WATER AND SANITATION PROGRAM: **FIELD NOTE**

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Supporting Poor-Inclusive Water and Sanitation Sector Reform

Wastewater Reuse for Irrigation in Bolivia

Production, Commercialization and Consumption of Wastewater Irrigated Crops in the Altiplano Region

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INTRODUCTION

The informal use of untreated wastewater for agricultural irrigation, either through direct application or diluted in natural waterways, is standard practice in Bolivia. At least 5,000 hectares of land are irrigated with wastewater, 86 percent in the departments of La Paz and Cochabamba, with the majority in the vicinity of metropolitan areas.[1]

The practice of water reuse in Bolivia shows that in a scenario of water scarcity for irrigation, wastewater is recognized as a source of water for agriculture. This bodes well for the sustainability of agriculture in the region. In the absence of controls, however, the practice of using wastewater for irrigation raises concern, given the possible impacts on the health of farmers, livestock, and consumers.

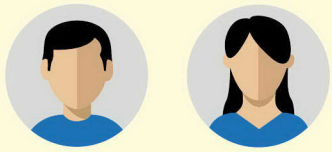
Urban expansion has significantly increased domestic and industrial water demand in Bolivia, and water originally intended for downstream irrigation is often appropriated. Wastewater is reused to compensate for the ensuing lack of uncontaminated water resources. In some cases, the concentration of wastewater flows that accompany urban growth not only meets the preexisting demand for irrigation but also drives an increase in agricultural activity.

The hectares under irrigation are mostly in areas of high water stress, both on the altiplano (high plains) and in the high valleys, as well as in the vicinity of metropolitan areas, particularly in the watersheds of the Rocha River in Cochabamba and the La Paz River.

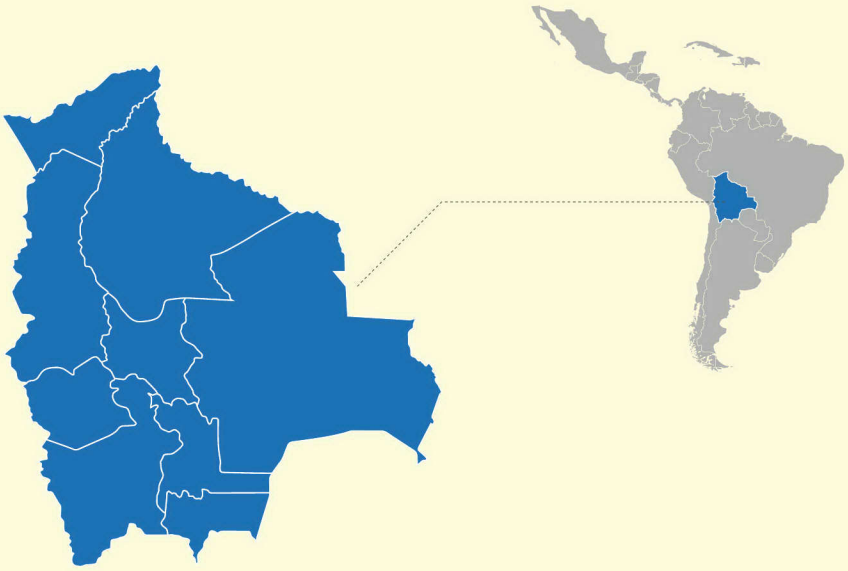
The reuse of wastewater in agriculture as a climate change adaptation and efficient water use measure is supported in the rural sector of the altiplano and highland valley regions. Photo: Gabriel Barcelo. The World Bank.

1 Ministry of Environment and Water (MMAyA), "Sistematización sobre tratamiento y reuso de aguas residuales". (La Paz: MMAyA, 2014).

BOLIVIA

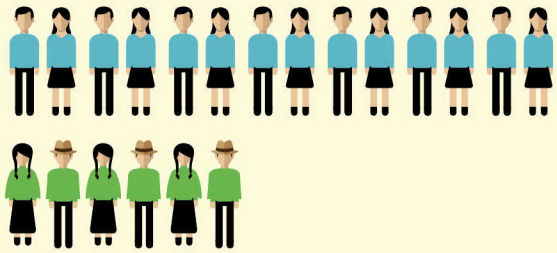


10.5
million inhabitants



Urban population **67.2%**

Rural population **32.7%**



Gross Domestic Product (GDP) per capita (annual growth %) (2012)

3.5%

Health expenditure per capita (2012)

US$148.7

Mortality rate in children under 5 per 1,000 live births (2012)

