Closing the water cycle: A comparison of the institutional settings for wastewater reuse in 4 countries with a focus on the agricultural sector

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Abstract: In the light of increasing water scarcity and pollution, wastewater reuse is considered an alternative to improve the efficiency of water consumption. However, if reuse occurs within the informal arena, it represents risks for health and environment. Formalization, leading to planned and controlled reuse reduces these risks. To gain insight in the process of formalization, this paper discusses the institutional settings for reuse in agriculture in four countries along a trajectory of formalization (Israel, South Africa, India and Bolivia). Identified factors determining formalization include: water scarcity, public pollution prevention awareness, an effective policy and regulatory framework, and a capital-intensive water use linked to profitable markets.

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Keywords: wastewater reuse; agriculture; institutional arrangements; Israel; South Africa; Bolivia; India

1. Introduction

Water has become more scarce almost everywhere, especially in semi-arid and arid regions. As water scarcity grows, so does the competition among water users. Consequently, in many regions, wastewater has become too valuable to be wasted (Mara, 2004). At the other hand due to the rapid urbanization around the world also more waste water is generated.

With the water scarcity and competition at the one hand and the increased generation of wastewater at the other hand, wastewater reuse [1] has grown in importance and it is now widely considered as a measure to reduce pressure on water resources (Friedler, 2001; Toze, 2006). In the agricultural sector, wastewater is in some cases even regarded as a low-cost alternative to conventional irrigation water (Scott et al., 2004).

[1] The terms 'water reuse', 'wastewater reuse' or 'wastewater use' are used interchangeably.

In developing countries, however, wastewater reuse for agriculture usually occurs within the informal arena, meaning that untreated wastewater (or diluted wastewater) is used for irrigation. This results from the lack of proper collection, treatment and disposal of wastewater (Drechsel and Evans, 2010). This reuse represents risks for the health of the people (farmers and consumers) and the environment (Raschid-Sally et al., 2005). In contrast, more developed countries have recognized these risks and have developed formal institutional arrangements for wastewater reuse. Such formalization implies planned and controlled use of treated wastewater. This helps to reduce the risks and exploits this additional water source. Already in 2001, Asano (2001) stated that wastewater reuse as a multi-disciplined and central element of water resources development and management, can help to close the loop between water supply and wastewater disposal.

This paper discusses the institutional settings for wastewater reuse in agriculture in four different countries: Israel, South Africa, India and Bolivia. Each of these countries represents a step along a trajectory of formalization of wastewater reuse, i.e. from informal towards formal use of wastewater. The purpose of this comparative analysis is to gain insight in the process of formalization of wastewater reuse by identifying key drivers, constraints and institutional arrangements influencing this process. Israel is the world leader in water reuse; it has established policies and regulations for water reuse since the mid-1950s; currently it uses about 70% of treated wastewater in agriculture (USEPA, 2012). Similarly, in South Africa the reuse of wastewater has been recognized since the 1970s as a vital strategy to ensure that more water resources remain available for the range of uses. Treated wastewater reuse is growing in importance and the regulatory framework has been further developed and enforced (Saldías et al., 2015a). In Bolivia, wastewater reuse is informal and unregulated, which presents high risks for the people. It results from the pollution of water sources due to the lack of wastewater management (incl. collection, treatment and disposal) and it is a main concern for environmental sustainability in the country (Marka, n/d). Recently Bolivia has formally recognized the importance of wastewater as alternative water source to cope with increasing pressure on water resources. This can be regarded as a milestone in water resources management for the country. India finally has also introduced water reuse in its water policy, but the focus is not on agriculture (Saldías et al., 2015b). As in the case of Bolivia, waste water reuse occurs and thrives in an informal way, with high risks for the population as well as for the environment.

The analysis of the institutional settings applies the Institutional Decomposition Analysis (IDA) framework proposed by Saleth (2004), which looks at three components of water institutions, namely, water law, water policy and water administration/organization. This framework is outlined in section two. The data for the institutional analysis comes from peer-reviewed articles, official reports, official websites, books and grey literature and was complemented with semi-structured interviews with local informants in Bolivia, India and South Africa collected in different periods between 2013 and 2014.

