COMMENTARY

Integrated assessments of payments for ecosystem services programs

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Ecosystems provide crucial services such as clean water to humans. Numerous payments for ecosystem services (PES) programs have been implemented around the world. However, their socioeconomic and environmental consequences are rarely quantified simultaneously. In PNAS, Zheng et al. (1) present an insightful empirical analysis of socioeconomic and environmental effects of a PES program that supplies drinking water to ∼20 million residents in Beijing, China. The work also brings ecosystem service research closer to fully account for the pros and cons of PES programs, laying important groundwork to quantify telecouplings—socioeconomic and environmental interactions over distances (2).

Using the Paddy Land to Dry Land (PLDL) program as a case study, Zheng et al. (1) quantify benefits and costs to both service providers and beneficiaries. Beneficiaries are residents in Beijing, which is >100 km away from the service providers who are farmers participating in the PLDL program in the Miyun Reservoir watershed. Miyun Reservoir is the only surface water reservoir serving Beijing. Approximately 20% of the Miyun Reservoir watershed is located in the greater municipality of Beijing, whereas the remaining 80% is in the upstream Hebei Province (1). Specifically, PLDL converts the majority of paddy land to dry land by growing corn instead of rice so that less water is used for agricultural production and more water is available to Beijing residents. Zheng et al. (1) provide convincing evidence how integrated approaches can help address complex water resources management challenges.

Counting Dollars and Cents

Cost–benefit analyses are typical in many areas of policy or decision evaluation (3, 4), but they have not been commonly used in research on PES. Among the studies on PES thus far, economic costs (e.g., opportunity costs to service providers, direct payments to service providers, and associated transaction costs to the beneficiaries) are better known than economic benefits derived from the PES programs. For example, from 1999 to 2009, the Chinese government invested a total of 200 billion yuan (1 USD = 6.1 yuan, September 2013) in one of the world's largest PES program—Grain to Green Program, which converts cropland on steep slopes to forest or grassland, but information on economic benefits from this program is largely fragmented (5). Although some studies have been conducted on economic benefits, many of the economic benefits remain unknown until many years later because of time lags (6).

Zheng et al. (1) conduct cost–benefit analyses for ecosystem service providers and beneficiaries separately and as a whole. Overall, the benefits are 50% higher than the costs, and both upstream providers and downstream beneficiaries are win–win partners.

Revealing Unexpected Social and Environmental Impacts

PES programs not only have economic consequences, but also social and environmental impacts. Although the former is usually obvious, the latter is more complex and often with surprises. Although there are increasingly more analyses of the costs and benefits of PES programs, relatively little is known about changes in program participants' livelihoods. Livelihood changes in turn can cause cascading socioeconomic and environmental effects. Thus, assessing livelihood changes is of particular importance to sustainability and cost-effectiveness of PES programs.

Zheng et al. (1) find that the PLDL program has led to changes in livelihood portfolios, household production and consumption activities, and export of nutrients to waterways. Specifically, participant households' agricultural income on average decreases by ∼2,000 yuan in comparison with that of nonparticipant households, but the relative decrease of agricultural income appears to be offset by a higher increase in migrant earnings (>3,000 yuan on average). Participant households spend more on education than nonparticipants.

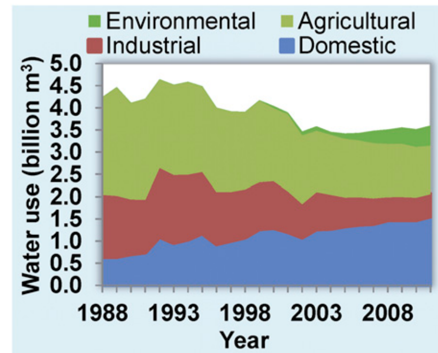

Fig. 1. Dynamics of water use by sector in Beijing (data from ref. 9).

They have less labor allocation in corn cultivation than rice production but more nutrient applications.

Interestingly, although participant households have higher increases in nutrient application rates, the PLDL program still leads to lower export of total nitrogen and total phosphorus to waterways (thus a positive net effect on water quality) because growing corn in dry land has lower nutrient export rates than growing rice in irrigated paddy land. Many studies (7, 8) evaluated environmental benefits with proxies (e.g., slope), which may not be sufficient for quantifying environmental conditions (e.g., soil erosion severity). In contrast, Zheng et al. (1) directly measure changes in environmental conditions (i.e., water yield and nutrient loadings).