41.4%

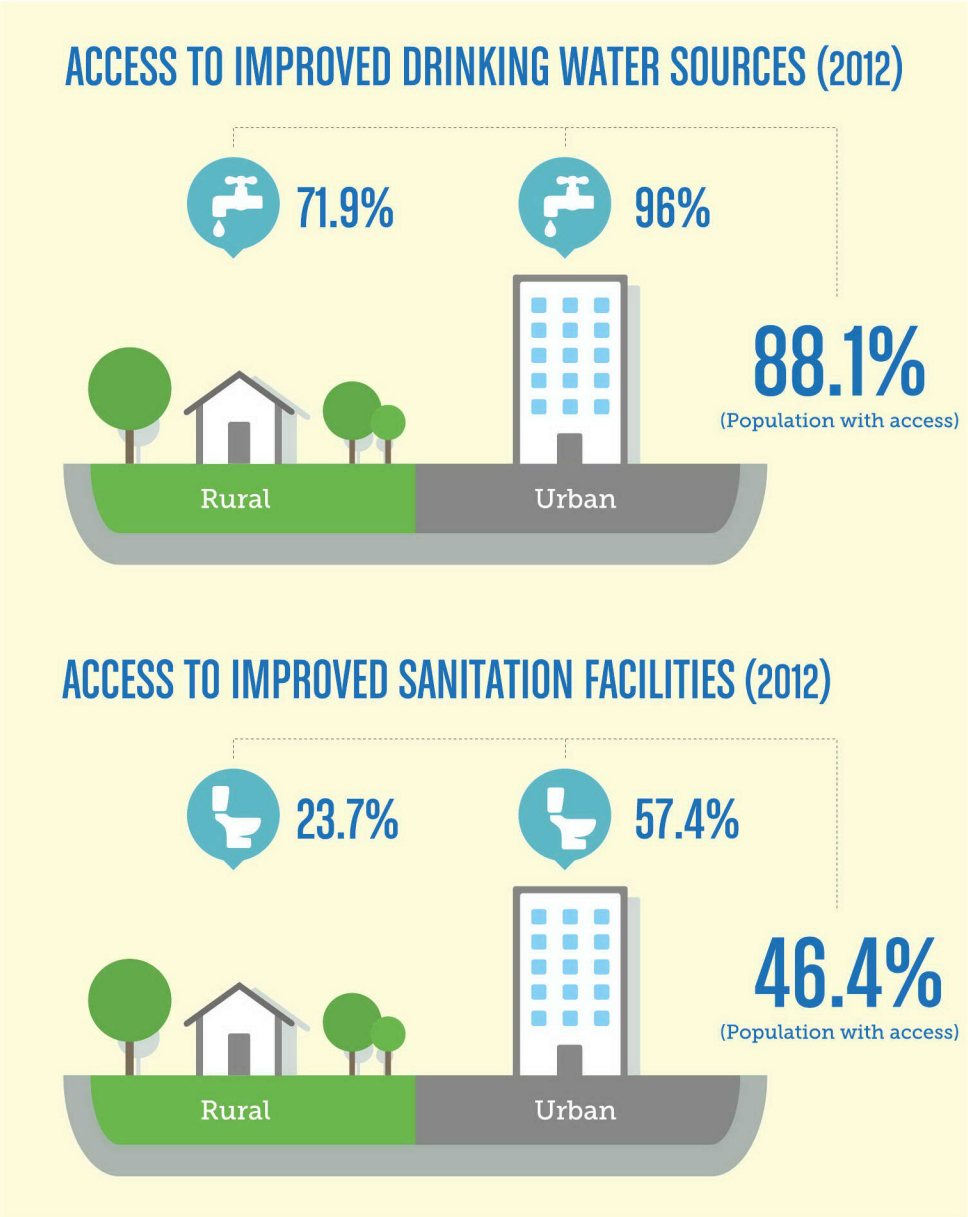
Annual growth of the population (2012)

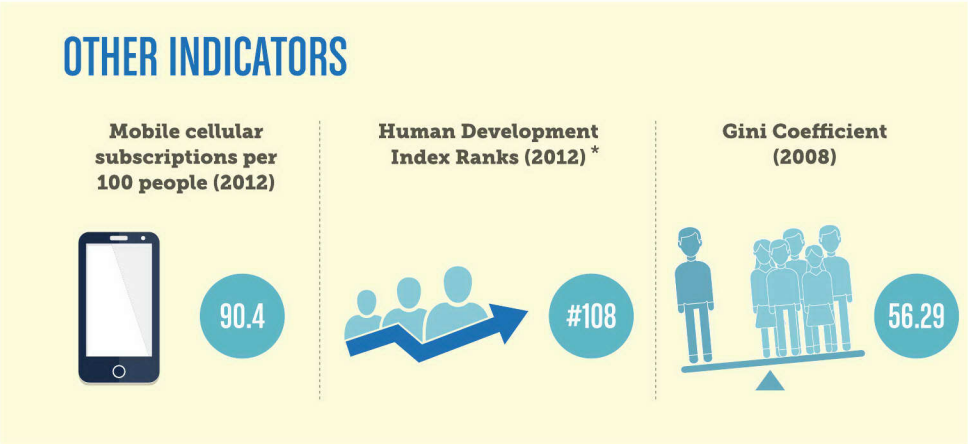
1.7%

Population living in poverty (2007)

Daily income under US$ 2 **24.6%**

Daily income under US$ 1.25 **13.6%**





SOURCES: World Development Indicators, 2012. The World Bank.
* Human Development Report, 2013. United Nations Development Programme.