2. Theoretical approach

Already in 1984 Ingram et al. (1984) recognized that institutional problems in water resources development are more prominent and complex than technical or economic problems The importance of institutional analysis for the water sector lies in the need to understand how institutional factors affect water resources planning, and how to

manage the opportunities and barriers presented by such factors (Ingram et al., 1984). Saleth (2004) distinguishes two parts in his Institutional Decomposition Analysis (IDA) framework : the institutional environment, determined by e.g., historical, socio-economic, political and physical conditions, and the institutional structure of water institutions, composed of water law, water policy and water administration/organization. Similarly, Ostrom (2005) highlights, in her Institutional Analysis and Development (IAD) framework, the role of exogenous variables such as biophysical conditions, community attributes and rules-in-use. While the institutional environment describes the external factors influencing water institutions, the components of the institutional structure are central for water governance. The water law component consists of e.g., inter-governmental responsibility, water rights and accountability; whereas the water policy component includes policies, aspects of users' participation and privatization initiatives. The organizational component finally consists of the organizational framework, financing and management responsibilities, regulatory arrangements, and conflict resolution mechanisms (Saleth, 2004).

Based on the three components of the institutional structure, this paper analyzes the formalization of wastewater reuse for agriculture taking into consideration the external factors that might influence the process.

3. Degree of formalization of wastewater reuse

The extended use of wastewater in irrigation in countries such as Israel, South Africa, Bolivia and India is mostly related to water scarcity. Essentially, wastewater is used (treated or untreated) because there is no alternative water source. Next to the notion of water scarcity, there are concerns about water pollution. Both are linked since water pollution increases water scarcity. In effect, water pollution, due to discharges of untreated wastewater in rivers and lakes, is a major problem in most countries around the world (Asano, 2001).

Israel is one of the most water scarce countries in the world. Aware of its limitations in terms of water resources availability to meet water demand, Israel had realized the potential of wastewater early, particularly for the irrigation sector. But at the same time, pollution of valuable water resources and outbreaks of epidemics raised awareness of the risks of wastewater and the need to establish appropriate sewage systems and treatment facilities (Kislev, 2011; Tal, 2010). Water conservation and pollution prevention were identified as important components of water resources management in the country, which pushed forward wastewater reuse for agricultural irrigation (Tal, 2010). These aspects were accompanied with an effective campaign to raise people's awareness regarding water scarcity and water conservation issues (OECD, 2011).

Also South Africa is considered as a water scarce country. The country faces difficulties to supply safe water to its population. The department of water affairs (DWA, 2013) identified security of supply, environmental degradation and water pollution and inefficient use of water as major challenges. As a response to the water crisis in South Africa, water reuse has been introduced in the water policy as one of the key strategies to reduce pressure on water resources. Although reuse is growing in importance; it is still not fully implemented across the country. There are few examples where wastewater is reused in agriculture, such as the case of a small group of farmers in Durbanville in Western Cape Province; a private initiative where farmers use treated wastewater from a municipal treatment plant. This experience, however, has been perceived as positive and serves as example to be replicated elsewhere.

In most parts of Bolivia and India, the use of wastewater is mostly a consequence of water scarcity and pollution of water sources [see e.g., Marka, n/d; Van Rooijen et al., 2010]. In both cases, water scarcity is largely affected by deterioration of water sources, which compels farmers to use polluted water for irrigation. Degradation of water sources is linked to inadequate wastewater management, including lack of infrastructure and institutional support. Bolivia has recently incorporated the concept of water reuse in its water policy framework (VRHR, 2013), which responds to the need of improving water quality in rivers and lakes, whereas the ultimate objective is to increase overall water availability. This was triggered by the realization that wastewater is a potential water source – to cope with increasing water scarcity – and needs to be exploited safely. Also in India water degradation is a main concern (Rao and Mamatha, 2004). Considering the limited water resources for such large population, more attention has been given to water quality issues. Water recycling and reuse have recently been introduced in the water policy framework (Saldías et al., 2015b). Again, the rationale behind this is to reduce the pressure on water resources. In practice however both in Bolivia and India the operational framework for a formal reuse is still lacking.

