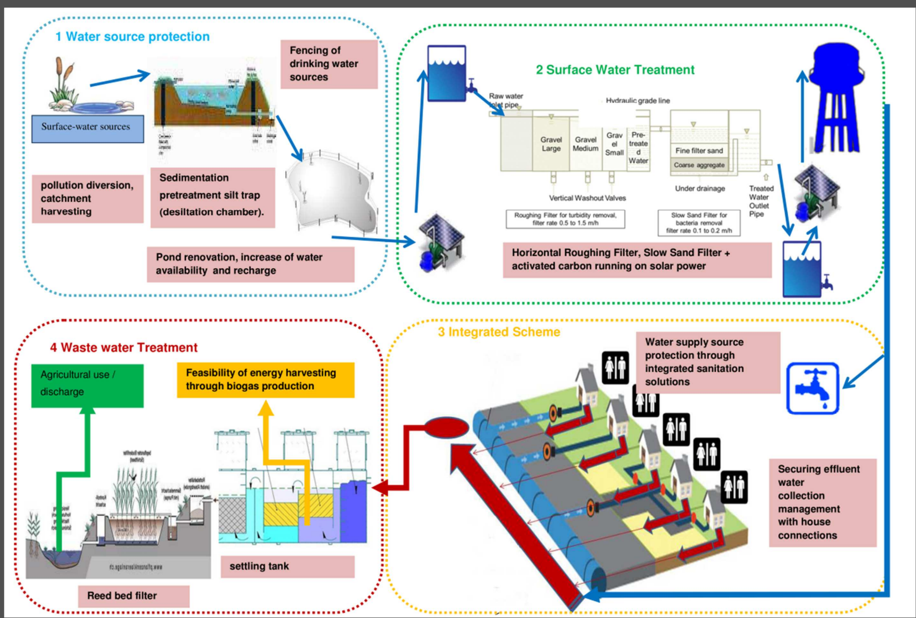

Sustainable Integrated Water Supply for Rural Communities

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Abstract

In the past various challenges were encountered when setting up community based water supply schemes. Especially in remote villages not covered by governmental water supply schemes and not having safe drinking water sources the development of a water supply owned and operated by the community is a core necessity. Participatory approaches have always been claimed to be the only successful way for a sustainable setup. Thus the best suitable concept is derived from an extensive needs assessment conducted in the community with the focus of applicability of the approach. In Public Rural Appraisal workshops the design parameters are further elaborated. Detailed designs of the catchment area and reservoir management, the treatment process, distribution network as well as waste water collection and treatment are developed by innovative combination of reliable and sturdy technological solutions with state of the art equipment which can be operated by the local community.

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1 Introduction

The presented case study is a pilot project having the intention to showcase a best practice example for sustainable solutions for the provision of safe drinking water to communities suffering from contaminated groundwater sources. The community based pilot project in JyotSujan, Murshidabad District, West Bengal, India is designed considering the region specific technical, social, economic and ecological background. The solution makes use of traditionally widely available surface water bodies. The local affected population, especially women and the poor are involved in the assessment, planning and design of the technological, logistical and financial management of the water resources and infrastructure. This participatory approach leads to sovereign decisions on the most appropriate model of water management, treatment and distribution. Field activities in this regard set up the capacity and infrastructure assuring safe drinking water and the integrated management of water sources which is needs driven.

The pilot project is taken up and evaluated for its performance in the framework of the DST, EC funded ECO-India project (EC Grant No. 308467). In this paper the first stage of assessment and planning of the basic water supply scheme are being dealt with. In a second step of the collaborative research project the basic filtration process is upgraded with state of the art activated filter media filtration and enhanced disinfection by mixed oxidants. The overall process is monitored online with sensors as well as verified by offline laboratory measurements. In the 3 year feasibility study the performance is evaluated and optimization options for the basic treatment process identified.

2 Materials and Methods

The fundamental conceptualisation of the water supply which served as an entry point for the discussion with the community and its stakeholders is based on a literature and field research. Past and current approaches to community based drinking water supply (Daniel A.Okun, 1984), (WSP, 2011), were compared and analysed regarding their suitability for areas in West Bengal, India with arsenic contaminated groundwater aquifers (Murcott, 2013) or areas similarly suffering from non potable groundwater sources.