Although the city of Cochabamba treats its wastewater somewhat before discharging it into the Rocha River, La Paz does not perform any wastewater treatment.

According to the World Health Organization,[2] whenever there is contact with untreated wastewater there is a risk of several types of infection and disease in children and adults who do farm work. For consumers of farm products, there are significant risks of infection of the digestive tract from bacteria and viruses or infections from contact with protozoa.

Livestock farmers in the region have found that their animals contract brucellosis, possibly from ingesting wastewater and foods irrigated with untreated sewage. Other diseases that livestock can contract from eating forage irrigated with wastewater are Taenia Saginata and Taenia Solium, which stunt growth in cattle and can also affect the health of consumers who eat undercooked beef.[3]

Bolivia's National Plan of Basic Sanitation 2008–2014 anticipates that as a result of the effects of climate change, the volume of available surface water will decrease and water tables will drop, which may lead to overuse of aquifers, incremental costs for supplying water, and a likely loss of water quality. As a result of falling reservoir levels, there is a risk that concentrations of dissolved contaminants will increase. The cyclonic characteristics of rains will cause more erosion and more turbidity and high nutrient loads in water. In this scenario, and given the attendant decrease in available water for irrigation, it is likely that use of wastewater for agricultural purposes will intensify, and if adequate planning and controls are not in place, there could be serious consequences for public health.[4]

2 World Health Organization (WHO), Guidelines for the Safe Use of Wastewater, Excreta and Greywater. (Geneva: WHO Water Sanitation and Health, 2006).
3 CEPIS, "Aspectos sanitarios de la utilización de aguas residuales y excretas en la agricultura..." Hojas de divulgación técnica 37. (Lima: CEPIS, February 2007).
4 Ministry of Environment and Water (MMAyA), National Plan of Basic Sanitation. (La Paz: MMAyA, updated between August and November 2009).

Main sewage line to the Puchukollo wastewater treatment plant breached by local people to divert water for irrigation and cattle raising. Photo: Gabriel Barcelo. The World Bank.

As a result of these practices and concerns, the Ministry of Environment and Water (MMAyA), with the support of the World Bank's Water and Sanitation Program, hired CARE Bolivia to conduct a study that would compile information to help guide the right policy decisions on wastewater reuse in agriculture. This Field Note summarizes the findings from that report.[5]

PURPOSE AND METHODOLOGY

The MMAyA has recently launched a number of initiatives aimed at defining a road map for the operationalization of the policies set by the Government of Bolivia on the promotion of safe wastewater reuse practices as a climate change adaptation measure.

This study was aimed at complementing said initiatives - which were focused on financial and technical aspects of wastewater reuse - by gathering relevant information on four main areas:

1. Farmers' knowledge of and perceptions about wastewater reuse.
2. Farmers' ability and willingness to pay for services to manage complementary wastewater treatment, regulation, and/or distribution infrastructure that might be built to reduce risks and maximize the benefits of reuse.
3. Social barriers and risks affecting the introduction of planned wastewater reuse schemes.
4. Information related to the sale and marketing of farm products grown with wastewater in the region, such as crop selection criteria, pricing mechanisms, identification of points of sale, distribution channels, and the level of end consumers' knowledge.

For this study, primary sources of information were used, drawing on discussions with focus groups in 12 municipalities, surveys of 650 households in six of those municipalities, panels, polls, and in-depth interviews. The six communities selected for the survey are located in the high valley municipalities of Palca and Mecapaca and the altiplano municipalities of El Alto, Batallas, Viacha (in two different production areas) and Patacamaya. Said communities are located either at the outflow of wastewater treatment facilities or on riverside areas of the Rio Seco and Rio La Paz located downstream of wastewater discharges. The six municipalities all in the department of La Paz, receive wastewater from the big cities of La Paz and El Alto, and are major suppliers of agricultural products, most irrigated with wastewater. Palca was chosen, however, because although it is a major supplier of farm products for the cities of La Paz and El Alto, it does not use wastewater for irrigation. It serves as a point of comparison to the other high valley community, Mecapaca.

Opinion polls of sellers and consumers were carried out at the Villa Dolores markets of El Alto, at the Rodriguez and Villa Fatima markets in the central area of the city of La Paz, and at itinerant fairs that are held weekly in the southern district of La Paz.

5 CARE Bolivia, Socio-economic dimensions associated with the practices of wastewater reuse for productive purposes in the altiplano. (La Paz: CARE Bolivia, 2009).

