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Water transfer from irrigation tanks for urban use: can payment for ecosystem services produce efficient outcomes?

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ABSTRACT

Many Indian states have begun to transfer water meant for irrigation to non-agricultural purposes, but the economic and environmental consequences are not adequately understood. Transfer of water out of water bodies from rural areas not only reduces the economic welfare of the traditional water users but also reduces their incentives to manage these water bodies on a sustainable basis. The study explores the possibility of introducing the mechanism of 'payment for ecosystem services' at the grass-roots level in the Indian context as a return for reallocation of water from irrigation to urban uses so that it can produce a non-zero-sum outcome for villagers, farmers, urban consumers and governments.

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Introduction

Acquisition of agricultural land for development projects in India has prompted political unrest in many states and produced economic consequences detrimental to sustainable agricultural development at micro level. Such acquisition reduces economic welfare, especially for the unwilling farmers (Chaudhry, 2015; Ghosh, 2012; Levien, 2012; Ramachandraiah & Srinivasan, 2011) and landless agricultural labourers and sharecroppers (Narain, 2009; Vij & Narain, 2016), if they are driven away from their principal source of livelihood. The welfare loss is high if the affected parties lack alternative economic opportunities. The literature on land acquisition does not focus on this welfare loss, which either destroys or degrades water resources and their ecosystem services. In addition to land acquisition, governments and private entities transfer water out of rural water sources for urban uses (Chandran, 2016; Gandy, 2008; Narain, 2009), mostly without compensating the affected. What institutional mechanism is required that can address the consequences of this scenario?

This study analyzes the consequences of transfer of water for urban use from water bodies traditionally used for irrigation purposes and then explores *payment for ecosystem services* (PES) to address the economic trade-offs associated with water transfer. This is achieved by analyzing the case of irrigation tanks in the state of Tamil Nadu in India, which are historically well known for their contribution to agriculture development in the state.

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The article first discusses the process of water transfer from traditional irrigation sources for non-agricultural uses and its possible economic consequences. This is followed by an overview of challenges in conservation and management of irrigation tanks in Tamil Nadu, including an appraisal of large-scale transfer of water from irrigation tanks for non-agricultural purposes and how the current institutional challenges in tank management can be overcome by introducing PES. It then describes the concept of PES for water usage and the ramifications of its implementation based on empirical literature. Finally, this study analyzes conditions for implementing water PES in the Indian context, followed by conclusions.

Water transfer for non-agricultural uses and its economic consequences

Traditionally, water for urban use in India has been drawn largely from rivers, lakes, large reservoirs and subsurface sources. Due to urbanization, state governments are transferring water from traditional irrigation sources such as large reservoirs and tanks in rural areas, for the benefit of urban consumers. Such interventions by the state can hurt water users in rural areas. While the issues associated with land acquisition are being widely debated and discussed in both political and academic spheres (Ghatak, Mitra, Mookherjee, & Nath, 2013; Singh, 2012), the economic and environmental impacts of water transfer do not get adequate attention in the existing literature on water management in the Indian context. Water is acquired in two different ways. First, when irrigated land is converted to development purposes, under either forced or voluntary arrangements, the water rights attached to the land ownership are also taken away from the farmers. As a consequence, a variety of water-based non-market ecosystem services enjoyed by different stakeholders in rural areas are also lost. Second, when water is directly transferred from irrigation sources for high-value urban use, the water users in rural areas are deprived of various non-market ecosystem services associated with irrigation water. In both situations, the economic value of welfare loss is not accounted for anywhere in the system.

Water sources generate multiple ecosystem services (Barbier et al., 2008; TEEB, 2010) that are used by farm and non-farm users across wide geographical regions. These services are of four types: *provisioning services,* which include food, freshwater, fibre, fuel, and biochemical and genetic materials; *regulating services,* consisting of climate regulation, hydrological regulation, water purification and wastewater treatment, erosion regulation and regulation of pollination; *cultural services,* comprising spiritual, inspirational, recreational, cultural and educational values; and *supporting services,* in the form of soil formation and nutrient recycling (Millennium Ecosystem Assessment, 2005).

