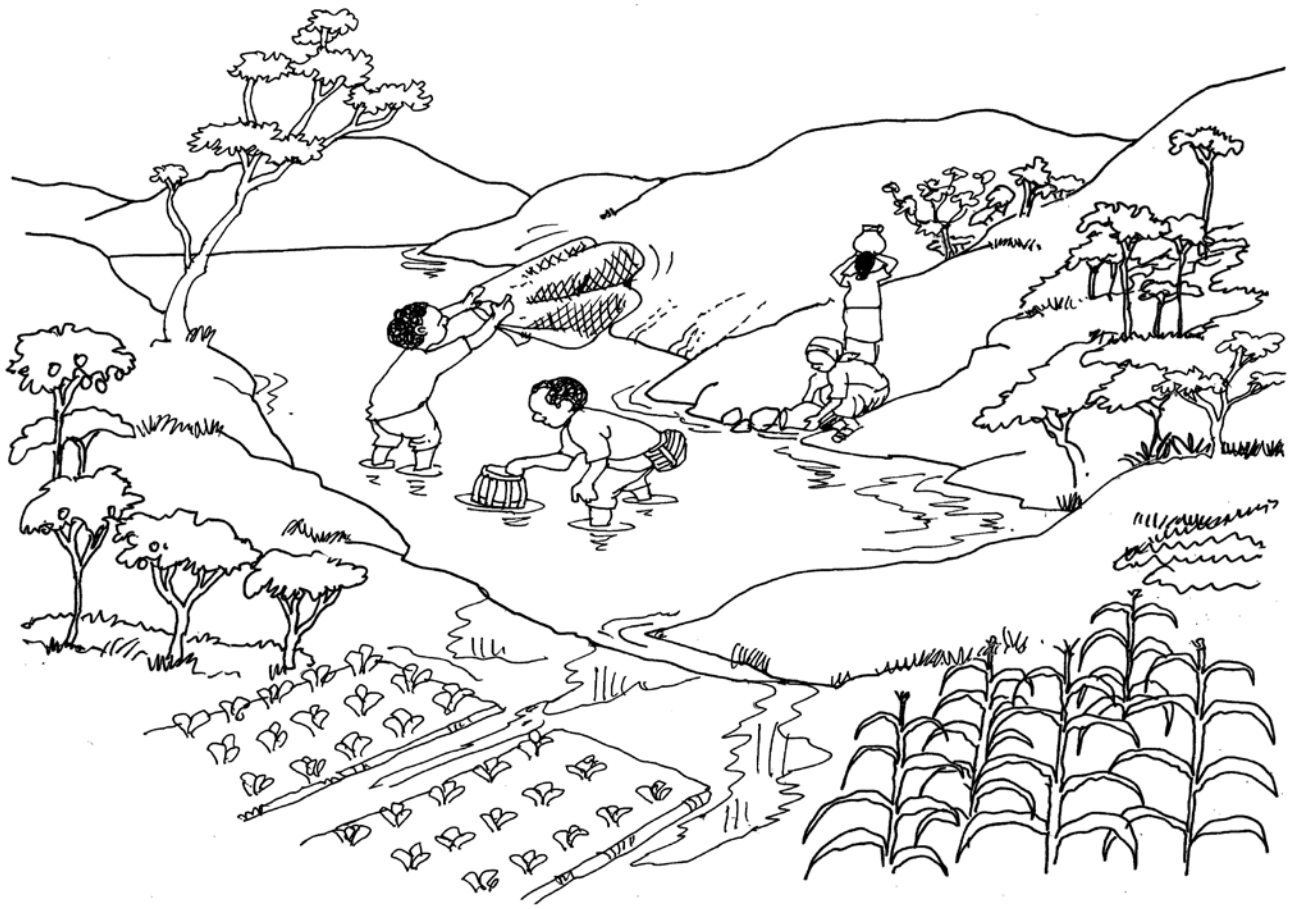
A Toolkit to Assist Small Reservoir Design and Management



Small multi-purpose reservoirs are widely utilized to supply water for domestic use, livestock watering, small-scale irrigation and other uses. The reservoirs are hydrolologically linked by streams that have been dammed. Reservoirs store a large quantity of water that has significant effect on downstream flows. They are considered as systems, with synergies and tradeoffs. Often, reservoirs are constructed with little or no coordination among the implementing partners. A significant number are functioning sub-optimally and/or are not properly maintained. This indicates that there is room for improvement in the planning, operation and maintenance of small reservoirs.