BOX 1: Comparison of Advantages, Risks, and Problems Identified by Farmers

	Highland Valley		Altiplano	
ADVANTAGES	**Palca**	**Mecapaca**	**El Alto**	**Viacha-Chonchocoro**
Less fertilizer use	53.3%	48.3%	77.8%	57.9%
Several harvests per year	40.0%	38.8%	37.0%	31.6%
Greater productivity	40.0%	52.6%	48.1%	57.9%
No need to pay	33.3%	50.0%	40.7%	57.9%
Improved soil	13.3%	28.4%	59.3%	5.3%
Available year-round	16.7%	20.7%	3.7%	15.8%

	Highland Valley		Altiplano	
RISKS AND PROBLEMS	**Palca**	**Mecapaca**	**El Alto**	**Viacha-Chonchocoro**
Diseases	97.6%	90.3%	100.0%	90.0%
Skin problems	16.7%	41.9%	42.9%	62.5%
Soil salinization	40.5%	22.6%	23.2%	22.5%
Difficulty selling products	7.1%	16.1%	14.3%	15.0%
Lower prices	31.0%	24.7%	60.7%	72.50%
Livestock diseases	42.9%	23.7%	17.9%	15.0%

Source: Survey of 650 Households in 6 Municipalities.

ANALYSIS

Bolivia's National Basic Sanitation Plan sets several targets for 2015, and these include providing adequate treatment of 80 percent of wastewater at the national level, which will require an estimated investment of about US$390 million. Investment in treatment plants on its own, however, does not ensure the efficacy of treatment. It also does not control for risks or maximize the benefits associated with reuse. Mechanisms must be developed to ensure the technical, environmental, economic, and social sustainability not only of infrastructure but also of the entire production and economic system that would be built around it. Adequate sanitary control systems must be implemented as well. In short, doing it right is doable but complex, and a comprehensive approach to wastewater reuse is needed for any initiative to succeed.

The Government of Bolivia has also developed the National Program for Efficient Water Use. In particular, the program proposes the development and implementation of a wastewater reuse policy that will promote the treatment of all wastewater that is collected and conduct research for reusing this wastewater, including the optimization of treatment models that make it possible to reuse wastewater for irrigation, delivering nutrient-rich water.[6]

The knowledge generated by this study is meant to assist in the development of an appropriate policy framework for the promotion of safe wastewater reuse and in the design of the required strategies, programs and projects for its effective implementation.

The main findings of this study are summarized as follows:

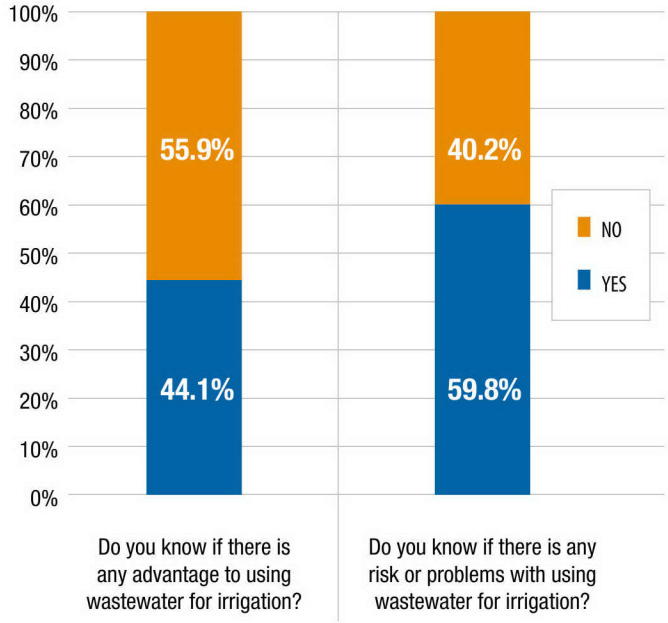
Farmers recognize there are both advantages and risks of reusing water for irrigation, although this awareness is not be confused with specific knowledge about best practices or risks. In the highland valley municipalities (Palca and Mecapaca), the most recognized advantages of reusing wastewater are less need for fertilizers, the potential for more harvests, and in the specific case of Mecapaca, greater productivity and no payment obligation for reuse (box 1). The farmers also recognize the risk of disease for themselves, as well as possible livestock diseases and soil salinization.

6 Ministry of Environment and Water (MMAyA), National Plan of Basic Sanitation. (La Paz: MMAyA, updated between August and November 2009).

The altiplano farmers (El Alto and Viacha-Chonchocoro), too, identify advantages related to less need for fertilizers, greater productivity, and not having to pay to reuse water. They are also aware of the risks of disease generally, and for livestock specifically, although farmers in Viacha-Chonchocoro are especially concerned about skin diseases.