Ecosystem services contribute both directly and indirectly to the economic welfare of innumerable stakeholders: farmers benefit directly in economic terms from irrigation water use; rural households use water for various extractive and in-stream uses; landless households rearing ducks and livestock are (indirectly) dependent on irrigated agriculture, especially during the post-harvest period. Environmental economists (e.g. Kolstad, 2011) have identified *non-use values,* such as *option value, quasi-option value* and *existence value,* which generate utility for individuals and households, expressed in terms of either their willingness to pay to preserve these benefits or willingness to accept compensation for forgoing them. The non-use values become positive whenever households attach cultural and religious values to some unique water source, for instance, temple tanks in rural areas of India. The nature and the size of all these benefits differ across different water users and different water sources, and also across climatic conditions (Kumar, Panda, Niranjan, & Bassi, 2012).

Water-based ecosystem services have certain unique characteristics: (a) most of them have high economic value but do not have a market price; (b) some are tangible and some are intangible; (c) some are visible and some are invisible; (d) some are objective while others are subjective; and (e) some are local while others are global. Therefore, identifying and quantifying the economic damage due to loss of ecosystem services from water reallocation is hard. Since the compensation to water users is linked to the underlying property rights, the users are rarely compensated; they have no well-defined ownership rights over water. De jure, the government is the custodian of water resources. Yet it can, in many cases, transfer irrigation water without bothering about the effects of such an act on the current users. In such situations, the resulting welfare loss is significant if the lost ecosystem service does not have any substitute and if the users of that ecosystem service belong to an economically vulnerable group. Water can become a non-renewable resource locally for short time frames due to reasons such as monsoon failure and climatic variations. Therefore, diverting water from a local source without due consideration for its future availability will impose social costs not only on the present generation but also on future generations.

The urban water utilities divert water from distant irrigation tanks and lakes to cities as water bodies around these cities have either dried up or disappeared due to encroachment for other activities (Seenivasan & Kanagavalli, 2014). In many situations, water from existing sources has become insufficient for the growing needs of ever-increasing urban populations (Kumar, 2014). Though the supply of freshwater to cities from their traditional sources is declining for a variety of reasons, the demand for water is increasing, leading to an ever-widening supply–demand gap. Hence, cities have to resort to diversion of water from far-away sources primarily meant for agricultural uses. In Tamil Nadu, diversion of irrigation water for urban use is becoming common. For example, over 180 million litres of water is being drawn every day from the Veeranam tank, a large irrigation tank with a catchment area of 25 km^2 in the state, to meet supplementary water requirements in the Chennai Metropolitan Area; the tank is 145 km south of Chennai (http://chennaimetrowater.gov.in). In addition, many water supply augmentation schemes currently being implemented in the Chennai Metropolitan Area have resulted in water withdrawal in bulk from neighbouring irrigation sources such as the Palar River, approximately 82 km south of Chennai, with a basin area of 18,300 km^2 and potentially supplying 4200 m^3 of water per year for agricultural, industrial and household uses in the basin area. This water transfer deprives the farmers of water from these sources. With the increasing urban population, water diversion from the neighbouring irrigation sources is likely to accelerate in the coming years, potentially at the cost of economic welfare for diverse water users.

In a water-scarce economy, diverting water from a low-value irrigation use to high-value urban uses results in efficiency gains and can produce beneficial effects in the aggregate. In a strict economic sense, the maximum benefits from water diversion can be achieved only if the marginal benefits of an extra unit of water allocated across all users are maximised. With careful and systematic planning, a significant quantity of water from the agriculture sector can be diverted to non-agricultural purposes without significant loss in agricultural production, productivity or profit (Cullet, Bhullar, & Koonan, 2015; Molle & Berkoff, 2006). For example, taking some water out of over-irrigated or waterlogged areas can reduce soil salinity and raise crop yields, increasing the net marginal benefits in the concerned sectors.

Table 1. Number of tanks and tank irrigated area in Tamil Nadu, India.

