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Crop Diversity as a Livelihood Strategy? The Case of Wastewater Irrigated Vegetable Cultivation Along the Musi River in Periurban Hyderabad, India

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Summary
The objective of this study was to contribute to a larger research project on the risks and benefits of wastewater use in irrigated agriculture along the Musi River in South India ("Ensuring Health and Food Safety from Rapidly Expanding Wastewater Irrigation in South Asia"). The Musi River enters the city of Hyderabad as a perennial river and leaves it as a permanent one due to more than one billion litres of wastewater entering it daily with a variety of pollutants, from sewage to industrial wastes (IWMI 2009). The river provides a ready source of water for irrigation in agriculture and other livelihood activities downstream (Buechler 2004). A broad diversity of wastewater irrigated vegetables is increasingly cultivated, maintained by the usage of a broad variety of vegetables in traditional dishes and the possibility for the producers to react to fluctuating market prices. Further, it mitigates vulnerability to pest infections and plant diseases. The farmers in the research area regarded agrobiodiversity as something positive mainly for economic and ecological reasons.

Context: wastewater as a resource
More and more urban wastewater is used for irrigation in urban and periurban agriculture, especially in many countries of the South. The global extent of wastewater irrigated agriculture is unclear, but more than 20 million hectares are estimated (Scott et al. 2004). Due to its high nutrient content and the proximity to urban markets, wastewater is often used for very intensive agriculture.
The use of wastewater in irrigated agriculture can be linked to the following key factors:

- **Fresh water scarcity** on the one hand and a growing world population on the other hand result in the need to use and reuse existing water resources more efficiently.
- **Rapid urbanization processes** with vast amounts of waste and sewage overcharging the often already insufficiently developed infrastructure.
- Due to **poor sanitation** and the **lack of treatment facilities**, most of the urban wastewater is discharged into the nearest water bodies.
- **A growing demand of food** from the growing urban population.

Vegetable cultivation with wastewater irrigation near Hyderabad, India
Along the Musi River in urban and periurban Hyderabad, besides rice and fodder grass, wastewater irrigated vegetables are increasingly grown**.** Earlier studies show that these livelihood

activities along the Musi River support a diverse group of people from different castes, religions and social classes (Buechler 2004, Krishnagopal & Simmons 2007). Agricultural biodiversity in the cultivation of vegetables is sustained by a diversified demand of the mostly vegetarian population. Mainly leafy vegetables are cultivated due their use in traditional dishes and the possibility for the producers to react to fluctuating market prices and demand. Moreover, crop diversity mitigates vulnerability to pest infections and plant diseases.

Expected risks and benefits from wastewater irrigation for producers and consumers
Regarding the issue of wastewater irrigation, mostly the risks as described by the WHO are discussed. However, there are also benefits. Surprisingly, both with regard to human health and the environment, the risks evaluated in the research project were much lower than expected:

- **No significant correlation** between wastewater irrigation and disease prevalence could be verified in the research areas (Weckenbrock et al. 2009).
- **No risk to consumers resulting from heavy metals** (lead and cadmium) in the vegetables tested could be verified (IWMI 2009).
- Farmers in the research area in Pakistan **preferred untreated to treated wastewater** and diverted it before it reached the treatment plant (Clemett & Ensink 2006).

Another finding during a rapid appraisal of wastewater irrigated vegetables in 2007 was that, contrary to expectations, a large number of vegetable varieties were found where wastewater was used for irrigation. Previously, several authors had stated that wastewater irrigation lead to a decline in crop diversity (e. g. Clemett & Ensink 2006). In order to test this hypothesis, the study was extended in 2008. Another aim was to better understand the role of crop diversity in livelihood strategies and farmers' decision making using the *Sustainable Livelihoods Approach* and the *Homegarden Model* as a theoretical background (Drescher et al. 2006).

Research Questions and Methods
The research for this study was divided into two parts: On the one hand a mapping of the total area under vegetable cultivation in three periurban villages and a detailed mapping of the cultivated crops, on the other hand semi-structured, open ended interviews to investigate the farmers' decision making processes and the parameters influencing their choice of crops. The following questions were addressed using GPS/ArcGIS mapping, remote sensing, semi-structured interviews and seasonal calendars:

- What are the vegetable varieties cultivated and what is the extent of the cultivation in the research area?
- Is there a difference between the range of agricultural biodiversity in wastewater-irrigated and groundwater-irrigated gardens?
- Which factors influence the farmers' decision making on what to cultivate where and in what quantity?
- What is the role of agricultural biodiversity for the producers' livelihoods and their adaptation strategies to ecological and economic threats?

