the payment standards, some scholars have agreed that they are not as appropriate as they should be (Li et al. 2007). The generalized standards and unclearly related subjects probably created unsustainable policies (Wang and Song 2005). Meanwhile, some calculated that the subsidies to farmers who participated in the SLCP program were more than the opportunity cost of the converted land. Compared with Conservation Reserve Program (CRP) in the United States (Claassen, Cattaneo, and Johansson 2008; Baylis et al. 2008), Uchida, Xu, and Rozelle (2005) claimed that the subsidies in Yangtze and the Yellow River basins in SLCP were 2.5 to 3.6 times more than the 116 US dollars per ha in CRP. According to Ai et al. (2008), CRP was considered to be an inspiration to rebuild SLCP’s own policies after the first stage of the program to avoid the reforested land turning to crop production and returning to poverty. SLCP is considered to be a successful example of PWES study in China, and it has also influenced the PLDL program.

The PLDL program, one of the watershed programs implemented in the Chao River and Bai River, upstream from the Miyun reservoir, was initiated by Beijing Municipality and Hebei Province. The so-called Jing-Jin-Ji (Beijing, Taijin, and Hebei) region belongs to the Hai River watershed. In May 2001, a Plan for Sustainable Usage of Water Resources in Beijing in the Early twenty-first Century (2001–2005) was approved to address the reality of water shortages. According to this plan, micro-watershed control, water resources, and water environmental controls, a source of water protection forest project and PLDL program, were initiated between Jing and Ji. Although these were at a smaller scale and more provincial than SLCP, the program has several merits, such as easier operations, more benefits, and better effects. Since 2003, the PLDL program was approved to preserve the upstream water for both the quality and the quantity of the Miyun Reservoir. Both Beijing and two cities in Hebei Province participated in this program. It was always conducted along with the SLCP in local villages and by means of converting paddy land to dry land (PLDL) and paying for the losses from upstream villagers. The program was implemented in upstream rivers that converged at the Miyun Reservoir to aim at three issues: no

| Program             | Start year | Ecosystem services             | ES providers          | ES users                     | Intermediaries    | Initiator                  |
|---------------------|------------|--------------------------------|-----------------------|-----------------------------|-------------------|----------------------------|
| SLCP                | 1999       | Water and soil conservation    | Local farmers         | Beneficiary                 | Local government  | National government        |
| PLDL                | 2003       | Water quality and water quantity | Local farmers   | Water users of Miyun reservoir | Local governments | Jing-Ji governments      |
| Jinhua River        | 1996       | Water quality, soil and water conservation | Pan’an County | Jinhua City | None                        | Local government |
| Meijiang – orange orchards Min River | 2003 | Soil and water conservation | Orchard investors | Fuzhou City | Village committee | Local government |
| Jin River           | 2003       | Pollution control, garbage disposal | Xiamen City | Government | Government |
| Xin’an River        | 2010       | Water conservation             | Huangshan City       | Hangzhou City | National and local governments |
| Dongjiang Headwaters Deqing | 2003 | Soil and water conservation | Dongjiang Headwaters Farmers | Guangdong, Hong Kong | Government fund to protect water and the environment | Local government |
paddy, no fertilizer, and no pesticide. The agreement was later converted to rational use. Zheng Hua et al. (2013) reviewed this program and initiated a survey on the households enrolled in or not in the programs. They found that “the PLDL program generates benefits of improved water quantity and quality that exceed the costs of reduced agricultural output.” The program has continued into 2016 with the concept of water-saving agriculture.

Some other schemes have been implemented between towns or villages, such as in the cases of Jindong and Jinhua in Zhejiang (Li et al. 2007) and the case of Xiaozhai River in Yunnan (Zheng 2010). Furthermore, a type of outbound water quality monitoring program has arisen that depends on local government policy regulations where polluters pay. Compensation amounts by cities that did not reach the standard contributed to the special funds for pollution compensation. They include the Ziya River case in Hebei (Wang, Hou, and Yan 2011), the Hai River watershed case in Henan (Lu et al., 2011), the Qingshui River case in Guizhou (Ren and Ma 2015), and the Wei River case in Shaanxi (Wang 2010). These types of programs are based on water quantity agreements, whereas other programs are based on protecting water sources (Table 2).