4. Current institutional settings for waste water reuse

How wastewater is included in water resources management varies in the countries of analysis. In Israel, for instance, water sources are public property and are controlled by the state. Water resources management is centralized in one Water Authority that overlooks all aspects including water allocation (Kislev, 2011). Management of wastewater is an integral component of the overall water resources planning and development. Wastewater is recognized as a main source for agricultural irrigation in the national water policy (Water Authority, 2011) and appropriate measures are installed to realize this. The state has implemented large water reuse systems, which provide treated wastewater to the agricultural sector (OECD, 2010). The water and sanitation sector is responsible for wastewater treatment; the health sector looks after quality issues; whereas the agricultural sector uses the treated wastewater. Even if wastewater would not be reused in agriculture, it undergoes treatment in order to protect the environment as well as other water sources. Protection of water quality is essential for sustainability of water resources in Israel (Ben-Gal, 2010). These arrangements are based on transparency and accountability.

In the same way, Also in South Africa water resources are public property, which dissolves the concepts of private water ownership and water rights. Instead, rights of access to water exist through fixed-period water use licenses. Furthermore, water governance is based on decentralization with catchment management agencies as managing authorities (Naidoo and Constantinides, 2000). In contrast to the traditional approach, which focused primarily on supply management; the new water policy seeks for a smart water management approach. The latter includes water conservation and demand management as drivers for efficient use of water, effective and sustainable use of water, local resource optimization, water systems management and control, desalination, and water reuse (DWA, 2012). Through different strategies, the South African water policy tries to address the growing competition for water. Moreover, water pollution and resource quality are priorities due to their implications for society, the economy and the environment (DWA, 2012). Although water reuse has been formally introduced in the water policy, through a specific General Authorization [General Authorizations in terms of Section 39 of the National Water Act (RSA, 2013)],

which serves as nationwide applicable legal instrument for water reuse, the development of state projects for water reuse is almost inexistent. The initiatives for water reuse in agriculture come mainly from the private sector. They primarily evolve on an *ad hoc* basis. Unfortunately, the public sector still lacks people's trust regarding the provision of water services, especially for wastewater management. In effect, as in many other developing countries and countries in transition, South Africa still struggles to deliver optimal services to the people, creating a general dissatisfaction. This is attested by widespread public protests against the quality of public service delivery (Mpehle, 2012).

In Bolivia, water resources management is mainly communal, place-based, and adjustable in time and space (Perreault, 2008). Water for irrigation is basically managed by the users' community based on customary laws. This denotes the lack of formal legal framework for water management in the country (Perreault, 2005). The state's participation in water resources planning and development, for the agricultural sector, is limited to the development of infrastructure, i.e., construction of storage, conveyance and distribution infrastructure. Management of water in irrigation systems is done entirely by the users. Wastewater use remains highly informal, resulting from pollution of water sources [see Huibers et al., 2004)]. With the introduction of water reuse in the water policy framework, Bolivia aims to reduce pressure on water resources and address the concerns on water pollution. In effect, the National Development Plan 2006 (Ministry of Development Planning, Plurinational State of Bolivia, 2006) identifies the low and inadequate coverage of drinking water and sanitation, the legal uncertainty and the pollution, including water pollution as main problems in the sanitation sector. Nevertheless, the Bolivian government has made the goal to increase the number of people with access to safe drinking water and sanitation under the framework of 'vivir bien' (to live well) explicit. This is in compliance with the State Constitution in Art.16 and Art.20, which establishes the right to water and to universal and equitable access to basic services of drinking water and sanitation (Plurinational State of Bolivia, 2009). This is also reflected in both the National Development Plan 2006 (Ministry of Development Planning, Plurinational State of Bolivia, 2006) and the Sectorial Development Plan of Basic Sanitation 2011-2015 (Ministry of Environment and Water, Plurinational State of Bolivia, 2011). The development of formal water reuse projects, however, is still in infancy. It is not clear how this will be incorporated in the overall water management. However, considering the risks of wastewater, it requires careful planning, control and monitoring, which are essential for the sustainability of such endeavor. This calls for more involvement of the state in water management.