The Indian issues regarding water scarcity and water pollution (UNICEF, 2013) as well as common global challenges regarding policies, planning and coordination as well as financing and human capacities (UN-Water, 2012) have been considered while developing the planning approach in the pilot community. Community based approaches and lessons learned from past projects where helpful in conducting the needs assessment (WaterAid Bangladesh, 2006) (Anna University, Dhan Foundation, 2006).

The specific regional circumstances of the project communities were assed with surveys on demography, geography, infrastructure, situation of water supply and potential community involvement in the project activities (RUDEP, 2007) (kudat, 1995) . These surveys were based on qualitative questionnaires with local authorities (n=5) and quantitative questionnaires with villagers. The survey with quantitative questionnaire is done in approx. 90 % of the households (n=413). In each household responses from one male and a female is collected.

The following basic parameters for the design of the water supply were assessed: The project community JyotSujan has a population of approx. 2000 out of which approx. 1500 are above 18 years belonging to about 250 households. There are 200 pupils studying in primary school, and 50 children in ICDS (integrated child development service) JyotSujan has a community Mosque where about 100 people offer prayers. The adjacent project community Malpara has a population of approx. 400. The main occupation of both communities is farming, 40% of the surveyed people are farmers, and women are mostly house wife amounting to 45 % of the surveyed population. Apart from farmers, about 14% of the population are occupied with labour jobs on daily basis. Fishery and animal husbandry are also a source of income for the villagers. The average monthly income for each household ranges from 1500 to 4500 INR. General needs identified from the interview partners are provision of safe drinking water, improvement of sanitation facilities and increase of awareness on hygienic practices regarding water contamination. Further solid waste and waste water management would be welcome.

JyotSujan and Malpara are partly in the Diar Chaitanpur and partly in the Khosbag Mouza of Murshidabad Jiaganj Gram Panchayat in the Murshidabad district. The next bigger village Khosbag is 2km away, Murshidabad is 5km away reachable by ferry and Berhampore is around 15km away reachable by road. Kolkata is around 220km away and can be reached by train in around 4 to 4.5 hours or by road in 6 to 7 hours. The village is situated in the plains of the river Bhagirathi, flowing 300 to 700 meters away from the settlement with an average flow rate of approx. 40000 Cu Sec. The village surroundings are grass lands used for animal husbandry, ponds for aquaculture and agricultural fields used for growing rice, wheat, pulses, spices, vegetables. Fruits are mainly grown in mango orchard and banana garden. There are substantial use of chemicals fertilizer, pesticides and insecticides in the agricultural (paddy, vegetable, fruits (Mango orchards)) and usage of medicines and food for the aquaculture in the ponds. The fields are irrigated with flood irrigation fed by the water from the river Bhagirathi and shallow or deep tube wells partly canalized to the fields. The agricultural runoff goes to the river Bhagirathi. The top soil is sandy alluvial (mix of sand and clay) and in different strata sand and clay layers are present with partly clay patches. For a soil mixture of sand, silt and clay, the assumed hydraulic conductivity is found to be 0.1 m/day. The temperature in the area ranges from Min 8° to Max 43° C in a year. The rainy season stretches from June till September and the average annual rainfall is 1400 mm.

Transportation to the village is possible by boat and motor or man driven carts. The people in the village mostly use bicycles, and some motor bikes. Electricity is unavailable only 1 hour a day in average. Single and three phase power supply is available at 200 to 220 volts and 440Volts supply is available for mills. A 11000 Volt transformer is located in the village. For electric load connections permission has to be obtained from Azimganj electricity office. For cooking, wood, cow dung and residue of agricultural harvest is used. Diesel and petrol is used for pumps, motors etc. Mobile network of 2G is available with service providers like Reliance, Airtel ,Vodafone, MTS and Uninor. GPRS data connections have an average download rate of around 15 kB/s, partly faster 3G network is also available.

Almost all households have individual tubewells which are used for drinking water but the ground water level decreases by about 3 m in dry seasons. Most of these tubewells are expected to be Arsenic contaminated. The assessed average household water demand per day and some special water demands of the community are shown in Table 1. They differ from the assumed 40 LPCD for standpost and 70 LPCD for rural household connection.