The government plays very powerful and effective roles in implementing PWES programs in China, and the implementation has been effective thus far for quickly controlling the ecosystem degradation and impacts in the down-reach areas. However, it overlooked the social costs that emerged in the implementation, such as neglecting livelihood costs caused by resource use restriction. Top-down implementation approaches lack consultation with resource users within the watershed and lack of engagement with NGOs/NPOs and other intermediaries.

**International cases**

Not only the government but also the market has played a key role in the PWES practices. Landell-Mills and Porras (2002) in Silver Bullet or Fools’ Gold divided 287 market-oriented case studies into several markets, including markets for biodiversity conservation, markets for carbon sequestration, markets for watershed protection, markets for landscape beauty, and markets for bundled services. Governments standardize the processes using laws and regulations. Moreover, they suggest that markets and governments should be put into a broader context where they are not only interdependent but also pay more attention to governance and cooperative resource utilization.

Porras, Grieg-Gran, and Neves (2008) in All That Glitters: A Review of Payments for Watershed Services in Developing Countries reviewed the former works of IIED and noted that 66 market-based incentives (including bundled schemes) were identified, of which 42 were located in developing countries. They found that some of the proposals listed in Silver Bullet or Fools’ Gold were in a very early stage; in some cases, they were earlier ideas that did not proceed further. The latest data of IIED watershed markets includes approximately 69 cases in the developing countries of Africa, Central America & the Caribbean, East and South Asia, Southeast Asia, and North and South America. This study selected 13 typical and successful international cases referring to both the IIED data and other research achievements and made a comparison of these different case studies.

There are several successful governmental PWES programs, such as the National PES Program in Costa Rica (Morse et al. 2009; Daniels et al. 2010), Working for Water program in South Africa (Turpie, Marais, and Blignaut 2008), and New York City scheme in the United States (Table 3).

There are more market-driven PWES programs, including foundation-initiated, NGO-initiated, company-initiated, and resident-spontaneous cases. In the Ecoservicios project in El Salvador (Rosa, Kandel, and Dimas 2003; World Bank 2005) and the Quito-FONAG scheme in Ecuador (Southgate and Wunder 2009), foundations, NGOs, and governments participated. The Jesus de Otoro scheme in Honduras was initiated by the NGO PASOLAC (Kosoy et al. 2007). In the ESPH (Heredia) scheme in Costa Rica (Kosoy et al. 2007) and the Munich-Mangfalltal scheme in Germany (Escobar, Hollaender, and Weffer 2013), water supply companies were the initiators, whereas in the Vittel program in France (Perrot-Maître 2006), a water production company started the program. In Sukhomajri village in India, a downstream water user association played a major role,

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**Table 2. Market-based PWES programs in China.**

| Program       | Start year | Ecosystem services | ES providers | ES users             | Intermediaries                                      | Initiator               |
|---------------|------------|--------------------|--------------|----------------------|-----------------------------------------------------|-------------------------|
| Jindong, Jinhua | 2004       | Water quality and quantity | Yuandong Town Village | Fucun Town           | None                                                 | Township government     |
|               |            | Water quality and quantity |              | Village              | None                                                 | Village committees      |
| Xiaozhai River | 2002       | Water quality       | Jinhua Town Village | City                | Funds by government                                 | Local government        |
| Ziya River    | 2008       | Water quality       | Upstream cities | Cities that do not reach the standard | Funds by government | Local government |
| Qingshui River | 2009       | Water quality       | Upstream area   | Cities that do not reach the standard | Funds by government | Local government |
and both Sukhomajri villagers and water users downstream benefited from the program (Seckler and Joshi 1982; Kerr 2002; Kerr et al. 2007) (Table 4).