Year	Tanks: With command area of 40 ha or more	Tanks: With command area of less than 40 ha	Total number of tanks	Area irrigated by tanks (thousand ha): Gross area irrigated	Area irrigated by tanks (thousand ha): Net area irrigated
2001–02	7,529	31,837	39,366	607	537
2002–03	7,529	31,837	39,366	461	422
2003–04	7,529	31,837	39,366	419	385
2004–05	7,933	32,386	40,319	504	465
2005–06	7,933	32,386	40,319	641	575
2006–07	7,982	33,278	41,260	569	531
2007–08	7,982	33,278	41,260	546	506
2008–09	7,984	33,278	41,262	580	540
2009–10	7,984	33,278	41,262	534	503
2010–11	N/A	N/A	N/A	573	533
2011–12	N/A	N/A	N/A	567	528

Source: Season and Crop Report of Tamil Nadu, 2001–02 to 2011–12, Department of Economics and Statistics, Government of Tamil Nadu, Chennai.

Over the years, the gross irrigated area and net irrigated area under tank irrigation in Tamil Nadu have declined significantly (Narayanamoorthy, 2004; also see Table 1) for reasons such as farmers giving up agricultural activities, or agricultural land being used for non-agricultural purposes. As water previously used for cultivation is now available for other uses, efficiency can be gained if the government adopts a systematic approach to identify and divert such unutilized water for urban use.

Since drinking water gets top priority in India's National Water Policy (MoWR, 2012), governments find the traditional irrigation sources easy targets for diverting water for urban use. Nonetheless, an approach like the one currently being adopted by government agencies to divert irrigation water can certainly cause distortions in water supply among rural households that are already experiencing water scarcity in many parts of Tamil Nadu, which also results in economic losses from agricultural and allied activities such as duck rearing and animal husbandry. Moreover, many irrigation tanks are not being properly maintained, so water diversion from such tanks will be devastating for agriculture and allied activities. Since water scarcity is a key factor of distress among many Indian farmers at present (Reddy & Mishra, 2009), the command-and-control method of water transfer, with governments solely deciding how much water is to be transferred and from where without consulting the stakeholders, would make the condition of the farmers much worse.

Challenges in conservation and management of irrigation tanks

Tanks have been an important source of irrigation since ancient times in India, but empirical evidence suggests that over time the land area irrigated by the tanks has declined significantly (Palanisami, Meinzen-Dick, & Giordano, 2010). According to Narayanamoorthy and Suresh (2017), the area irrigated by tanks across India declined from 4.56 million ha in 1960–61 to 2.04 million ha in 2010–11, and the share of tank irrigation in the net irrigated area fell from 18.49% to about 3% during this period. Narayanamoorthy and Suresh also point out that encroachment of tanks for agricultural and urban use, collapse of traditional village institutions that managed irrigation tanks efficiently, and a shift in the preferences of the farmers from tank irrigation to tube-well irrigation are the reasons for the declining trend in tank irrigation.

In Tamil Nadu, the cultivable area irrigated by tanks fell from 38% of the gross cropped area in 1960–61 to 19.47% in 2000 (Narayanamoorthy, 2004). On the other hand, reports by the Department of Economics and Statistics of the Government of Tamil Nadu for the period 2001–02 to 2011–12 show that while the total number of tanks increased, the area irrigated by them declined (Table 1). This is because the farm ponds created by the farmers in their agricultural lands were also included in the estimation of the number of tanks by government officials (A. Narayanamoorthy, personal communication). However, anecdotal evidence suggests that not only has the area under tank irrigation shrunk but also the number of traditional irrigation tanks has declined, especially at the regional level. For example, of a sample of 1350 tanks in Thiruvallur and Kancheepuram Districts, 90 were abandoned and 210 were completely encroached upon (Lakshmi, 2013). Most of these water bodies served as drinking water sources as well.

The reasons identified by Narayanamoorthy (2007) for the decline in the number of tanks include the spread of tube-well technology, change in land-use patterns in the catchment area, heavy siltation of tanks due to negative externalities of upstream activities (e.g. over-grazing), encroachment of catchment areas, changing patterns of rainfall, poor governance, fractured village institutions, changes in land ownership, and conversion of agricultural land under the tank command to non-agricultural purposes. Specifically, tanks and lakes closer to cities experience irreversibility problems arising from discharge of sewage and industrial effluents, dumping of urban solid waste and encroachment by industrial and commercial establishments (Venkatachalam & Jayanthi, 2016).