Table 1: water demand in the pilot project community

Drinking water demand per person

Drinking	4
Cooking	4
Hygiene	12
Total	20 LPD

Water demand/Household/day*

Drinking	20
Cooking	20
Cleaning	10
Bathing	50
Clothes washing	40
Sanitation	50
Domestic animals or other uses (average)	30
Total	220 L/d

***in case of a house connection and usage of water for all needs for 5 people**

Special water demands

Masjid with health centers 100 people 5 times a day demands 5 L each time.	2500 L/d
Primary school, 200 pupil, 5 L each	1000 L/d
ICDS integrated child development service, 50 children,5 L each	250 L/d
Total	3750 L/d

Additional water demands for irrigation, animal husbandry, commercial activities like food processing etc. have not been taken into account as they are not carried out on regular basis in the community. Instead an average additional usage of 30 L/d per household has been assumed.

About 10 % of community uses improved (sanitary) pit latrine. Users of unimproved (unsanitary) pit latrine and temporary shallow pits are 60 % and about 30% of the population practice open defecation on the field as they have no latrines. The household waste, garbage and grey water are collected in a shallow pit, partly near to the tubewells. There is no waste water or solid waste management system in the village.

3 Results and Discussion

In order to increase the sense of ownership in the community the project involves as many local actors as possible in the assessment, planning designing as well as construction, operation and maintenance of the water supply. It is thus assessed in how far skills necessary for the various tasks are available in the community. The interview partners mentioned that has skilled labour for electric works, for masonry and plumbing as well as unskilled labour. Local materials like bricks, sand and cement are available with members of the community. Currently there is no committee handling the drinking water issues but an irrigation committee which is also running a deep tubewell used by many farmers of the village. It is a consensus among the interview partners that a committee should be formed to approach a solution for the drinking water supply. The committee formed consists of the the following members:

- Owners of ponds, tubewells and lands involved in the water scheme
- Elected representative
- Representative of each group of the community
- Proactive people of the community
- Technical experts
- Health centre and school representative
- At least 50% of the members are women
- EcoIndia project members

The committee is organised in 9 working groups which have the role distribution as given in **Fehler! Verweisquelle konnte nicht gefunden werden.**. Each working group consists of at least 3 members, with one group leader, in some groups the leader was decided to be a women, in other groups women or men were group leaders.

Table 2 : working groups of the water comittee Jyot Sujan

Group no.	Role in water committee
1	Documentation and taking of minutes (female).
2	Assessment and information collection .
3	Working out consents and approvals for the usage of land.
4	Regular communication with JU /adelphi.
5	Sample collection / water quality monitoring.
6	Working out WC budget, fee structure and collection of user fees.
7	Book keeping, opening and managing a bank account (female).

8	Catchment area protection, management and monitoring.
9	Technical operator in charge of technical planning, implementation and maintenance.

For a sustainable working of the water committee its funding options were elaborated. In order to assess the independent maintenance capacity of the community the willingness to pay for the water supply service was surveyed. The users are willing to pay a monthly fee for the operation and maintenance of the scheme. The average amount a villager would pay according to the survey is INR 18.87. It was calculated that each household would need to pay approx. 50 INR. The main expenses would be the salary of the operator of the scheme.

The needs assessment and participatory planning process led to the conceptualisation of a surface water based drinking water supply system which is augmented with a groundwater scheme. For a small part of the community an integrated water supply is setup which consists of household connections and a sewerage system. This integrated water supply focuses on a long term approach to mitigate arsenic groundwater contamination by making improved usage of surface water sources, which in general do not contain elevated arsenic concentrations. Reintroducing surface water usage for human consumption implies taking a special care of typical surface water contaminants related to serious diseases e.g. diarrhoea, hepatitis, typhoid fever and cholera. Thus awareness on quality maintenance and sound technologies for the treatment are prerequisites for a successful usage.

Overall prerequisite for setting up a surface water supply scheme is that all stages of the local and regional water cycle are being tackled. The quality of the water resources is to be improved. Integrated Water Resource Management will have to involve all the user groups in the watershed including farmers, fishers among other economic and domestic water users. Pollution sources have to be identified and water resource protection measures put into place.