Some joint-initiated PWES programs worked well, such as the PCJ Consortium scheme in Brazil (Porras et al. 2008), the PASOLAC initiatives scheme in El Salvador (Porras and Neves 2006), and the Pimampiro scheme in Ecuador (Wunder and Albán 2008; Southgate and Wunder 2009) (Table 5).

The above cases concern PWES studies wherein inhabitants or government using the water in downstream areas pay for it and villagers in upstream areas benefit from the water quality protection through restoration or other measures. Land use conversion or management in PES studies also comprises a PWES field. In most of cases, new forests were built on originally cultivated lands. Such cases include Ecoservicios in El Salvador and the Heredia program in Costa Rica.

**Comparison**

The government plays an active role in the market in China and abroad, although their initiator and intermediaries are different. Government-facilitated consultation between upper reach and down reach stakeholders can mediate the conflicts of interest between sellers and buyers. PWES cases in China include national and local government initiated programs, joint market programs, and outbound water-quality monitoring programs. Many are supported by the government through certain regulations, and some are based on water fees. International PWES cases include government initiated (national and local), market initiated (foundation, NGO, company, resident-spontaneous), and joint initiated programs. In the United States, besides the state single laws, a New York City Watershed Memorandum of Agreement was established for a long-term watershed management strategy. The government supports most of the funds to subsidize upstream landowners. In Costa Rica, a Forestry Law was revised and finally approved; a foundation was set up by the government and paid for by water companies. In Ecuador, environmental services have been recognized in the Constitution, and other laws and regulations concerning water use exist, although land-use change was originally forbidden; the proposal first came from industrial or agricultural water users. These schemes involved a number of stakeholders. Grass-roots organizations, such as village committees

**Table 3. Government-driven PWES programs abroad.**

| Program                          | Start year | Ecosystem services                                                                 | ES providers            | ES users                     | Intermediaries                                      | Initiator                                      |
|---------------------------------|------------|------------------------------------------------------------------------------------|-------------------------|------------------------------|----------------------------------------------------|------------------------------------------------|
| National PES Program in Costa Rica | 1997       | Biodiversity and watershed protection, carbon sequestration, and landscape beauty   | Private landowners      | Water users downstream       | Government, NGO, FONAFIFO Fund                     | National government                           |
| WWF (working for water) in South Africa | 1995       | Water quantity, flow regulation, and erosion control                                | Local rural contractors | Water users downstream       | None                                               | Government (National and local)                |
| New York in the United States   | 1990s      | Water quality                                                                       | Upstream landowners     | Water users downstream       | None                                               | New York city government                      |

**Table 4. Global market-driven PWES programs.**

| Program                      | Start year | Ecosystem services                                                                 | ES providers            | ES users                     | Intermediaries                                      | Initiator                                      |
|------------------------------|------------|------------------------------------------------------------------------------------|-------------------------|------------------------------|----------------------------------------------------|------------------------------------------------|
| Ecoservicios in El Salvador  | 2005       | Water quality; reducing sediment loads; regulating groundwater and surface flows  | Private landowners      | Service users, including government, residents, and NGOs | National Environmental Services Fund – FONASA | FONASA (by the World Bank and Global Environment Facility) and the national government (NGO – The Nature Conservancy (TNC), and the government NGO – PASOLAC |
| Quito-FONAG in Ecuador       | 1998       | Water quality and quantity                                                        | Public reserve inhabited by local communities | Water users downstream       | The Water Conservation Fund (FONAG)               | NGO – The Nature Conservancy (TNC), and the government NGO – PASOLAC |
| Jesus de Otoro in Honduras ESPH (Heredia) in Costa Rica | 2002       | Water quality                                                                       | Upstream landowners     | Water users downstream       | Local NGO – JAPOE                                  | Heredia’s water company, ESPH                  |
| Munich- Mangfalltal in Germany | 1992       | Nitrates, pesticides and water quality control                                     | Upstream landowners     | Water users in Munich        | Water supply company                               | Water supply company, organic agriculture associations |
| Vittel program in France Sukhomajri in India | 1993       | Water quality                                                                       | 27 upstream farmers     | Mineral water bottler Vittel Sukhomajri villagers and water users downstream | None                                               | Vittel company                                 |
|                              | 1970s      | Water quality                                                                       | Villagers at Sukhomajri | Water users association – HRMS | Downstream residents                               |                                                |
and user associations, often play a supplementary role in addition to the typical intermediaries.