As can be seen in box 1 and figure 1, however, knowledge is limited. Based on the study findings, farmers do not have enough knowledge about the advantages and problems associated with using wastewater to irrigate food products, and as a result, the protection measures they take are limited, although they report frequent use of some types of protection. According to field inquiries, only 44.1 percent of farmers surveyed know that there are advantages to using wastewater for irrigation.

Figure 1. Knowledge of Advantages and Problems

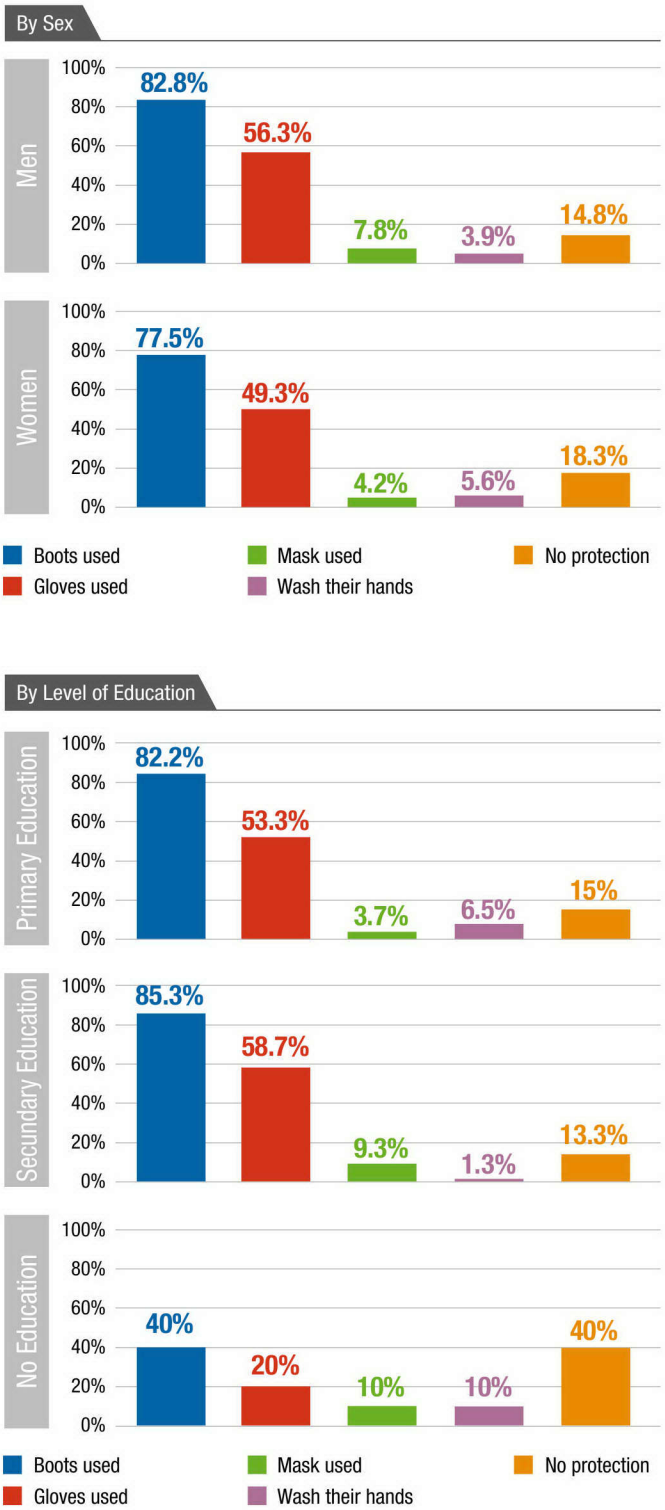


Source: Survey of 650 Households in 6 Municipalities.

Although most of the heads of household who were interviewed reported taking precautions (figure 2), the more in-depth interviews revealed that, for example, boots were used more often in the rainy season, for reasons having more to do with comfort than precautionary practice. As can be seen in figure 2, level of education correlated strongly with the use of protective measures.

The vast majority of the farmers who were interviewed in the highland valley and altiplano municipalities report a strong interest in receiving water from planned reuse schemes. A full 91.2 percent of respondents would be in favor of implementing wastewater reuse programs for production purposes (figure 3). This interest suggests that the farmers are confident that the risks and problems

Figure 2. Protection Measures Used



Source: Survey of 650 Households in 6 Municipalities.