The surface water source has been selected on the basis of a weighted multi-criteria decision matrix. Criteria for the selection were:

- Current surface water quality
- Potential water quality as per usage of the pond
- Current water quantity and potential capacity
- Suitability of catchment area surrounding the pond regarding topography and usage (runoff quality)
- Availability of adjacent land for the construction of the treatment units
- Monetary implication for the usage of pond (lease costs)

Finally the source which has been decided on is a village pond of 7300 m³ capacity with adjacent 25.000m² catchment area which is engineered with bunds and harvesting cannels. Farmers in the region are keen in introducing organic farming in order to protect the water source. Contrary to many studies reporting hesitations by local populations in using pond water as drinking water source the local population is convinced that the surface water is a safe alternative to the contaminated groundwater.

The treatment process is conceptualized so that no external electrical power and as less as possible chemical consumables are needed. In order to achieve this, the pumping power is sourced by photovoltaic cells and the raw water and clear water tanks are dimensioned as to cater sufficient water to the filter units in order to make them run continuously for 24h a day. This gravity based filtration process and distribution running on solar power, makes it a green technology setup mitigating climate change.

The basic treatment process for the drinking water consists of roughing filters, slow sand filters (HRF/SSF) and activated charcoal filter with modifications to established concepts (Wegelin, 1996) with recent research results (Pereira, 2012). The roughing filters are dimensioned to run with a filtration rate of 0.5 to 1 m/hr, the slow sand filter has a flow rate of 0.1 to 0.2 m/hr and the activated charcoal filter has an empty bed contact time between 24 and 48 min.

The piped water is protected from external contamination and better quality control through monitoring is possible. The 24x7 supply ensures suitable quality at the point of collection by not letting any contamination infiltrate into the distribution network due to continuous positive pressure in the pipeline.

Taking into account the future development of increasing usage of supply water by the consumer and assuming individual sanitation installations with flushed toilets the waste water collection has been planned to be setup at the same time. The construction at the same point of time is efficient from the point of view of having to do earthen works only once.

The collected wastewater is then treated with a Waste Water Settling Tank (WWST) and A Waste Water Reedbed System (WWRBS). It is intended to produce biogas from the wastewater sludge and locally available abundant biomass. Community members are eager to connect their houses to the water supply network and upgrade their sanitation unit to flushed toilets connected to a sewer line.

For the selection of the area for the integrated scheme the quantitative questionnaire survey was evaluated focusing on the following criteria:

- Necessity of adjacent habitations for sanitation
- Willingness to connect to the integrated scheme
- Willingness to pay for the water supply service
- Topography of the area for free gravity flow of sewage
- Availability of land for waste water treatment
- Beneficial usage of treated wastewater e.g. in agriculture
- Acceptance of the setup by the villagers
- Infrastructural suitability (access road, electricity, cellphone network)
- Safety of installed equipment
- Protection of catchment area
- Cost analysis regarding investment and running operation and maintenance costs

In addition to the surface water based water supply a groundwater based supply adds additional capacities to the water supply. The location for the installation of the groundwater unit was selected on the basis of the following criteria:

- Availability of arsenic contaminated tubewell
- Acceptance by villagers
- Availability of adjacent land for treatment units
- Safety of installed equipment
- Cost analyses regarding investment and running operation and maintenance costs

The groundwater sourced from tubewells is treated by an Arsenic Removal Unit (ARU) working on co-precipitation and adsorption. The arsenic rich sludge which is generated by this process will be treated in a way that the arsenic will not leach back into the environment. Options like brick manufacturing are being looked into.