To understand the similarities and differences between cases in China and cases in other countries, such as the United States, Germany, France and other developing countries, the following comparison table provides the key stakeholders, effectiveness, and constraints in these transactions (Table 7).

### Discussion

There is an ongoing debate over “government versus market” among free-market economists who disbelieve in government intervention and another group of economists who claim “market failures” in market require government intervention. Landell-Mills and Porras (2002) evaluated interdependent government and market approaches and their cooperation. Nevertheless, markets or governments who play a leading role, both in China and in international countries, have arrived at a state where both sides are workable and run smoothly most of the time. Government regulations and controls are also active in international countries; meanwhile, market participation programs, such as outbound water quality monitoring programs, also have a great impact in China. Determining the characteristics, how the programs were established, and how they work are important issues that we discuss in this section. In many cases, foundations, NGOs, and companies which participated in the implementation processes of international cases were also active as intermediaries. Intermediaries existed when payments were determined, but the payment transfer to beneficiaries (receivers) stagnated due to the existence of constraining factors. The government sometimes plays an intermediary role.

### PWES characteristics

To compare the initial elements of the selected PWES programs, it is quite useful to understand the characteristics of these cases. Each case mentioned above will be categorized as having been implemented by a government, foundation, NGO, company, or residents in Table 7. It is not surprising that most of these types of PWES schemes are government implemented in China, often at a local level.

How is a “government-financed” or “user-financed” approach that includes NGOs, companies, foundations, and residents determined? Pagiola and Platais (2007) argue that actors in the latter type are directly involved, know the value of the service clearly, understand whether the mechanism is functioning well, can observe the service delivery directly, and have the ability to renegotiate. Wunder, Engel, and Pagiola (2008) presented case studies of 14 different PES schemes with government-financed or user-financed approaches; they considered the buyer to be a third party acting on behalf of service users in a former type of program and found that the program has less willingness to enforce conditionality and more confounding side objectives than the latter. However, it should be noted that government-financed PES might be more cost-effective than user-financed PES because of economies of scale and related transaction costs (Engel, Pagiola, and Wunder 2008). Hecken and Bastiaensen (2010) noted the risk of market-based PES, wherein “user-funded” might aggravate the regressive situation of global commons financed by poor local communities. Engel and others (2008) also proposed that even if the programs operated by the government are “financed through compulsory fees charged to service users rather than from general revenue,” it is better to “believe that they are properly considered to be government-financed.” In the above examples, although this article did not divide them into two types of schemes, classifying both national and local government implemented cases in China as government-financed programs would be possible. To those that have mixed-implementation actors, this article divided them into respective implementing patterns. As an example of implementation, both the Quito-FONAG program in Ecuador and the Ecoservicios program in El Salvador have different buyers, such as governments, NGOs, and residents. Chinese cases such as the Deqing model and Jinjiang program also have special funds for fulfilling ecological services but