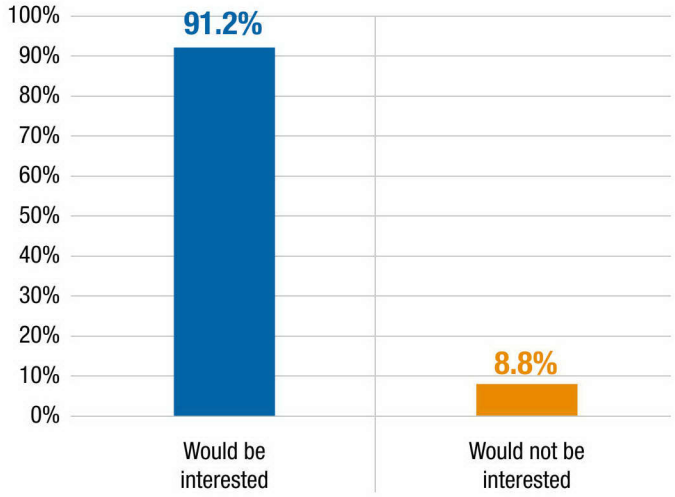
associated with wastewater reuse could be controlled and that these systems could improve their productive activities.

The farmers who were consulted in the in-depth interviews and who presently have an adequate supply of water expressed interest in receiving treated wastewater, inasmuch as periods of drought in the altiplano and highland valley ecosystems are becoming longer and longer. Moreover, they report having information about the likelihood that water resources will diminish due to the effects of climate change.

The farmers would be amenable to helping to manage a planned reuse scheme if it were to increase and improve the opportunities for irrigation while at the same time implementing health protection mechanisms. Of the farmers interested in the installation of a planned scheme, 95 percent reported that they are willing to contribute their labor and 83 percent would make cash contributions. In all, 97.4 percent would be willing to collaborate on managing the system in one way or another.

Despite this willingness to contribute, however, farmers' contributions are likely to be small. The practice of contributing time or money to matters of importance to the community is deeply rooted in the country, which bodes well in terms of the likelihood of participation in a hypothetical planned reuse project. However, the information shared in the focus groups and in-depth interviews seem to indicate that actual contributions to the irrigation committees to which the farmers belong are minimal to the point of being symbolic.

Figure 3: Percentage of Farmers Interested in Participating in a Planned Reuse System



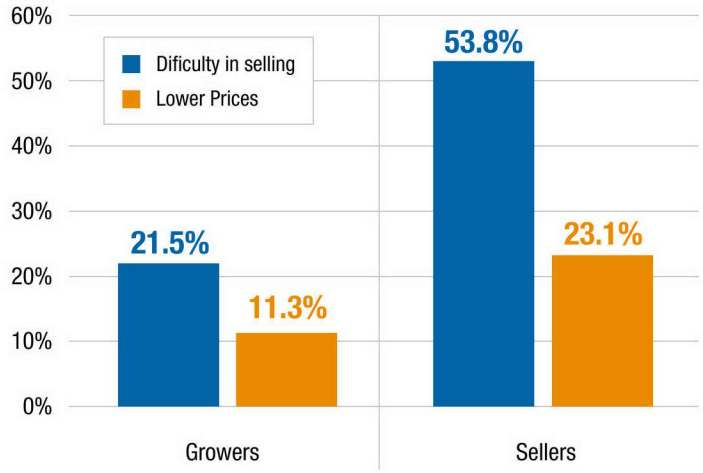
Source: Survey of 650 Households in 6 Municipalities.

As far as local market effects are concerned, no direct link could be established between the type of water used for irrigation and the sales and/or distribution channels for the corresponding products—for better or for worse, retailers and consumers express little knowledge or concern about products grown with reused water. No real difference in price could be detected between products irrigated with wastewater and products irrigated with clean water. Fewer than 20 percent of the farmers believe that consumers would be able to differentiate the products by origin in terms of sales and price. Yet, although 50 percent of sellers believe that products irrigated with wastewater could be harder to sell, only 20 percent believe that the final price of sale could be affected. As seen in figure 4, sellers are more concerned than farmers about the use of wastewater's effect on price of produce. The farmers who practice reuse are very knowledgeable about their market, are able to identify the times of year when their products have competition from domestic or foreign production, and rotate their crops in an attempt to obtain the highest price. The financial costs and benefits of reusing wastewater on their farms is of undeniable interest to them.

With regard to the retail marketing process, officials at a large supermarket in the city of La Paz who were interviewed reported that their product mix (the fruits and vegetables sold at the supermarket) was purchased from a buyer once per week. The buyer selects and purchases the products at the wholesale Rodriguez Market directly off the trucks that bring the products from Rio Abajo (Mecapaca), Palca, and other places (Cochabamba, Peru, Chile, and so forth) depending on the season and availability. Thus, this supermarket would not have any particular microbiological control over the products it selects; it simply chooses products based on appearance, size, and color, trusting that the buyer would have made a good initial selection. While the grocers at this supermarket do not differentiate the products by origin, they also said they had not received any complaints about illnesses caused by the products they sell.