To cope with increasing water scarcity, the Tamil Nadu government has taken steps to restore and rehabilitate the traditional irrigation tanks. For instance, 569 tanks governed by the state's public works department and 80 ex-*zamindari* tanks – tanks managed by rich landlords from the end of the eighteenth century till 1956 – were rehabilitated and modernized with assistance from the European Union, with a financial outlay of INR 1793.90 million (USD 1 = INR 64.07 as of 15 May 2017). These tanks serve a command area of 73,161 ha (Sakthivadivel, Gomathinayagam, & Shah, 2004). Similarly, the government rehabilitated various system and non-system tanks through the World Bank–assisted Irrigated Agriculture Modernization and Water Bodies Restoration and Management Project at the cost of INR 25,470 million (http://tniamwarmtnau.org/). Despite these measures, a major question that remains unanswered is: how can these rehabilitated tanks be managed on a sustainable basis?

A larger part of the recent literature on tank management claims that failure of the traditional institutions governing irrigation tanks led to their poor performance at present (Palanisami et al., 2010). How to fix institutions that can not only revive the tanks but also manage them on an intertemporal basis has become a serious policy question. On the other hand, the existing literature that emphasizes the importance of issues related to engineering and sociological aspects of tank management seems to downplay other aspects, such as hydrology of the tank systems, e.g. how runoff into the tank is affected by land-use patterns in the catchment and command areas, how increased groundwater exploitation in the upper catchment areas reduces inflows into the tank, etc. (see e.g. Kumar, Vedantam, Bassi, Puri, & Sivamohan, 2012; Lele, Patil, Badiger, Menon, & Kumar, 2011). This implies that institutional interventions to conserve and manage irrigation tanks need to address the above issues concerning tank hydrology rather than merely looking at the civil engineering works of development and management of tanks and their command area.

The institutions governing irrigation tanks determine efficiency, equity and sustainability in the use of tank water. However, identifying appropriate institutions and making them work in the field is a challenging task. A study by Sakthivadivel et al. (2004) showed that each of the best performing tanks has its own techno-institutional mechanisms (such as norms for desilting or repairing feeder canals and tanks) for water management, and the success of the traditional institutions depended largely on a decision-making process that addressed the concerns of all stakeholders; the final decisions reached through consensus were accepted by all as 'fair'. This study found that lack of cohesiveness, non-inclusiveness and faction-ridden institutions cause low performance of the tanks. Shah and Raju (2001) found in the context of Rajasthan tanks that lack of commonality of interests among key stakeholders – the command area farmers, tank-bed farmers, fishermen and other user groups – led to poor performance of rehabilitated tanks. Jegadeesan and Koiji (2011) attributed the deterioration of village tanks to disappearing caste hierarchy in rural areas, which once played a crucial role in efficiently managing those tanks. That is, the people belonging to lower castes in rural areas were responsible for managing irrigation and agriculture while the upper caste people owned the majority of the cultivable land; when the educational and economic status of the lower-caste people improved over a period of time, these people moved from agriculture to non-agricultural activities, and therefore tank management gradually deteriorated.

From the review of the existing literature, it emerges that the irrigation tanks are already experiencing management-related problems in the wake of increased demand for the limited tank resources, and hence water transfer from the tanks for urban use may not be feasible unless or until new institutional arrangements are put in place to strengthen collective action and improve the performance of the tanks.

Studies on water governance pertaining to irrigation tanks focus mainly on whether 'participatory irrigation management' can help improve their performance (Bhatt, 2013; Pant, 2008). For example, Pant (2008) argued that the modern water users' associations (WUAs) that are established by the governments through political process of empowerment of users can fill the vacuum created by the end of traditional village institutions, which successfully managed the irrigation tanks in the past. He prescribes creating such associations as an enabling environment for tank management. Similar prescriptions are reported in other studies as well (e.g. Mukherji et al., 2010). Since such studies selectively choose only a handful of successful cases, Meinzen-Dick (2007) found it doubtful whether the institutional panaceas manufactured from such results can be replicated and proven effective elsewhere. Moreover, a closer look at these institutional prescriptions reveals that they are based on a lack of understanding of how institutions evolve in the socio-ecological domain.