### Table 5. Global joint-initiated PWES programs.

| Program                          | Start year | Ecosystem services                                      | ES providers                  | ES users          | Intermediaries                                       | Initiator                                      |
|----------------------------------|------------|--------------------------------------------------------|-------------------------------|-------------------|------------------------------------------------------|------------------------------------------------|
| PCI Consortium in Brazil         | 1989       | Water flow regulation; water quality; erosion control  | Private landowners            | Water users downstream | Trust PCI Consortium                                 | Municipalities and businesses                  |
| PASOLAC Initiatives in El Salvador| 2002       | Water flows and water quality                          | Municipalities and public utility company | Local municipalities, water utilities, and residents | Local NGO – CODECA                               | Local municipalities and water utilities PASOLAC |
| Pimampiro in Ecuador             | 2000       | Maintenance of water quality and quantity through forest conservation | Private landowners            | Water users downstream | None/NGO Cederena                                   | Local municipality, NGO – Cederena             |
Table 6. Comparison among different countries.

| Countries | Initiator | ES providers | ES buyers | ES users | Intermediaries | Mechanism | Experience | Effectiveness | Constraints | Challenges |
|-----------|-----------|--------------|-----------|----------|----------------|-----------|------------|--------------|-------------|------------|
| China     | Government| Farmers      | Government| Water users downstream | Government | Government leading | Top-down implementation approaches Multi-stakeholder negotiation | ES, poverty | Voluntary participation, intermediaries Feasibility | Monotonous compensation standard Protecting natural resources and alleviating rural poverty |
| US (NY)   | Government| Landowners   | Government| Water users downstream | None       | Government + market |                | ES (water quality) |                | Feasibility Long-term agreement |
| Germany (Munich) | Company, Associations | Landowners | Company | Water users downstream | Company | Company + associations | Company + associations Public-private partnership | ES (water quality) | Agreement transition period Achieve agreement Insufficient to guarantee environmental services provided |
| France (Vittel) | Company | Landowners | Company | Water users downstream | None | Company + associations | Company + associations Public-private partnership | ES (water quality) | Agreement transition period Achieve agreement Insufficient to guarantee environmental services provided |
| Other developing countries | Government, companies, residents, foundations, NGOs | Farmers/landowners | Government, companies, residents, foundations, NGOs | Water users downstream | Government, foundations, NGOs, companies | Government, companies, residents, foundations, NGOs-joint | Multi-stakeholder negotiation | ES (water quality, quantity), poverty | Payments assurance Legislation, negotiation |

Table 7. Initiators of PWES schemes implemented in China and in other countries.

| Type | National government | Local government | Foundation | NGO | Company | Resident-spontaneous |
|------|---------------------|------------------|------------|-----|---------|---------------------|
| International Program | WW, South Africa; National PES program, Costa Rica (2) | PCJ Consortium, Brazil; Pimampiro, Ecuador; WW, South Africa; PASOLAC Initiatives, El Salvador; New York, US (5) | Quito-FONAG, Ecuador; Ecoservicios, El Salvador (2) | Quito-FONAG, Ecuador; PASOLAC Initiatives, El Salvador; Jesus de Otoro, Honduras; Pimampiro, Ecuador (4) | PCJ Consortium, Brazil; ESPH (Heredia), Costa Rica; Munich in Germany; Vittel program, France (4) | Sukhomajri, India (1) |
| Chinese Program | SLCP (1) | PLDL, Jinhu River, Mei River, Min River, Jiulong River, Jin River, Xinian River, Dongjiang Headwater, Deqing, Ziya River, Qingshui River (11) | Jin River, Deqing, Ziya River, Qingshui River (4) | Qingshui River (11) | Jindong, Xiaozhaizi River (2) | D. FENG ET AL. |
they are government-financed. Joint-initiated programs that include NGOs are rare in China.

The authors set out different examples according to the patterns of PWES mechanisms put forward by Wang and Hou (2013) based on financial sources. (1) Negotiated transaction approaches occur between upstream and downstream governments, such as along the Jinhua River; (2) jointly funded approaches occur between upstream and downstream governments, such as along the Min River, Jiulong River, and Jin River; (3) financial transfer payment approaches occur between governments and intergovernmental actors, such as in the Dongjiang Headwaters and PLDL; and (4) compulsory withholding approaches are based on outbound water quality, such as along the Ziya River and Qingshui River.

