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A Supply-Chain Analysis of Food Safety Standards Related to the Use of Wastewater for Irrigation of Crops

Carl Johan Lagerkvist [1], Helena Johansson (Lund University), Ekin Birol, Devesh Roy and Clare Narrod (IFPRI).

[1]Depart of Economics, Swedish University of Agricultural Sciences (SLU). P.O.Box 7013, SE-750 07 Uppsala

carl-johan.lagerkvist@ekon.slu.se

Background and purpose

Irrigation with raw or diluted wastewater is a widespread phenomenon, occurring on 20 million hectares across the developing world, especially in Asian countries, but also in peri-urban areas around almost every city of sub-Saharan Africa and in many Latin American cities. Growing urban populations and consequent increases in demand for food and water has spurred the use of sewage to water crops as this is, in many cases, the only form of irrigation for farmers who either lack clean water or for whom clean water is too expensive. Wastewater has high nutrient value and constitutes a reliable source (Scott et al., 2004). It is mostly used to produce cash crops (e.g. vegetables and cereals). For example, it has been estimated that in most parts of Sub-Saharan Africa, urban and peri-urban farms irrigated with polluted water resources contribute 60-100 percent of the vegetables needed in most cities (IFPRI, 2008). Production of these cash crops is found to generate significant livelihood opportunities, not only for urban and peri-urban farmers but also for traders, input suppliers and other service providers (Scott et al., 2004; Water Policy Briefing, 2006).

The use of wastewater for irrigation without adequate regulations and technology, however, generates major health risks to farmers, farm families, domestic consumers, farm animals, as well as to wildlife as land watered with sewage threatens to spread epidemics. It has been widely documented that the use of untreated wastewater generates several health risks, such as internal parasites; bacterial and viral infections; as well as cancer and congetial problems (Scott et al., 2004; Shan et al., 2008; Arora et al., 2008).

To minimize the potential health hazards from the use of wastewater, the World Health organization (WHO) has laid out strict guidelines for the safer use of wastewater for agriculture and aqualculture (Husain et al., 2002). Different non-treatment options, following the WHO guidelines, at farm, market, and household level has been tested for health risk reduction with particular attention given to efficiency and adoption potential (Drechsel et al., 2008). Some, but not comprehensive evidence exists for that compliance with the WHO guidelines for unrestricted irrigation should result in crops (i.e. salads) acceptable for consumption (Bastos et al., 2008).

Risk management strategies for food safety and for water quality might conflict. Vegetation used to stabilize soils and measures to control runoff can serve as habitat for wildlife. Animal husbandry practices, including manure treatment, represent additional factors that can vector pathogens into fields for food production. An increasing concern on food safety can affect water quality by increasing the export of nutrients, pesticides, and pathogens into surface water and thus causing contamination.

In developing countries, consumers are becoming increasingly aware of that food that they consume is irrigated with wastewater, as well as aware of potential health risks associated with such production practices (Sydsvenska Dagbladet, October 25, 2008). The number of persons in Sweden reported to be food poisoned by fruit and vegetables has tripled since the mid 1990s and might include half a million persons annually (R. Lindquist, The Swedish Food Agency). Imports of these products have increased by 60 percent over the same time period. Major Swedish retailers such as ICA now advocates for stronger use of certification systems and quality assurance schemes (Sydsvenska Dagbladet, October 25, 2008).

The food industry finds food safety guidance through the U.S. Food and Drug Administration (FDA) Good agricultural Practices (GAPs) guide (Food Safety Initiative Staff, 1998) and in a 2006 industry-sponsored supplement to the GAPs. Recent revisions of the GAPs have increased the level of specificity in measures and standards (LGMA, 2007). Other food standards come from private initiatives, often initiated by food retailer firms. Examples are the UN's Hazard Analysis and Critical Control Point (HACCP), and the European Retailers Representative Group's Good Agricultural practices (EUREP-GAP). Evidence exists that the prevailing precautionary principle entailed in such standards provides incentives for private buyers to exercise rigorous precaution against private growers when food safety is in concern. This results in collateral damage to government and private investments in water quality (Chron & Bianchi, 2008).