The evolutionary theory of institutions predicts that efficient institutions replace the inefficient ones irrespective of the nature of their outcomes (North, 1990). What is actually happening in the tank command area is what this theory predicts. A significant number of farmers wanted to minimize the transaction costs of surface irrigation, which was unreliable, and they moved from tank irrigation to bore-well irrigation. This is because the marginal benefits (as against the costs) of bore-well irrigation are relatively higher (whereas those of tank irrigation are lower), due to its reliability, and the transaction costs of bore-well irrigation are relatively lower (whereas those of tank irrigation are higher), although the initial investment in bore-well irrigation is high. Therefore, when the number of farmers available for collectively maintaining the tanks falls below a tipping point, the tank management system collapses. In this context, Kumar, Vedantam, et al. (2012) devised certain protocols for choosing tanks for rehabilitation so that the benefits of using the rehabilitated tanks are significantly higher than the costs of creating and sustaining the tank management institutions. The catchment area of the tank must yield sufficient water for inflow, and only tanks with catchments having low well density and a high 'command area to wetland area ratio' should be used for rehabilitation. They further suggested the use of a rainfall-runoff model to assess tank inflow (in case the catchment area underwent major land-use changes), and realistic estimation of water demand for irrigation in the command area (see also Kumar & Rao, 2017).

The discussion above suggests that governments merely creating and deploying WUAs in an institutional vacuum, without taking into account the economic and institutional dynamisms in both agriculture and rural areas, would result in social costs exceeding social benefits. Unlike traditional institutions, the roles of the WUAs created by the governments are not well defined. These WUAs suffer from the problems of elite capture and non-cooperation (Reddy & Reddy, 2005). Moreover, when an irrigation tank can provide large-scale, multiple ecosystem benefits, WUAs with a narrow irrigation management objective could trigger conflicts among various stakeholders using other ecosystem benefits. So, restoring collective action requires bringing all major stakeholders under one umbrella and deploying appropriate incentive-based institutional mechanisms that can favourably change the relative benefits and costs of overall tank management. In addition to government, communities and WUAs, a market-based institutional mechanism, namely PES, can play a significant role in implementing an effective governance system to manage tanks for multi-purpose use in general, and for water diversion for urban use in particular.

Payment for ecosystem services in the water sector

PES has been successfully implemented to manage certain critical environmental resources in general and water resources in particular around the world (Clements et al., 2010; Engel, Pagiola, & Wunder, 2008; Lipper, Sakuyama, Stringer, & Zilberman, 2009; Locatelli, Rojas, & Salinas, 2008; Pagiola, 2002; Wunder, 2008). In north-eastern France, for instance, Nestlé Waters, which sells Vittel, a mineral water brand, has been successfully compensating farmers for adopting best practices in dairy farming (measures such as abandoning agrochemicals, composting animal waste and reducing animal stocks) to improve the quality of raw water obtained from the catchment areas of the Vosges Mountains (Perrot-Maitre, 2006). In Bolivia, an in-kind compensation programme encourages upstream farmers to protect cloud forests and provide water services to an international donor agency interested in conservation and to the downstream farmers, who benefit from dry-season water flows (Asquith & Wunder, 2008). In the Central American region, Costa Rica implemented PES (*pago por servicios ambientales* in Spanish) to compensate land owners for implementing sustainable forest management plans so that an increase in the hydrological services such as groundwater recharge, along with benefits that include reduced greenhouse gases and increased biodiversity, could be accomplished (Pagiola, 2002, 2008). Mexico's payment for hydrological services (e.g. groundwater recharge), implemented in different segments of the forest areas, aims at conserving the forests to maintain the quantity and quality of water (Fisher, Kulindwa, Mwanyoka, Turner, & Burgess, 2010; Munoz-Pina, Guevara, Torres, & Brana, 2008). In some parts of Mexico, PES increased the participation of especially the poor in conservation activities, helping reduce poverty (Alix-Garcia, de Janvry, Sadoulet, & Torres, 2008).