When market failures occur, government intervention includes taxing polluters and subsidizing ES providers. In government-oriented programs, the governments enforce national or local regulations and adopt optimal standards calculated by experts to compensate ES providers. In a spontaneous watershed program, governments are not directly active but rely on consultation between water users and water providers. Communities, such as village committees and user associations, often play a central role in helping to adopt an optimal plan to carry out agreement with expert opinions and consultations.

**PWES mechanisms**

Comparing the Chinese cases with international cases identified some differences. China has the potential to form more flexible and diverse mechanisms, with some basic principles. According to the “Developer protects, Saboteur rehabilitates” idea, there are financial allocations for upstream protection funded by national and local governments. According to the “Beneficiary compensates” approach, most of the cases between downstream and upstream regions are combined. An example of this type is a traditional compensation approach to water diversion between Shiga County and Kyoto City in Japan since the early twentieth century (Feng 2012). According to the “Polluter pays” approach, even upstream cities that did not achieve a water quality standard should pay for downstream city protection. It is clear that although governments played a key role in this process, NGOs and other entities were not active. As a main form of land use conversion, planting trees and forest is an element of most PWES cases. In the majority of these cases, the original land type is under cultivation for grains or rice paddies. Land use changes should be undertaken with permission from the national and local government because only the county government and higher authorities can approve cultivated land being converted into other types.

Figure 2 provides a description of the mechanisms of PWES cases in China. Governments are often the initiators. Who does the government consult and what is the basis for regulations and laws? An expert panel played a very crucial role in decision-making about the final ES values that follow. How does the mechanism work? The transaction between ES providers and ES users is an action where users as ES buyers who pay for ES providers are the sellers. Because externality factors in this market platform, a market failure will occur according to Pigouvian theory. The government then interferes in such a situation by taxing or subsidizing, but sometimes also faces a failure according to the Coasean theory. In such a situation, the government should reduce its intervention in the market and make a balance.

In some of the developing countries, administratively determined payments are also popular. The Pimampiro scheme in Ecuador is an example. The payment levels were determined by the local municipality and a local NGO who designed the project, without any prior examination of opportunity costs (Echavarría et al. 2004). The national PES program in Costa Rica is another case where a government agency administered the scheme. The payments were transferred among stakeholders, either direct from buyer to seller or through intermediaries. Examples of the former are the ESPH in Costa Rica, Jesus de Otoro in Honduras, and Pimampiro in Ecuador. The latter includes trust funds. In the case of Quito-FONAG in Ecuador, several stakeholders (TNC, a local NGO, and the municipality) established the fund on the basis of user payments and it operated for several years (Krchnak, Brown, and Stem 2007). One type was the Fucuene program in Colombia, which functions through revolving funds that provide money from a continuing source and cyclical cash flows. Also in this scheme, local farmers favored commercial loans to cover costs because the scheme involves a guarantee (Rubiano et al. 2006).

Figure 3 provides a description of PWES cases in international countries. The mechanisms are similar to China and are based on Pigouvian and Coasean theories. However, the initiators are not only governments but also companies, residents, foundations, and NGOs who also play an active part as intermediaries. These participants, who are both initiators and intermediaries, can avoid or mediate the situation when governments are confronted with a failure. Particularly, in cases when NGOs play a role as sponsor, such as in the Jesus de Otoro program, PASOLAC supported the local NGO JAPOE, who took the role of the local municipality and charged additional water fees from local water user households.
Figure 2. Diagram of PWES mechanisms in China.

Figure 3. Diagram of PWES mechanisms in other countries.
Assessing impacts on watershed services

An evaluation of the above PWS schemes involved three basic elements: environmental, social, and economic impacts. On the one hand, it is important to determine whether the environmental goal they set for each project ultimately satisfied their watershed services requirements. On the other hand, comprehensively assessing the social and economic impacts also attracts widespread attention. In most cases, maximizing watershed services through payment systems has led to poverty reduction.