In addition, the use of GAPs functions as a non-tariff barrier to trade from the perspective of a technical measure. Technical measures are the most frequented used non-tariff barrier (OECD, 2002) and represents measures referring to product characteristics such as quality, safety and health. As such, however, they may be WTO-compatible barriers which allow for countries to impose standards on foodstuffs under the condition that the same standards apply to both domestic and imported products. Ultimately, this might affect the welfare of developing countries, and farmers in such economies, if farm practices related to water quality is used as an argument to shield developed countries from imported food products, At the same time, in order to protect both public health in both developed and developing countries, and the environment, industry, government, and consumers should all be interested in work that relate food safety standards to water quality practices.

The overall objective of this study is to investigate the potential for improved market access of vegetables from current wastewater production to high value domestic and export markets. Use of wastewater for irrigation is, in most cases, mainly a domestic food safety reason for two reasons: (*i*) vegetables produced with wastewater are mainly consumed by small scale farm families who produce them and if there is any residual it is sold in the urban market, and (*ii*) for developing countries to export fruits and vegetables to the EU they must meet EUREP-GAP and HACCP stipulations as well as the company codes of individual retailers (IDS, 2003). We focus on the compliance of private standards in the international fresh produce trade and strategic responses by suppliers in developing countries. An important question here is to ask to what extent compliance can lead to competitive advantage for local firm in developing countries, or to what extent market access can be gained. It has been argued that compliance is a necessary but not sufficient basis for competition in major markets (IDS, 2003). Evidence from the Kenyan horticulture industry indicates that large farms and pack-houses are capable of complying with the range of prevailing standards (Barrientos *et al*., 2001). In relation to compliance with process standards larger firms have been found to be able to access necessary resources for plant and equipment; to cover management, documenting and inspection costs; to be less reliant than smaller units on sub-contractors – while the opposite seems to be the case for smaller firms (Barrientos *et al*., 2001). Thus, there is a risk that product and process standards, besides acting as non-tariff barriers to trade, works to exclude small firms from high value market access. An additional aspect here is that the complexity of the value chain seems to reduce the likelihood

that standards extends to firms throughout its length (IDS, 2003). Hence, fulfillment of our objective requires analyzing and understanding the following:

- Supply/value chains currently linking vegetable producers to different markets
- Demand for food safety domestically and internationally for vegetables produced with sewage water given various management practices to handle food safety risks.
- How various public and private standards and associated requirements for food safety and water quality are affecting a sustained profitability and livelihood of producers/farm families?
- Market failures preventing this type of vegetable production to be considered as reliable.
- Role of various institutions in maintaining access to markets in light of changing food safety and quality requirements.

Relation to other research

Food safety has moved away from being only a public health issue to also include market development and trade issues due to consumers' preferences for safer produced food. Major food retailers have developed several private food safety and quality initiatives, building upon or going further from prevailing legislation. While this movement might be related to industry competitiveness, an additional explanation might be related to protection of consumer confidence in the food system (Jaffee & Maskare, 2005). On the other hand, evidence suggest that there is an increasing marginal cost of certification and accreditation, which puts pressure on company profits of wholesalers/retailers in industrialized countries (Trikekens & Zuurrbier, 2008).