The overall planning thus considers the best option for the surface water source, the groundwater source and the integrated scheme and derives the most sustainable option by elaborating the optimal combination. The result of the participatory planning can be seen in Figure **1**

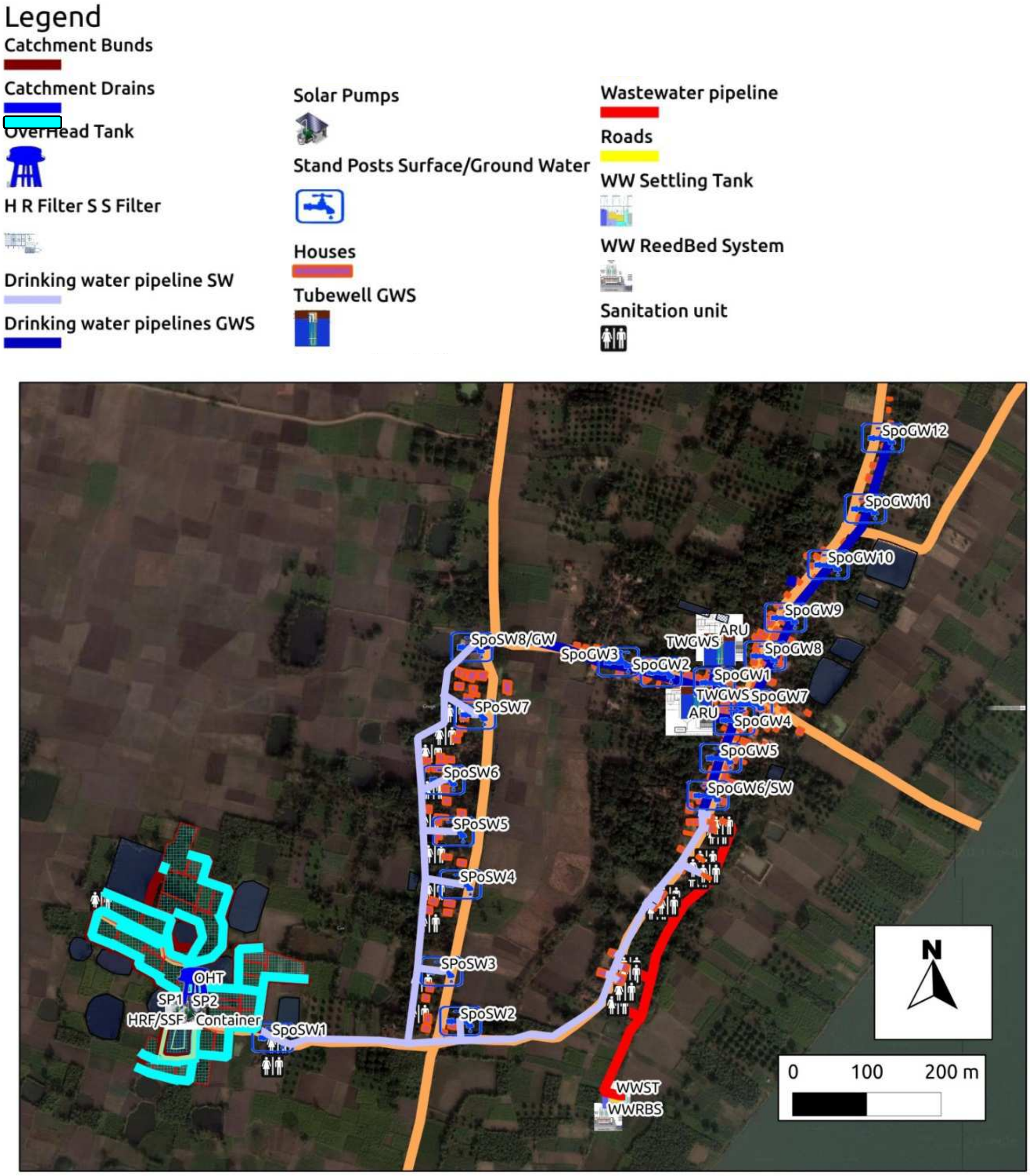

Figure 1 plan of the water supply infrastructure in the project pilot community

4 Conclusion

A technical feasible, socially acceptable and financially viable solution has been elaborated with the participatory approach in all stages of the planning of the water supply. The main challenges of awareness and ownership by the community are overcome by involving all relevant groups of the community in the water committee and patiently working out compromises which are supported by all water committee members. The developed concept promises an overall sustainable operation and maintenance regime. The performance evaluation will proof the scope of the pilot as a best practice model for communities in areas with non-potable groundwater sources.

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