In India, each state translates the national water policy into state water policies. States are responsible for the planning, implementation, funding and management of water resources development (EBTC, 2011). The national water policy adopted an Integrated Water Resources Management approach for multi-sectoral planning according to hydrological units, and the Participatory Irrigation Management approach [see Ministry of Water Resources Republic of India, 2002]. The latter aimed for sustainability of irrigation systems through water users' participation. Water quality is an important component of the national water policy, which recognizes the need to eliminate pollution of water bodies (Ministry of Water Resources Republic of India, 2002). A key element of this policy is the polluter pays principle, and it proposes the development of a third-party system for periodic inspection and punitive actions to be taken against polluters. This principle, however, is not enforced on the ground (Chigurupati and Manikonda, 2007). Furthermore, although the concept of wastewater

reuse is acknowledged in the water policy (version 2002 and 2012), encouraging reuse of grey water and giving incentives to industries for recovery of industrial pollutants [see Ministry of Water Resources, Republic of India, 2002; 2012], it does not address agricultural irrigation. Therefore, current use of wastewater in agricultural irrigation is done primarily indirectly and unplanned. Again, this is due to the lack of adequate infrastructure to collect and properly treat wastewater. The practice represents health risks for the farmers and consumers of raw crops.

5. Discussion

5.1 The need for changes in the institutional settings

Wastewater is a transversal component for various subsectors of the water sector. As sub-product of urban and industrial users, wastewater is directly related to the water and sanitation sector. Untreated wastewater represents potential risks for the environmental sector. It degrades water sources affecting life in aquatic systems; it can also affect the soils negatively, as it may add components which reduce the soils' adequacy for agricultural production. Furthermore, untreated wastewater is a potential risk for public health because it contains pathogens that cause illness. On the other hand, wastewater is an alternative source of irrigation water. Consequently, several subsectors should be connected for wastewater management. Bazza (2003) argues that the large number of institutions involved and the complexity of wastewater production and reuse requires the establishment of sound institutional frameworks to improve coordination among agencies.

Although worldwide wastewater management can still be improved considerably, the general perception regarding treated wastewater reuse is positive. Especially in water scarce regions it is considered as an important potential additional water source. Some countries already realized that wastewater management has to be included in the broader water management framework. This is for instance the case in the four countries of analysis and especially Israel is a good example of how this can be put in practice. But other countries such as Tunisia and Jordan also have policies in place that address wastewater treatment and reuse through a range of instruments. Their policymakers consider the use of treated wastewater to be an essential aspect of strategic water and wastewater planning and management (Qadir et al., 2010a). Likewise South Africa recognizes the potential of wastewater. In some parts of the country, such as in Western Cape Province, institutional changes were supported to facilitate wastewater reuse. In other countries like Bolivia or India, notwithstanding the inclusion in the water policy comprehensive wastewater treatment programs are still lacking. This is illustrated by of the high degree of water pollution and the fact that still large number of people who lack access to appropriate sanitation. The central problem still is the lack of governmental support to engage in long lasting sanitation programs [see Ghneim, 2010]. Bazza (2003) argues that institutional arrangements in developing countries are often too complex and that conflicts exist among concerned agencies ranging from overlapping of responsibilities to the absence of well-defined mandates. The general rule is that each party wants to benefit without taking responsibility. The role of the international community in water and sanitation programs, including wastewater reuse, is central for the engagement of countries in various activities. The more the issues of water and sanitation are discussed, the more

policymakers feel pressure to introduce changes in the institutional settings. The Bolivian case illustrates this aspect.