Cow's milk is produced, distributed, and marketed in very different fashion, but with similar results at the retail level. In the study area on the altiplano, milk is sold through 12 bulking centers in Pucarani, Viacha, Guaqui, Patacamaya, Batallas, Achacachi, Achocalla, and other municipalities. The dairy processing plant that buys the milk uses quality control criteria that include alcohol content, temperature, and soluble solids. It rates the incoming product against international standards. The plant also collects and maintains information on the health status of its suppliers' cows, based on which it provides assistance with forage management, the use of hydroponic crops, veterinary services, milking techniques, and other matters. The plant's industrial procedures such as cold storage and pasteurization guarantee the safety of the final product that reaches the consumer. Milk from all sources is mixed, and by the time the milk reaches market the question of whether or not cows have been fed forage grown with wastewater is moot.

Figure 4: Perceptions about the Difficulties of Selling Products Irrigated with Wastewater



Source: Survey of 650 Households in 6 Municipalities and polls in markets of La Paz.

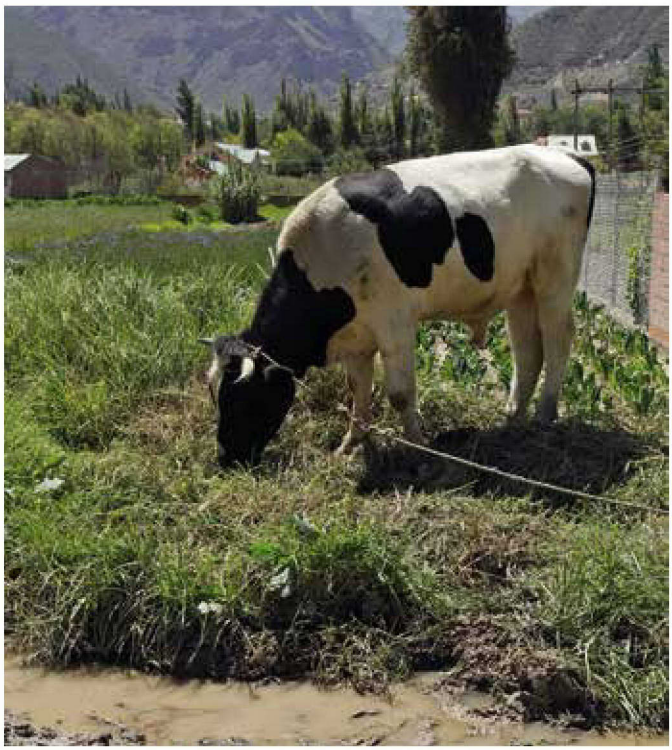
KEY LESSONS

Although farmers are cognizant of the potential risk of irrigating with reused water, they do not have enough specific knowledge about either the advantages or problems associated with using wastewater to irrigate food products. As a result, the protection measures they take are limited, although they report frequent use of some types of protection. Almost 60 percent of the respondents recognize risks and problems for health, citing primarily the strong likelihood of rheumatic, lung, gastrointestinal, and skin diseases, and to a lesser extent, diseases affecting their livestock. This, however, still leaves a sizable portion of the community unfamiliar with the risks.

Farmers in the region support water reuse schemes and are willing to contribute to their success, but their contributions would likely not result much of a contribution to the construction or sustainability of reuse infrastructure. The sector authorities who were interviewed recognize that there are no criteria for setting rates for reuse of wastewater, and payments or contributions in kind or in labor for irrigation systems are not recognized as rates but rather as contributions for repairs and corrective maintenance. In the 12 municipalities that participated in the initial focus group portion of the study, when farmers made voluntary payments to finance operation and maintenance of systems, according to study participants the contributions ranged from US$4.3 to US$5.8 per hectare per year.

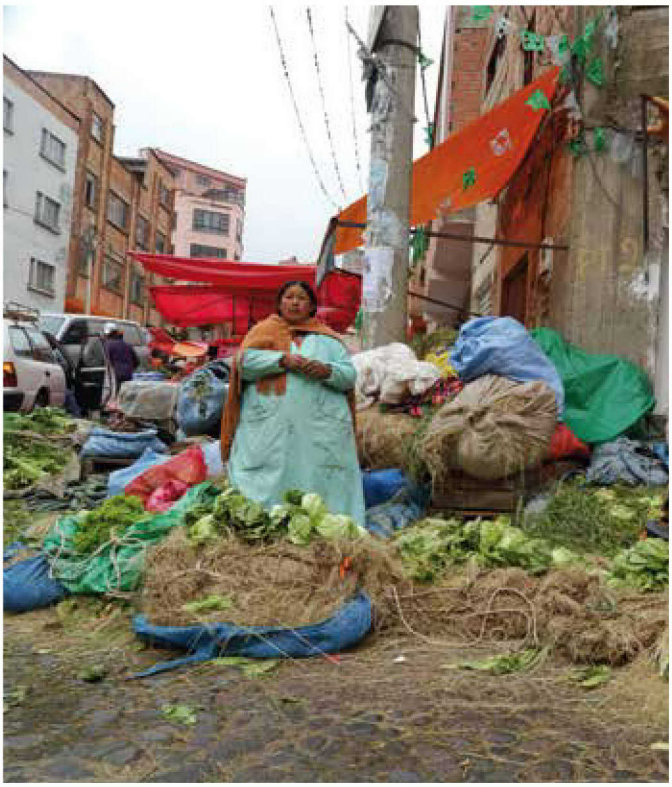
According to a case study done by the MMAyA, with the support of the World Bank, for the cities of Tarija, Cochabamba, and Viacha, in which wastewater reuse would be considered as a way of easing water scarcity,[7] based on the installation of wastewater stabilization reservoirs for reuse in irrigation systems,[8] the operating and maintenance costs for Cochabamba would be US$145 per hectare per year, and for Tarija US$143 per hectare per year. As a result, it seems unlikely that the farmers could assume the operating and maintenance costs of systems if they did not have the financial support of state entities.