Jaffee & Masukare (2005) examined how European retailers are using private standards for food safety and quality risk management and the strategic responses of leading Kenyan and other developing country suppliers/exporters of vegetables to such standards. The examination is focused upon needed restructuring of the supply chain and they do not study the problems related to trade-offs between food safety and water quality, neither do they examine the issue of consumer/retailer trust and preferences for various measures to improve production processes with respect to food safety concerns. This line of research has though emerged for meat products. Gellynck et al. (2006) focused on pathways to increase consumer trust in meat as a safe and wholesome food with data collected in Belgium. Interestingly, they report that the overload and complexity of information on food products gives that consumer trust is limited with respect to labeling, traceability systems and quality assurance schemes. However, process traceability attributes such as origin and production methods are of interest as a response to meat quality concerns. Future research is recommended with respect to the distribution of costs and benefits associated with meat quality initiatives among the chain participants. Another study by Fearne (2001), on retailer-led beef quality assurance schemes in Germany and Italy, concluded that considerable scope remains for improving the communication of quality assurance schemes in order that specific scheme objectives are clearly understood by consumers.

Buechler & Mekala (2005) focused on landless and smallholder households who use wastewater from the twin cities of Hyderabad and Secunderabad in India for various livelihood activities, and the contribution of wastewater to their food security. Buechler & Mekala (2005) consider the three factors: food availability; food access; and food utilization to constitute food security. Wastewater is the only source of water available in sufficient quantities around the year in the drought-prone Indian state. In the peri-urban and urban areas under study, the income generated by labor on wastewater irrigated fields and, especially, the sale of vegetables and fru-

its provided income to the households and gave the women access to a wider variety of vegetables to their households. A gender issue seems to be present here as the sale of vegetables is controlled by women. All of the producers surveyed retained part of their production for own consumption but it is important to note that the crop mix was adjusted so that cash crops were of higher valued crop types as compared to crops retained for own consumption. The household crop-mix decision thus seems to entail a portfolio problem that subsequently integrally relates wastewater-related livelihood activities and household food security.

Methods and procedures

This study suggests a case study with the foci of the city Nairobi in Kenya. As a result of lack of cold transportation and storage facilities, which are common phenomena in developing countries, urban and peri-urban agricultural areas in and around this already large and growing city have become the major suppliers of agricultural produce to the city. Kenya is also of interest since leading fresh produce suppliers have initiated strategies to re-position themselves towards export markets. To succeed in such strives; the industry has to continue to invest substantially in improved production, upgraded pack house facilities, and in quality assurance/food safety management systems.
The proposed project will be carried out in the following parts:

a) Focus groups interviews, farmer surveys and valuation exercises (stated preference methods; experimental approaches) to understand the demand for food safety domestically and inter nationally related to vegetable production based on wastewater in Nairobi. A particular focus will be given to sources of conflicts, or tradeoffs, related to water quality and food safety, as well as within food standards.
b) Use a risk assessment framework to demonstrate the base line risks associated with using wastewater for irrigation.
c) Identify cost-effective control measures for reducing this risk along the food chain.
d) Assessment of the impact of demand for increased food safety standards on crop farmers.
e) In depth analysis of the supply/value chains currently linking urban and peri-urban farmers to different markets for high-end value export markets for vegetables.
f) Institutional analysis to identify how various (e.g. quality assurance; food safety standards) institutional arrangements can/have facilitated implementing risk reduction strategies as well as the reduction of transaction costs through supply chain management so that farmers can successfully be linked to various markets.

It is important to recognize that there are several perspectives in analyzing the employment of irrigation with either clean water or wastewater for vegetable or fruit production: that of the policy-maker, who will want to ensure that national policies and legislation, institutional framework and regulations meet certain objectives; that of e.g. retailers, who will want to ensure that company goals and consumer needs are satisfied; and that of the producers (or households), who likely will want to ensure that current and future water use can comply with all relevant regulations and standards. For the latter category it is also of interest to take into account any presence of failure cost (i.e. a ‘poor quality cost’ affecting the producer by the way of a loss of market access, or other penalties, related to a revealed lack of compliance).

The following sections will further develop on our research problem.