According to the data, the earnings from national PES schemes became part of the participant incomes. A study of participation in Costa Rica’s national PES scheme indicated that most of the participants are relatively affluent and only 15% are below the poverty line. “The results show that 81% of their sample had not lived on their farms in the past five years, demonstrating that the farm is only a minor source of income for them” (Ortiz Malavasi, Sage Mora, and Borge Carvajal 2003; Porras, Grieg-Gran, and Neves 2008). Another household survey in 2002 indicated that participants in the national PES scheme were better educated, and had considerably larger farms and higher household income than non-participants (Zbinden and Lee 2005). Approximately, 77% of the non-participants lived on the farm, and off-farm income was low relative to the PES participants. Referring to Porras, Grieg-Gran, and Neves (2008), revised approaches to assess the impacts on watershed services include the following: the impact on the livelihoods of service providers, the impact on downstream water users, and the impact on other groups. Zheng Haixia (2013) reviewed the PES case of the Miyun reservoir in Beijing’s watershed. Through an analysis of all stakeholders, she assessed the environmental services using a contingent valuation method and obtained statistics on the willingness-to-pay by service users for setting a reference standard for PES programs in the Miyun Reservoir; this amount was 208.94 yuan per mu per year, which is 576 million yuan in total. Several programs, such as small watershed management, water forest protection, and PLDL in this watershed, provide services to downstream users. Take PLDL for example; it is difficult for water users to distinguish the services of this program from the services of other programs. Thus, it is not entirely reciprocal in the same way to equate the valuations by downstream water users to those by upstream service providers. In such a situation, it is better to pay more attention to the livelihoods of upstream service providers. Through a fieldwork survey, Dong and Li (2007) investigated the impacts of PLDL policy on the livelihoods of farmers in three typical villages of Hebei Province. They found that if the policy were implemented, the incomes of the village families would decrease at an average rate of 4.23% for all family incomes in these villages. Therefore, they did not consider non-farm opportunities. Clearly, a household livelihood survey conducted by Zheng et al. (2013) with 394 households participating in the program and 329 non-participating households indicated that the benefits of water quality and quantity improvement were greater than the costs.

The efficiency of a PWES scheme complied with the efficiency of PES schemes. According to Engel, Pagiola, and Wunder (2008), the value of ES, along with onsite profits, could be distributed in four types (Figure 4). The top quadrants generated win–win positive externalities, whereas the bottom quadrants generated negative externalities. Whether an activity induces a positive or a negative externality is related to the definition of property rights. The top-left shows what land-use practices are not profitable to land users but have positive externalities. Meanwhile, the bottom-right shows what practices are privately profitable but have negative externalities. To acquire positive externalities, such as better water quality and a healthier environment, when the practices are unprofitable, the government should compensate local farmers, gradually reaching a win–win state. In the process, although it seems unprofitable in the beginning, if labor reductions and the achievement of environmental goals are considered, the deficit would finally be compensated for.

Figure 4. A framework to analyze the efficiency of PES.
Source: Engel, Pagiola, and Wunder (2008), adapted from Pagiola (2005).
Note: Four cases A–D refer to socially desirable, socially undesirable, socially undesirable, and any determined land use practices, respectively.
Wunder, Engel, and Pagiola (2008) found that it is difficult to pursue both the targets of ES and poverty alleviation. Although government-financed programs are often designed to achieve side objectives, “targeting the poor explicitly is not a necessary condition for PES to benefit,” and the program’s effectiveness would decline under certain conditions. In the Maasin Watershed Rehabilitation Project in the Philippines, people considered the payments as a reward “due to them” to reduce local poverty.