No differences are observed in distribution channels, price, or point of sale in relation to the type of water used for irrigation. Produce irrigated with wastewater does not sell at lower prices, mainly because the sales success will depend generally on how visually attractive they are (size, above all). For the most part, there is no indication of origin, and these products are mixed with others grown with traditional irrigation. Only some of the farmers who engage in reuse (17.4 percent) identify lower prices as a disadvantage of using wastewater for irrigation. As for milk, because the product from all sources is mixed together under strict quality control criteria, there can be no distinction among sources at the retail level. The



Livestock eating and drinking near to Rio Abajo River. Photo: Gabriel Barcelo. The World Bank.

7 L. M. Gonzalez, A. Orozco, C. Quiton, Z. Sanz, I. Klytchnikova, Reuse of wastewater to mitigate water scarcity: case studies in Cochabamba and Tarija. World Bank, 2013.
8 This technology maximizes the number of hectares that can be irrigated with the available flow of wastewater, simplifies the wastewater treatment process while maintaining the required level of quality, and minimizes the specific costs (per irrigated hectare) of operation and maintenance.



Vegetables (lettuces and chards, among other) watered with contaminated water offered in "Gran Poder" market. Photo: Gabriel Barcelo. The World Bank.

price is regulated and kept within price bands agreed upon by the government and the distributing companies.

In general, consumers do not explicitly recognize that they are buying products irrigated with wastewater, which may explain why they do not take extra precautions. Washing produce with water is the most common protective measure, although consumers from areas with greater purchasing power (southern region) do wash with chemicals. The opinion poll reveals that consumers would buy products irrigated with treated wastewater because they assume that these would be better and cleaner products than those grown with untreated water. Consumers who say they would not buy products grown with wastewater do not believe that the waters have been properly treated, and at any rate, they believe that the growers would still irrigate with water that is dirty, contaminated, or infected, even if treated water was also available.

IMPLICATIONS FOR PRACTITIONERS

As noted, the informal use of wastewater for agricultural irrigation is standard practice in Bolivia. This informal reuse often occurs downstream of outfalls of wastewater that is untreated (La Paz) or insufficiently treated (Puchukollo) to achieve acceptable risk levels for the health of farmers and consumers.

Reducing health risks by increasing treatment coverage and improving the performance of existing plants, while necessary, entails large investments in rehabilitation and new construction and thus lengthy implementation times. For this reason, and to contain the risks inherent in consuming farm products that are already being irrigated with wastewater, other complementary measures with short- and medium-term impacts must be adopted in parallel, such as those proposed by WHO.

An economic rationality principle would offer solutions under a multibarrier approach, as proposed by WHO in its 2006 guidelines. This approach would bring about the same degree of reduction in health risks associated with reuse based on treatment requirements that are less demanding and thus entail lower investment costs than wholesale infrastructure construction. WHO proposes the adoption of measures such as crop restrictions; use of irrigation techniques that minimize contamination; introduction of minimum waiting periods between last irrigation and harvest; promotion of hygienic food preparation practices; education on health, product washing, disinfection, and cooking of food; and immunization.

The study reveals strong support in the rural sector of the altiplano and highland valleys to the objectives and principles set by the MMAyA for the National Program for Wastewater Treatment Plants. These include promoting the reuse of wastewater in agriculture as a climate change adaptation and as an efficient water use measure. Creative and effective measures would be welcomed by communities, making change possible.

The study also points up the need for a major initiative to educate farmers, sellers, and consumers about the specific benefits and risks of wastewater reuse in agriculture. Such an effort would cover the complete product cycle, from growing the crop to its sale and consumption.

In any effort to move forward with reuse strategies, there is also a need to provide concrete technical assistance to farmers. This would help ensure the success of reuse initiatives by, for example, helping farmers to select crops best suited for wastewater irrigation and improve related practices in production management.

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