In South Africa, the Working for Water programme, a version of PES, has been fruitfully implemented to restore mountain catchments to enhance streamflow to downstream water bodies. Clearing of invasive alien species in the catchments and riparian zones, which impaired streamflow, was taken up by certain municipalities, and the clearing cost was met through government subsidies, and payment by water utilities and water consumers (Turpie, Marais, & Blignaut, 2008). Water charges were imposed on water consumers for control of invasive alien species, planning and implementation of a catchment management programme, pollution control, demand management and water use control. Working for Water has been hailed as a most successful integrated land and water management programme, since paying for improved environmental services brought palpable benefits to different stakeholders (Turpie et al., 2008). In Uganda, PES played a critical role in protecting wetlands and enhancing their ecosystem services to support the livelihoods of a significant number of poor households (Nalukenge, Antle, & Stoorvogel, 2008). In China, two nationwide programmes – the Sloping Land Conversion Programme and the Forest Ecological Services Compensation Fund – have incorporated payment for water services to protect major river basins against siltation and floods (Huang, Upadhyaya, Jindal, & Kerr, 2009). Programmes that use payment for water services are being implemented in various developing and industrialized countries (Schomers & Matzdorf, 2013).

India is also planning to introduce market-based instruments in a significant way in select areas of environmental management (MoEF, 2006). There is a scope for adopting PES to protect and allocate some of India's critical environmental resources, including water (Behera, Mishra, & Nayak, 2011). Indeed, market-based instruments are already in operation in different parts of India. For example, an arrangement to share benefits (an in-kind payment) among villagers who participated in protecting upstream water sources from siltation in the Sukhomajri watershed region in Northern India is a classic example of how PES-like programmes can work efficiently in the Indian context (Huang et al., 2009; Kerr, 2002). Similarly, in Maharashtra, unused water from reservoirs of incomplete irrigation projects is being successfully transported, with the help of private operators and through networked pipes (mostly underground), to supply water to the farmers. There are around 100,000 such schemes successfully operating in Maharashtra (Ackermann, 2013).

In Tamil Nadu, water users use market-based instruments to manage irrigation tanks and to allocate irrigation services in an efficient and equitable manner. For example, the Rettaikulam tank, in Thirunelveli District of Tamil Nadu, exemplifies an efficiently functioning water tax system (Sakthivadivel et al., 2004). This example shows that the user groups managing the tanks levy *ayacut vari* (a tax based on landholding) and use the tax revenue to meet the financial requirements for maintaining the tanks. The tax rate per acre is determined by the user groups, based on the extent of repair and maintenance work to be done and the funds required for such work. The tax is collected from water users in the command area.

Some empirical studies demonstrate that farmers in certain river basins in South India are willing to trade their excess water to other farmers, provided they are adequately compensated (Biswas, 2015; Venkatachalam & Narayanamoorthy, 2012). A similar kind of trade can take place between farmers and high-value users of water, as the compensation in this case may be much higher than that of water trade among farmers themselves. Such practices are based on the *user-pays* principle, a fundamental principle of market-based instruments, which provides financial self-sufficiency and incentives for the user groups to sustain conservation efforts collectively. Since the user groups act as utility-maximizing individuals, introducing PES within an appropriate institutional set-up (Asquith & Wunder, 2008) generates adequate economic incentives for conservation of critical resources as well as further scaling-up. Experience with PES schemes around the world suggests that by implementing PES effectively, future water transfer from irrigation tanks to high-value urban use could generate a win-win outcome for water managers, farmers, municipalities and urban dwellers.

Conditions for implementing water PES

Despite many advantages, PES schemes face many implementation challenges (Behera et al., 2011). The very fact that PES has not yet percolated deeply in the environmental domain suggests that many details need to be worked out during implementation. It may work better under certain conditions, such as in conducive ecological settings, with improved nature and quantity of services and their continuous provision, well-defined and secure property rights, appropriate legal framework, and trust among the parties involved (Behera et al., 2011). Broader guidelines for success have emerged from several PES schemes implemented in other parts of the world, such as Vietnam, Indonesia, China and Mexico (Adhikari, 2009; Alix-Garcia et al., 2008; Asquith & Wunder, 2008; Huang et al., 2009; Pagiola, 2002).