The main advantage of formalizing the use of wastewater for agricultural irrigation is in terms of additional safe water for the sector. Next, there is the public health and environmental protection aspect. Formalization allows for planning and control. In turn, this guarantees protection for the people as well as for the environment. The high risks associated with untreated wastewater give little room for uncontrolled practices. In general, the establishment of a coordinating committee, consisting of representatives of multiple agencies, to formulate clear rules and mandates to ensure development and planning of wastewater reuse is fundamental (Bazza, 2003). The formalization of wastewater reuse in Israel was an example of this. There it was shown how the agricultural can benefit from water supply while releasing fresh water for other sectors. In this way, pressure on water resources is reduced. An important component of the formalization of wastewater reuse in Israel was the strong role of the state in water resources planning and management, through the Water Authority. Next to this there was the strong commitment of the state to transform the water resources paradigm by introducing alternative water sources. In contrast, in South Africa, formal wastewater reuse is mainly introduced on an *ad hoc* basis. Although wastewater reuse is part of the water policy framework, it is not central to water resources planning and management. Similarly, in countries like India or Bolivia, water reuse remains at large an isolated measure.

The main constraint in the development of formal structures for wastewater reuse is the lack of political will. It seems that countries are unwilling to incorporate formal wastewater reuse unless there is a feeling of severe water scarcity. Similarly to what happens in the water and sanitation sector, the level of risk awareness of untreated wastewater helps to increase political will, but it is not enough to take actions. It might be that other elements are necessary to push governments to address these issues, for instance, a perceived water crisis. This can catalyze change and facilitate formalization of wastewater reuse.

Another factor that constrains formal structures for wastewater reuse is related to public budgets. Wastewater reuse is far from being a priority in most countries. On the other hand, the costs associated with wastewater collection and treatment in conventional centralized systems remain high (Maurer et al., 2005), which might withhold countries from effectively setting up and running wastewater treatment systems. Bazza (2003) argues that high costs of treatment and management of wastewater reuse is one of the major limitations facing weak economies in most countries. Furthermore, other constraining issues include: unclear policies, institutional conflicts, unclear mandates, and lack of regulatory frameworks for implementing wastewater reuse (Bazza, 2003). In effect, as Angelakis et al. (1999) suggest, regulations for wastewater reuse are crucial to protect public health, increase water availability, prevent water pollution and enhance water resources and nature conservation policies.

Although a cost-benefit analysis is not presented here, there is enough evidence that supports the socio-economic benefits of moving from informal to formal structures, mostly expressed in terms of having additional water, safe environments (air, land and water) and healthy people. Informal practices of untreated wastewater are a burden for public budgets. Qadir et al. (2010a) draw attention to the long-term health effects of the increasing use of wastewater on public budgets, either directly in the form of public expenditures to protect health and welfare, or indirectly in declining productivity

of land irrigated with untreated wastewater. Certainly, these are issues to consider for countries that maintain the informal practices of wastewater reuse.

5.2 Formalization and water rights

In informal wastewater reuse systems, water rights might exist or not, depending on the local practices for water management. In Bolivia, for instance, customary laws are applicable to irrigation water. They imply that traditional uses of water are recognized by the state. When rivers become polluted, as is the case in most informal systems for wastewater use, the traditional uses of water remain valid. In some cases, however, because of the poor water quality, water rights might be dissolved, but in times of scarcity they might be restored. In other countries like India, water rights for irrigation water are associated to land tenancy. River water is normally distributed among the farmers within the command area. Farmers will receive water despite it being polluted.

In formal wastewater reuse systems, water rights are to be created based on a country's exiting laws. In Israel, for instance, treated wastewater is exchanged for fresh water. Treated wastewater is allocated to farmers in a way similar to fresh water. In Bolivia, which is engaging in the first formal wastewater reuse project, water rights are still not determined for the users of the irrigation system. This is because defining water rights is normally a sensitive issue. One aspect to consider, however, is that water rights for treated wastewater should be regarded as rights to access instead of property rights. This is because the quality of treated wastewater can fluctuate and is variable in time. Therefore it requires that authorities and operators can decide upon the use and application of treated wastewater, which might be difficult if property rights were in place.