Findings: Crop diversity
In general, wastewater allowed a highly intensive form of agriculture in which one acre directly supported 4.8 people on average. Even on the smallest production areas of around one quarter of an acre, up to 13 different vegetables were found**.** The small fields of approximately 2-8 m side length were framed by irrigation canals. Between the plots which were mostly cultivated with leafy vegetables, taller plants were grown, either for seeds (e. g. *Amaranthus tricolour*, L.), for tubers and leaves (such as *Colocasia esculenta*, L. or *Ipomoea batatas*, L.), or for fruits and

flowers which was not captured in this study. 54 vegetable varieties from 20 families were identified. Among those, 18 were cultivated for the leaves most of which were usually cooked like spinach. A positive, statistically significant correlation was found between the number of varieties and the size of the cultivated area**,** yet stronger was the positive correlation of crop diversity with the years of experience in vegetable farming. The extent of the cultivation of vegetables had increased considerably by 150% from 2002 to 2008.

Findings: Decision making

Factors influencing the farmers' decisions what to cultivate was for instance the insecure land tenure along the river, which resulted in the need for a short-term planning. Of importance was also the agricultural knowledge: several farmers stated "*I cultivate what my neighbour cultivates, because I learnt from him*". This was supported by the fact that the majority of the interviewees had shifted from other agricultural activities to vegetable cultivation in the last ten years. According to the responses, categories were formed such as *Input* (seeds, fertilizers, agrochemicals). The factor *Market* was on the first rank, followed by *Tradition and Agricultural Knowledge.* With regard to the importance of this category, the interviewees were also asked about the sources of their knowledge. By far the most important knowledge sources were neighbours and family, while nobody mentioned institutional sources like agricultural extension services. Telecasts or newspapers were only mentioned by one person. Wastewater was regarded as something positive by more than 80% of the interviewees. One groundwater farmer even regretted not being able to use wastewater.

Discussion

From the findings, the following livelihood and adaptation strategies related to crop diversity can be derived:

• Migration to periurban areas, where **wastewater is a reliable, uncontested source of irrigation water** that allows cultivation throughout the year is an adaptation to **physical water scarcity**: two thirds of the respondents came to Hyderabad in search of work and/or water.

• The statements indicate an adaptation through high crop diversity to several risk factors such as **attacks by pests, yield loss**, e. g. due to heavy rainfalls during the monsoon, and falling market demand and prices.

• The cultivation of fast growing crops **maintains mobility** in the context of **insecure land tenure** as an adaptation to the constant growth of the city.

• Short cultivation cycles allowed farmers to react to market demand and insecure land tenure: most of the farmers reported to cultivate fast-growing leafy vegetables such as amaranth and spinach in order to **guarantee a daily income and to be able to pay the monthly rent**: 70% leased the land on a monthly basis with no guarantee of continuation beyond the following month.

• **Close to the markets**, perishable vegetables can be produced and sold freshly at **profitable rates**.

• Through cultivation of their own vegetables, producers can **reduce their families' food expenditures**, enhancing their resilience with respect to the global food crisis: all interviewees stated to use part of the vegetables themselves.

• The cultivation of **leafy vegetables** is also in part an adaptation to the use of **wastewater**. Leafy vegetables seem to better cope with the high nitrogen supply than fruit-bearing vegetables, and can be **harvested up to two weeks earlier** than those irrigated with groundwater due to the fertilising effect.

• **Irrigation regulation** can help to alleviate risks from severely polluted water: several farmers stated that the fields were not irrigated on days when industrial effluents were released. These days were known to the farmers by experience.

Conclusion

Agricultural biodiversity can play an important role in rendering farmers' livelihoods less vulnerable to economic and ecological stress factors as observed in periurban Hyderabad. Wastewater irrigation can enable agricultural activities in water scarce areas, where otherwise no agriculture could take place. Since no negative impact on crop diversity was found in the research area and the findings of the larger research project indicate a low risk from heavy metals and pathogens, the conclusion is that wastewater has a great potential for irrigated agriculture if properly managed**.**

However, it should be assured that industrial effluents, which seem to be more hazard-prone, are separated from the domestic effluent. Cultivating a high diversity of crops in a sustainable way requires specialised knowledge. Therefore, meaningful ways of assisting the periurban farmers would be a better support through agricultural extension services and to strengthen farmers' associations and interest groups.

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