TRUST: Sustainable, fair and environmentally sound drinking water supply for prosperous regions with water shortage: Developing solutions and planning tools for achieving the Sustainable Development Goals using the river catchments of the region Lima/Peru as an example

Solutions and planning tools for water supply and wastewater management in prosperous regions tackling water scarcity

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Keywords: *Remote sensing, monitoring, water balance, risk management tool, water and wastewater concepts, conflict analysis*

ABSTRACT

Innovative solutions and planning tools for safe drinking water supply and sustainable wastewater management are the focus of the TRUST project. In many prosperous regions of the world population and economic growth in combination with competing water demand often lead to water scarcity, i.e. higher abstraction than natural regeneration. TRUST tackles this challenge by combining satellite-based remote sensing techniques, microbiological and chemical monitoring and water balance modelling with decision support tools, water supply and wastewater management concepts and inclusive procedures for the conflict analysis of interests and goals. The focus area of the project is the Lurín catchment in Lima/Peru. In strong cooperation with local partners (Peruvian water authority, water company of Lima and communities in the upper and lower catchment area) the developed tools and concepts are implemented and tested for their transferability to other regions. The main findings so far include the development of innovative and integrative water supply, wastewater disposal, treatment and reuse concepts for the upper and lower catchment area. These concepts will be evaluated using SDG indicators, national standards and criteria determined through participatory processes involving local stakeholders. This will create concepts for access to safe drinking water and wastewater disposal that are tailored to local hydrological, geographical, social, cultural and political conditions.

INTRODUCTION

Achieving the UN Sustainable Development Goals (SDGs) is a major challenge for planning, governance and water management – especially in prosperous regions with water scarcity. Climate change is exacerbating water shortages in regions that are already struggling with water scarcity. Particularly in regions with fast-growing urban centres, the demand for safe drinking water and sanitation, irrigation water for agriculture and process water for industry is growing, and often already outweighs the renewal rate of surface and groundwater.

Achieving the SDGs in the water sector in these regions requires stronger interdisciplinary approaches for solving specific challenges. These challenges include, in particular, incomplete monitoring of polluted and overexploited water resources, competitive pressure over limited water resources and resulting social conflicts and the rigidity of existing infrastructures and planning tools in the face of changing frameworks for water supply and wastewater management systems. The main research questions that are addressed in the TRUST project are threefold:

1. How can remote sensing techniques and hydrological modelling be applied for assessment of situation, prognosis of changes in qualitative and quantitative status of surface waters?

2. How can methods of conflict analysis combined with participatory processes be used to prevent conflicts and thus, for future-oriented strategic planning?

3. Which kind of integrated water supply and wastewater management concepts are applicable, considering evolving boundary conditions (e.g. demographic development, seasonally changing availability of water resources)?

These questions are closely interwoven, and thus require an inter- and transdisciplinary approach, which combines expertise from researchers and practitioners of natural sciences, engineering and social sciences.

METHODS

The focus area of the project is the Lurín catchment in Peru. The Lurín River is one of three rivers that supply the capital Lima. Although the Lurín River itself has hardly been used for water supply of Lima so far due to the strong seasonality of the runoff, ground water extraction is high. The study area combines typical characteristics of prosperous regions of the world, characterized by water scarcity and complex governance structures on the one hand, and data scarcity and partly extreme climatic conditions on the other hand. A fundamental part of the work in the Lurín catchment consists of characterizing the catchment and the water resources quantitatively. Towards this goal, terrestrial observations, remote sensing data, and hydrological modelling are combined. Data on discharge, precipitation or meteorology are available, but mostly from neighbouring catchments, and not always in the desired quality or resolution. The monitoring in Lurín is therefore complemented with rain gauges, water level gauges, and a meteo station. The newly collected data will be analysed together with historical data from Lurín and current data from the neighbouring catchments (Chillón and Rímac), which are already monitored more extensively. Setting up hydrological models like mHM (Samaniego et al., 2010) or WASA (Mueller et al., 2010), which will enable scenario-based analyses, additionally require comprehensive derivation of land use, soil and topographic data using remote sensing techniques.

Trust uses hyperspectral cameras (e.g. in the SWIR spectrum, 950nm - 2500nm) statically and on flexible small platforms like drones; furthermore, the local measurements are expanded on larger scales through the EnMAP satellite mission (400nm - 2500nm). These data are used to i) develop and implement a spatio-temporal context-based classifier, from which the general type and the temporal change of land use can be monitored, ii) develop and implement descriptors specifically designed for irrigated areas, iii) develop image analysis methods to derive the soil type in the project region, and iv) to derive parameters of spectral signatures for characterizing the water hygiene. The latter is also developed and tested at the Klingenberg reservoir in Germany, in cooperation with the Saxonian state dam authority (Landestalsperrenverwaltung Sachsen).

The sociological analysis in Trust is based on a thorough stakeholder analysis (supported by literature review and on-site interviews), characterizing actors from different sectors (e.g. state, economy, civil society), and different levels of action (global, national, regional, local) throughout the (upper, middle and lower) catchment area of the Lurín River. Actors are classified according to their objectives, resources as well as bargaining power. This allows identifying relevant actors, how to include them into the participatory activities of the project and to anticipate interests and positions towards different policies, as e.g. towards varying options for wastewater treatment and reuse. It is followed by an analysis of (latent) water conflicts: With the help of the cross-impact-balance analysis (CIB) (Weimer-Jehle, 2006), interrelations and effects of different policies are analysed to identify (latent) goal conflicts and to bundle integrated policy mixes that avoid contradiction, but could help to reach the different goals of the various water users at the same time. The feasibility (e.g. political will, acceptability etc.) of these policy mixes is then dealt within dialogues with the actors of the catchment area.