The prerequisites for water PES to work efficiently are: water accounting in physical units wherever possible (Perry, 2013); economic valuation of water and its ecosystem services; and institutional arrangements for facilitating voluntary trade of water services. Before implementing water PES for tanks, accounting for water resources – in physical as well as in economic terms – will have to be systematically done. In the case of system tanks (fed by a river system), river-basin-level water accounting will be more appropriate, as the hydrological changes taking place in the entire river basin have profound impacts on the water dynamics of the system tanks. In the case of physical accounting for water, both the 'stock' and the 'flow' components of water resources get into the accounting matrices. While the stock account considers the stock of water resources in the opening and closing periods, the flow account captures the 'additions' that increase the level of stock (total precipitation, inflow from tributaries, return flow from use sectors, and import from other basins) and 'subtractions' that reduce the stock (evaporation, evapotranspiration, non-recoverable deep percolation, amount of water consumed for various economic and non-economic entities, water exported to other basins, and water drained into the ocean). The net change (surplus or deficit) in the stock of the water in physical terms between accounting periods can be arrived at from the stock account. The flow account, on the other hand, depicts what happens to the available water in the basin, how much water is used for productive purposes, where the unproductive water goes and how much surplus water is available for transfer. Though 'physical accounts' are a necessary condition for water allocation decisions, 'economic accounts' fulfil the sufficient condition since allocation decisions will have to be based largely on the economic value of scarce water.

Economic accounts try to place a monetary value not only on the net change in the stock but also on different levels of services and benefits from water. It helps in assessing the marginal efficiency of water used in a particular sector as well as the marginal gains and losses of allocating water from a less productive to a more productive use or from a less efficient to a more efficient use (Balooni & Venkatachalam, 2016). The monetary value of water can be estimated by using non-market valuation techniques. Alternatively, such values can be generated by using a *benefit transfer method* (Plummer, 2009) – a method by which economic values of ecosystem services are derived from previous economic valuation studies – as the economic values for water-related ecosystem services have been already estimated by a significant number of non-market valuation studies in the Indian context (Kumar, Vedantam, et al., 2012; Mukherjee & Kumar, 2012). For non-system tanks, water accounting at a tank level will yield fruitful results.

Institutional arrangements for an efficient PES scheme and its sustainability depend largely on how different institutions – formal and informal, external and internal, modern and traditional – collaborate to enhance trade in environmental services (Greiber, 2009; Vatn, 2009). However, an unmet challenge is to identify an appropriate combination of different institutions that can produce economically efficient outcomes. Path dependency guides us when our decisions are governed by bounded rationality, i.e. efficient decisions are usually constrained by our lack of ability to collect and process relevant information, which in turn is influenced by our limited cognitive abilities. Drawing lessons from experience, an outline of the additional institutional arrangements required for PES schemes is laid down here.

First of all, identifying the sellers and buyers of water and assigning property rights over water in the irrigation tanks are prerequisites for effective implementation of PES schemes. In the case of tank water, the municipalities are the buyers, and the farmers are the sellers. If the farmers have to change their land-use patterns in various tank commands to save water for urban use, then WUAs can be assigned the property rights over the tank, and thus they become the owners of the water rights. The WUAs can in turn assign water rights to individual farmers. The farmers can be incentivized by the WUAs to use water-efficient crops and efficient irrigation technologies so that they can transfer the saved water to the WUAs (for a price), which in turn can sell the rights to the urban utility. Though WUAs have been created in different states, the underlying incentive/disincentive structure for their efficient functioning is not well defined. Water PES can make WUAs work more efficiently without additional transaction costs, since water PES would be built on the already existing WUAs. As the resource to be managed is relatively small, the WUAs have comparative advantages in monitoring and regulating water use (Fisher et al., 2010), curtailing 'free-riders'. If WUAs do not exist, or if the irrigation tanks belong to the *panchayat*, (i.e. the local government elected by the people to manage public goods such as irrigation canals and grazing lands, and deliver services such as water supply), then the property rights over the tank water could be assigned to the panchayat, and therefore the panchayat will have the selling rights; the households should unanimously decide on how to use the sales revenue through negotiations (Turpie et al., 2008). If the ecosystem services are sizeable, then the panchayats may be assigned property rights, and the WUAs/farmer groups can be part of the larger stakeholders making decisions.