5.3 Profitability of agricultural markets

Wastewater is used in agricultural irrigation because there is demand for it. But to expand the use of treated wastewater in agricultural irrigation requires that this option is cost-effective compared to other alternatives. In effect, current water shortages and the costs associated with freshwater have made wastewater reuse a viable option (Fatta and Kythreotou, 2005). Furthermore, Fatta and Kythreotou (2005) suggest that wastewater reuse, although costly at first, is quite cost-effective in the long run. But this might be applicable mostly to water scarce regions, where wastewater might be the only alternative. In Israel for instance, treated wastewater is more cost-effective than desalination of seawater, therefore it has been chosen to substitute fresh water in the agricultural sector. Another example is the group of farmers in the hinterland of Cape Town, in South Africa, who decided to reuse treated wastewater because other water alternatives became too expensive [see Saldías et al., 2015a]. In both cases, however, agriculture is linked to profitable markets. Consequently, implementation of treated wastewater irrigation systems might be justifiable when agricultural production is linked to profitable markets. Asano (2001) **Error! Reference source not found.** suggests that wastewater reuse is usually too expensive for traditional agricultural irrigation in most countries; only landscape irrigation and other urban application can afford to pay for the water.

In other cases, where subsistence agriculture is practiced, planned wastewater reuse systems might be too expensive for the users, if they are to share the costs. The evidence from the group of farmers in South Africa suggests that the most expensive part of the reuse system is the conveyance infrastructure (pipes, pump stations,

meters, etc.). Asano (2001) has acknowledged this fact and indicates that conveyance and distribution systems represent the principal cost of most wastewater reuse projects around the world. In countries like Israel, however, wastewater reuse systems are still largely subsidized, which decreases the burden on farmers [see Kislev, 2011]. Subsidies for wastewater reuse systems might be a suitable alternative in developing countries, at least in the initial phase. In any case, costs associated to wastewater treatment are not considered, since they are usually already included in the national budgets as pollution control costs (Asano, 2001). As a final point, planned wastewater reuse irrigation systems should not be considered as low-cost water supply, unless wastewater treatment facilities are conveniently located near large agricultural areas, and when no additional treatment is required beyond the existing wastewater treatment facilities from which treated wastewater is delivered (Asano, 2001).

6. Conclusions

Overall, agricultural wastewater reuse is rather complex, because it falls under various domains of water management. In turn, this impedes that institutions take responsibility for the practice. Therefore, a key element for the formalization of wastewater reuse is clarity in the institutional arrangements. It is fundamental that the various sub-sectors of water managements have clear mandates and responsibilities for wastewater management and reuse. The benefits of having a regulatory framework guiding the practice, which includes water quality standards, treatment levels and processes, crop restrictions, categories of types of uses, irrigation methods, etc., provides certainty to public agencies and the final users.

Next, formalization of wastewater reuse should be enforced across countries. This is because the informal practice of wastewater use represents high risks for public health and the environment. But also because wastewater reuse is additional water which should be reintroduced in overall water management. As the evidence suggests, in most countries a recognized level of water scarcity is a more powerful driver for the formalization of water reuse, than water pollution. However, public awareness with respect to water pollution is necessary to trigger changes in institutional arrangements and ultimately generate behavioral change. In general, this aspect lags behind in most societies in developing countries, as they fail at generating such changes. Much of this might be related to the overall low levels of education and to tolerance to current conditions, which need to be changed.

Wastewater offers a window of opportunities for water resources management, particularly for the agricultural sector. Countries can benefit enormously from this, but formalization of water reuse is required because it will guarantee that people enjoy the benefits while they are protected from the risks of wastewater reuse.

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