An analysis of the local water cycles on a catchment scale based on an extended Water Accounting approach (FAO, 2016) is the basis to develop integrated concepts for water supply, wastewater management and reuse in cooperation with local stakeholders. These concepts are developed for rural areas in the Andean Mountains at over 3000 m a.s.l., urban and semi urban areas in the lower catchment as well as formal and informal settlements. Using an adopted PINCH-technology approach, local potentials for a more efficient water use and reuse are identified. In a final step the potential contributions of these integrated solutions to the achievement of SDG 6, national policy objectives and local stakeholder needs will be evaluated. A pre-feasibility study will be conducted for selected concepts.

Finally, a decision support system (DSS) for ensuring and increasing the security of drinking water supply and to foster preventive and sustainable protection of water resources is developed (Gottwalt et al., 2018). The methodological approach supported by the DSS is based on the Water Safety Plan approach (WSP) suggested by the WHO as a globally applicable instrument for achieving strategic goals for clean drinking water at a local level (Bartram et al., 2009). The DSS helps to install and operate a systematic risk management for drinking water resources and establishes a basis for the development of monitoring systems and further measures to ensure drinking water quality. Building-up a database of all relevant data and information also prevents redundant data acquisition, input and storage. In general, the homogeneous documentation will reduce efforts for data administration and maintenance.

INTERIM RESULTS AND DISCUSSION

The discharge regime of the Lurín River is characterized by a pronounced seasonality due to the seasonal rainfall input, which is essentially restricted to the upper parts (> 2000 m a.s.l.). Other significant aspects are the infiltration into the groundwater and a multitude of local, small-scale water management structures like reservoirs and channels for irrigation and infiltration. Especially the data on rainfall input is highly uncertain, as the upper parts are not sufficiently covered by monitoring stations. A correlation of observed monthly rainfall sums with elevation was found to be the most reliable grounds for extra- and interpolating existing rainfall stations.

Land use and land cover changes for the Lurín region in Peru can now be estimated with deep neural networks and long short-term memory networks. The descriptors for irrigated areas are implemented with supervised and unsupervised machine learning approaches such as Self-Organizing Maps (Riese & Keller, 2018).

Based on literature review, online search and local interviews, actors of the upper, middle and lower catchment area have been mapped and categorized according to presumed attitudes towards or influence on innovative water supply and wastewater concepts (internal report available) and supports identification of relevant actors and their possible interrelations. Against the background of a city-country conflict, several types of latent conflicts have been identified in the Lurín catchment area: value conflicts and conflicts of visions, governance and power conflicts, as well as goal and policy conflicts. The project focusses on the latter two. Based on the analysis of interviews, literature, policy reports, expert input as well as a stakeholder workshop in Lurín, an overview has been established on the central aims of the different water users throughout the catchment including alternative policies that reach these different goals. In the next months, interrelations and effects of policies (also on SDG 6) will be evaluated with the help of interviews with experts in Germany and Peru.

Several integrated water supply and wastewater treatment and reuse concepts for urban and rural areas have been developed, which are discussed and will be consequently improved jointly with local stakeholders such as authorities, user groups, water companies. In the catchment area there is a high potential for reuse of treated wastewater, especially in the urban areas, where the annual wastewater flow is about the same magnitude as the mean flow of Lurín River. Results indicate so far that there is additional potential for groundwater recharge in the catchment area. Main challenges are planning and designing of appropriate wastewater treatment plants for safe wastewater reuse.

The locally adapted integrated water supply and wastewater treatment concepts have been evaluated and discussed on local level with stakeholders in the upper catchment as well as on regional or national level with decision making entities such as regulators or water suppliers (upscaling of possible local solutions). It became apparent that a deficient coordination between several actors and a lack of authority, i.e. scarce regional water governance, are main challenges. According to relevant actors, the implementation of water supply and wastewater treatment solutions depends strongly on local acceptance of the techniques as well as on maintenance and operation capacities of the responsible companies or community members (ownership). Empowerment of stakeholders at all levels has to be taken into account with regard to the proposal of feasible integrated concepts.

A prototype of the DSS is being implemented as an interactive, web-based software system for defining, describing and assessing all risks in the catchment area of a water-supply system. Further it allows the documentation of measures for risk management. In contrast to existing tools for WSP support, the Trust system is based on a geographic information system (GIS), which helps to analyse and manage risks in a spatial context, using GIS data on land-use, topography, soils, risk sources, and water-extraction points.

All implementation efforts are accompanied by capacity development activities.

CONCLUSIONS & OUTLOOK

The planning of water management measures and development of scenarios may benefit from data of various kinds and of different sources. A minimum network of monitoring stations is essential, but remote sensing offers increasing possibilities for detecting and monitoring spatial variables and parameters. The combination of both provides the opportunity for setting up more site-specific hydrological models for the Lurín River. Involving stakeholders and organizing local collaboration in the study area is time-consuming, but is absolutely necessary and fruitful at different levels. Stakeholder analysis serves as a base for the derivation of participation strategies and tools during evaluation workshops for water supply and wastewater treatment concepts and future stakeholder dialogues. Since in-depth stakeholder analysis is complex, it needs constant revision and refinement. The Trust research questions tackle urgent and salient problems in the area. The local and national stakeholders so far evaluated the developed water supply and wastewater treatment concepts as promising and applicable. Regulatory authorities indicate financial opportunities for implementing the rural water concepts with a local water fund. The local communities and the water and wastewater company of Lima are very cooperative and interested in jointly developing integrated solutions including planning and technical implementation of local pilots.

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BMBF Project ID: 02WGR1426A-G

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