Water PES works well if: (a) the buyers use the water for higher-value uses than the sellers; (b) the opportunity cost of providing water services is less than or equal to the amount paid to the service providers (Kosoy, Martinez-Tuna, Muradian, & Martinez-Alier, 2007) – in other words, the scheme can work smoothly only when willingness to pay is greater than or equal to willingness to accept compensation; and (c) transaction costs are negligible (Tacconi, 2012). In the Indian context, Venkatachalam (2015) has empirically demonstrated that urban consumers are already spending a significant part of their income on water and are willing to pay more for improved water supply.

PES can generate additional income for local farmers and can contribute to alleviating poverty (Tang, Shi, Nan, & Xu, 2012). For example, it is largely the poor who depend on the irrigation tanks for their livelihoods (Balasubramanian & Selvaraj, 2003; Narayanamoorthy, 2007), and the share of the economic benefits from ecosystem services from the tanks in the total income of the poor households is greater than that of the rich. So, water PES can generate relatively larger benefits for poor people. If the minimum number of stakeholders is not available for maintaining the tanks, then tank management becomes problematic because the higher marginal cost of maintenance will have to be borne by a smaller number of water users. On the other hand, some rich farmers may switch from tank water to tubewells, which would make more water available to the remaining farmers who happen to be poor. Poor farmers will have an incentive to efficiently manage the tanks if their expected benefits from their collective management efforts are substantial (Kumar, Bassi, Kishan, Chattopadhyay, & Ganguly, 2016). Hence, PES can not only allocate water more efficiently but can also contribute to local poverty reduction.

Conclusions

When agricultural land is acquired for non-agricultural purposes, the water which was used for irrigation in that land is lost. When water is withdrawn for urban use, the issues involved are not adequately addressed in the water development literature, especially in the Indian context. The wider supply–demand gap in urban water supply forces governments to withdraw water from distant irrigation sources, as is evident in the case of Tamil Nadu in India. In most cases, the irrigation sources happen to be small water bodies like irrigation tanks and lakes, which provide valuable ecosystem services to the local people.

Withdrawal of water from water bodies that are traditionally used for irrigation is done by government agencies, and as a result, the farmers depending on those water sources become the net losers. The trade-off involved in transferring water from agriculture to urban use can be reduced and a win-win situation can be created if innovative and efficient institutions are introduced for water transfer. This study described how a market-based approach, that is, water PES, can be effectively employed to make water reallocation beneficial to both the farmers and the urban consumers. Though water PES is relatively more efficient than the current command-and-control method of water transfer, the effectiveness of operationalizing the concept depends largely on institutional arrangements that appropriately combine the role of market, government, non-governmental organizations and user groups (Behera et al., 2011).

This study emphasizes that either the WUAs or the panchayat system managing the irrigation systems at the local level should own the water rights, so that the benefits of managing and transferring water from the tanks are fairly distributed among all those involved in tank management. However, proper water accounting in both physical and economic terms is key to making water trading efficient. A word of caution, though: there are no standard panaceas, and all negative externalities cannot be internalized with a typical model (Ostrom, Janssen, & Anderies, 2007). The effectiveness of PES depends mainly on how complexities related to uncertainty, distributional issues, social harmony and power relations, prevailing especially at the regional and local levels, are taken into account while designing such schemes (Muradian, Corbera, Pascual, Kosoy, & May, 2010).

To conclude, employment of PES at the grass-roots level to cater to the demand of the bourgeoning population in urban areas has the potential to produce efficient outcomes, as this study has shown in the context of irrigation tanks in the state of Tamil Nadu. However, there is a need to tread cautiously, as this institutional model needs further investigation.

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No potential conflict of interest was reported by the authors.

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