Benefits and costs related to use of wastewater for irrigation

Hinrichsen, Robey & Upadhyay (1998) estimated that within the next 50 years, more than 40% of the world's population will live in countries facing water stress or water scarcity. Growing competition between agriculture and urban areas for high-quality freshwater supplies will increase the pressure on this resource. In many cases, it is better to use wastewater or diluted water for crop production than to use higher-quality fresh water, because crops benefit from the nutrients they contain (WHO, 2006). Wastewater thus constitutes an economically important input working as a substitute for costly fertilizers, otherwise to be used. The reliability of the wastewater supply can lead to enlarged production opportunities (as it is available year-round). This is of particular relevance in situations where changes in precipitation can be expected for various reasons, including effects of climate change. In addition, population growth in developing countries is concentrated to urban and peri-urban areas. The use of wastewater in agriculture then provides a low-cost way to increase food production. Wastewater is used where it is generated and available. An additional aspect to be recognized is the environmental impact of wastewater use. The direct use of wastewater in agricultural production is a form of nutrient and water recycling, and this often reduces downstream environmental impacts on water resources and soil, as well as potential health impacts on downstream communities (WHO, 2006).
Depending on local circumstances, health hazards associated with wastewater use for irrigation of vegetables and fruits may turn into health risks. The probability of this occurring has a number of environmental and social determinants (WHO, 2006). The health risks most studied in the context of the use of wastewater are those associated with excreta-related pathogens resulting in infectious diseases; vector-borne pathogens such as vectors of lympathic filariasis which breeds in organically polluted water; skin irritants; and chemicals (WHO, 2006). The working conditions related to agricultural production using wastewater represents an additional cost item.

An overview of the decision problem

The management of risks related to use of wastewater for vegetable and fruit production should range over the entire production cycle from waste generation to consumption of the product. Such a system perspective provides a chance to identify health protection measures that can reduce health risks along the supply chain, in order to ensure trade of safe food products. A monitoring process to ensure compliance with the risk management measures and appropriate quality controls is needed to sustain the viability of such food production cycle.
WHO (2006: p. 11) lists a range of cost-effective categories related to public health intervention measures related to wastewater use:

- Treatment of wastewater to prevent contaminants from entering the environment.
- Crop/produce restriction (i.e. only crops that are not eaten directly by people or that are always processed or cooked before they are eaten) is used to minimize health risks to product consumers.
- Waste application techniques and withholding periods aim to reduce contamination of the products or allow sufficient time for pathogen die-off in the environment prior to harvest.
- Exposure control methods (e.g. protective equipment, good hygiene) will prevent environmental contamination from reaching exposed groups.

- Produce washing/rinsing/disinfection and cooking reduce exposure for product consumers.
- Vector control reduces exposure for workers and local communities.
- Chemotherapy and immunization can both prevent illness for those who are exposed or treat those are ill and thus reduce future pathogen inputs into the wastewater.

From a policy perspective the challenges are in setting standards, in monitoring compliance, in providing assistance in achieving compliance, and in enforcing sanctions on non-compliance. Retailers, representing global buyers have a role in assisting suppliers and improving buying practices. Ultimately, standards related to wastewater use in vegetable production raises costs for developing country firms and global buyers. Such standards also likely affects consumer trust and believes for food safety.

Study focus

Our case study will attempt to consider a full accounting of a firm's (households) decision to comply (choice of production process) with a set of standards related to vegetable and fruit production. A close study of both the costs and benefits related to compliance will thus be required. The firm can chose to comply with either domestic standards (i.e. regulating access to, say, domestic markets), or to export markets, or not to comply with any of non-mandatory regulations (i.e. chose to produce for own consumption only). In either market place the firm has, in addition, to chose a product mix. In the case when the firm chooses not to comply it is left with the opportunity as to produce for a domestic market and/or for own consumption. The production decision and the product mix, will be endogenous within the problem of the firm's decision to comply. Our aim (besides mentioned above) is to provide a quantification of the costs incurred by firms in peri-urban and urban areas of Nairobi to meet technical regulation required in a given market (domestic; export (EU)). An additional aim is to study the demand for compliance.

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