However, some scholars have positive opinions. Wang and Zhong (2009) found that most of the poor ES providers in PES programs increased their incomes and alleviated their poverty. Pagiola, Arcenas, and Platais (2005) indicated that important synergies occur when the program is well designed and local conditions are favorable. Groom et al. (2010) proposed that the SLCP is a “win–win” policy for poverty alleviation and environmental goals in China. “The model predicts that the impact of the SLCP on off-farm labor supply will be larger for constrained households if constraints are relaxed.” PLDL is also expected to be a win–win program for achieving both environmental goals and poverty alleviation, but livelihood improvements are not the ultimate aim and compensation is far from what is needed. A survey by the authors of this article indicated that the average value of willingness-to-accept payments in 391 households in Chicheng, Fengning, Luanning counties (Ji) and in the Huairou district (Jing) was approximately 759.56 yuan per mu, a total of 81.8 million yuan per year. This value is more than the 550 yuan standard in Hebei that has been paid prior to 2015 but it is acceptable compared with the willingness-to-pay value and is roughly the same as the new standard since 2016. Considering the disparity of farm product prices among different years, the farmer households should receive more reasonable compensation.

Conclusions and perspectives

All of the cases mentioned in this article are typical or successful PWES schemes. Among international case studies, 10 PWES cases were from developing countries; three more, the New York case, Munich-Mangfalltal, and Vittel, were from developed countries. Few national government-implemented schemes were selected, and more than half of the schemes were implemented by a local government. Though the governments participated in these schemes, their roles were weak. The NGOs and company-implemented payment schemes were successful because they also played a role as intermediaries. Intermediaries are helpful for determining payments or transferring payments from users to providers. However, according to Brouwer, Tesfaye, and Pauw (2011), community commitment and participation had a positive effect on environmental outcomes. Though market-driven and user-financed programs are more popular in international countries, government-driven and financed programs are seen as effective.

A total of 14 PWES case studies in China are discussed in this article. PLDL together with SLCP, are typical examples of PWES schemes in China. The study and research achievements of SLCP show that it is a successful program in practice. Although there are some measures that require improvement, it is making progress. A new round of policies was set forth to convert more sloping lands in 2014. The PLDL program emulates SLCP’s strong points. The volunteerism of local farmers, who decide whether to participate in the program, which program to participate in, and what type of plants or crops to grow, will be improved in the new plan. Most of the Chinese case studies are government-implemented and financed, which are more effective than user-financed programs. National or municipal governments served as an initiator, and the subordinate government was an intermediary. Markets came to play an active role in recent years along with the government. PPP and BPP are the main principles of PWES schemes in China.

In conclusion, international and Chinese PWES cases have common features in terms of implementation procedures, but they use different mechanisms. The government policies and regulations in international cases are more flexible due to using different initiators and intermediaries. To achieve positive externalities and avoid market failure, the government plays an important role. Governance of PWES in China is more effective than in other countries. There are several aspects that need to be taken into consideration in regard to implementation of PWES programs in China.

First, PWES laws and regulations should be systematically established. To establish acceptable standards for payments, it is necessary to estimate the economic losses from household livelihoods as well as the social costs that are caused by the change in resource-use patterns. Community development opportunity costs should also be considered when determining the compensation. A line is always drawn between additional livelihood costs to upstream farmers and their willingness-to-accept payment.

Second, although the government plays a key role, the intermediaries also play an active role in implementing PWES. Between the upstream and downstream watershed and inter-watershed cases, negotiation and consultation among stakeholders is indispensable. Multi-stakeholder negotiation mechanism for PWES implementation should consider the involvement of intermediaries, such as the local government, NGO/NPOs, village committees (communities), and user associations.
Third, benefits are criteria to determine whether a program fulfills its original environmental goal (positive externalities), and other social and economic outcomes, such as poverty alleviation (profits). In some cases, governments can administratively determine payments; in other cases, the market itself plays a key role. The government and market work with each other. To acquire positive externalities, when the practices are unprofitable, the government should compensate upstream farmers, gradually reaching an optimal win–win state. When facing government failure, the focus of regulation should be shifted. Although benefitting the poor is not a necessary condition of PWES, in most cases, the PWES schemes would help achieve both targets.

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