Embracing the Telecoupling Framework

Provision of and demand for ecosystem services are often spatially segregated (e.g., hundreds or even thousands of kilometers away) (2). This is especially true for megacities such as Beijing where there is a high concentration of human population and households and thus a high demand for ecosystem services. Although Beijing has reduced water use for agriculture and industry by shifting economic structure (e.g., reducing agricultural land and moving

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Table 1. Research gaps on PES programs in the context of telecoupling framework

Components of the telecoupling framework (2)	Definitions of the telecoupling components with regard to PES	Specific telecoupling components studied or not studied by Zheng et al. (1)
Sending systems	Systems that provide ecosystem services	Upstream of Miyun Reservoir watershed in Hebei Province
Receiving systems	Systems that receive ecosystem services	City of Beijing
Spillover systems	Systems that affect or are affected by interactions between sending and receiving systems	Other areas affected by the PLDL (e.g., surrounding areas in Hebei and other areas that send water to Beijing)
Flows	Movement of ecosystem services and associated materials, energy, information, such as cash payments	Movement of water and cash between Heibei and Beijing; movement of materials/energy/information between Beijing (or Hebei) and spillover systems
Agents	Service providers in sending systems; beneficiaries in receiving systems; involved organizations or people in sending, receiving, and spillover systems	Participant households in Hebei; local governments in Hebei and Beijing; agents in spillover systems
Causes	Environmental (e.g., availability of ecosystem services in sending systems); Socioeconomic (e.g., demand for ecosystem services in receiving systems); Political (e.g., agreements between sending and receiving systems); technological (e.g., channels to transfer ecosystem services)	Decline in water quantity and quality in Beijing and Hebei; population growth and household proliferation in Beijing; rapid economic growth; increasing water demand in Beijing; conflicts and shared political interests between Hebei and Beijing; feasible technologies of transferring water; systems that affect hydrological dynamics in Beijing and Hebei
Effects	Socioeconomic and environmental effects in sending, receiving, and spillover systems; feedbacks	Increase in water yield and decrease in nutrient pollution in Miyun Reservoir Watershed; opportunity costs of conserving water to service providers; transaction costs; economic costs to Beijing residents; changes in livelihood of service providers; changes in livelihood of beneficiaries; environmental effects (e.g., on groundwater level, land cover) in Beijing; feedbacks such as changes in payments according to changes in water quantity and quality; socioeconomic and environmental effects on spillover systems

Underlined items refer to issues that are not studied by Zheng et al. (1).

water-thirsty industries out of the city), domestic demand for water continues to increase because of population growth and especially household proliferation (Fig. 1). The demand for ecosystem services in megacities usually greatly exceeds the supply. As a result, meeting the demand often relies on ecosystem services from distant places and leads to telecouplings (2).

The telecoupling framework outlines interactions among three types of coupled systems (sending, receiving, and spillover) connected through flows of energy, matter, and information (Table 1). Applying the telecoupling framework to PES programs can help identify research gaps and standardize analytical approaches with flexibility based on specific contexts. For example, the spillover systems are relatively unexplored. Even for sending and receiving systems, ecosystem service providers and beneficiaries are often the focus. Other elements, such as the environment in the receiving systems, have received little attention (Table 1). Another important issue that warrants more research is feedback among sending, receiving, and spillover systems. For example, although the PLDL program adjusted the payments based on the land use market value (1), it is also important to adjust the payments based on the quantity and quality of water that the Miyun Reservoir Watershed provides to Beijing.

The telecoupling framework can also help evaluate tradeoffs and synergies between PES programs among coupled systems at different distances. For example, between the PLDL program and the ongoing 1,240-km Middle Route of the South-to-North Water Transfer Project (which aims to divert water to Beijing from southern China), which has stronger socioeconomic and environmental effects across sending, receiving, and spillover systems? How do the two programs offset or amplify the effects of each other?

The work by Zheng et al. (1) lays a nice foundation to fully account for socioeconomic and environmental effects across telecoupled systems. Understanding these effects can help design good policy to generate ecosystem services and improve human well-being. Their work also establishes an essential baseline to evaluate long-term effects that may be different from the short-term effects reported in ref. 1. Future research that embraces the telecoupling framework will add important insights toward sustaining ecosystem service provision, balancing tradeoffs, promoting regional and global cooperation, and achieving win–win–win outcomes among sending, receiving, and spillover systems at multiple scales.

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