The CGIAR Challenge Program on Water and Food (CPWF) Small Reservoirs Project (SRP) began in 2005 in the Volta, Limpopo and Sao Francisco basins. The SRP team developed a toolkit to support the planning, development and management of small reservoir ensembles at the basin level as well as to ensure that small multi-purpose reservoirs are properly located, well designed and operated, maintained in a sustainable fashion, and economically viable at the local community level. There are "tools" for intervention planning, storage estimation and analysis of the hydrology, ecology and health of small reservoirs, economic feasibility and governance. The toolkit

includes models and methodologies not only for analysis but also for participatory decision making. The toolkit is meant to be a "living document', wherein additional tools and experiences are to be added as they are developed.

The toolkit is designed for use by technical professionals from NGOs, research institutes, universities, donor agencies, multi-lateral organizations, and government agencies. There are approximately 30 tools and techniques presented in four topic areas, applicable at the local/ community level and basin/watershed level.

The Small Reservoir Toolkit (www.smallreservoirs.org) is organized into four topic/thematic areas.

1. The **Intervention Planning Toolkit .**focuses on developing plans, defining stakeholder and conflict relationships, fostering better communication and increasing understanding for the activity while emphasizing the importance of monitoring the implementation, adoption and changes in attitude and behavior of stakeholders.

   Examples:

   - **Participatory Impact Pathway Analysis (PIPA)**. Develop a plan to better bring about desired outputs, outcomes and impacts by helping make explicit links between activities and roles of partners and users of the technology. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/I%2001%20Impact%20pathways_MLA.pdf

   - **Stakeholder and Conflict Analysis (SCA)**. Assess the stakeholders' interest in the project's envisioned outcomes, their relationship with other stakeholders and relative power and capacities and to analyze the degree to which their interest conflict or complement each other. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/I%2002%20Stakeholder%20and%20Conflict%20Analysis_MLA.pdf

   - **Creating Common Ground for Dialogue**. Illustrate the users' views and perceptions to foster communication. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/I%2003%20Common%20Grounds_MLA.pdf

   - **Outcome Mapping**. Monitor implementation of activities and adoption of technology by focusing on the changes in the knowledge, skills and attitude (KSA) of the "boundary partners". For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/I%2004%20Outcome%20Mapping_MLA.pdf

2. **The Storage and Hydrology Toolkit** prioritizes reservoir ensemble measurements by outlining the steps required to obtain regional reservoir inventory using satellite imagery to monitor changes in small reservoir surface area, and thus, storage volumes, among others. This toolkit deals with measurement activities, from monitoring performance (by developing simple hydrological models for dammed upland watersheds based on monitoring reservoir surface areas with radar remote sensing) to predicting river discharge.

Examples:

Reservoir Ensemble Measurement

- **Reservoir Inventory Mapping**. Obtain a regional reservoir inventory with the use of satellite imagery. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IIa%2001%20Reservoirs%20Inventory%20Mapping_MLA.pdf

- **Atlas of Lakes and Reservoirs**. Obtain a regional reservoir inventory using secondary data. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IIa%2002%20Faso%20MAB_ML.pdf

- **Small Reservoir Capacity Estimation**. Estimate reservoir storage capacity as a function of remotely sensed surface area. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IIa%2003%20Reservoirs%20capacity%20estimation_NMA.pdf

- **Near Real -Time Monitoring of Small Reservoirs with Remote Sensing.** Monitor changes in the small reservoir surface area (storage volume) with the use of radar satellite imagery. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IIa%2004%20Near%20Real%20Monitoring_MLA.pdf

- **Hydrological Impact Assessment of Ensembles of Small Reservoirs**. Assess hydrological impact of ensembles of small reservoirs, particularly evaporative losses, spillage, water used for irrigation and excess irrigation drainage. This is an analytical framework that predicts what will happen when a new small reservoir is added to the collection without defining the location of the reservoir. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IIa%2005%20Hydrological%20Ensemble%20Assessment_MLA.pdf

Hydrology and Physical Measures of Performance

- **Calibration of Runoff Models with Remotely Sensed Reservoirs**. Develop simple hydrological models for dammed upland watersheds based on monitoring reservoir surface areas with radar remote sensing. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IIb%2001%20Watershed%20Run-off_MLA.pdf

- **Rainfall-Discharge Relationships for Monsoonal Climates.** Develop a simple water balance models for predicting river discharge. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IIb%2002%20Run-off%20Monsoonal%20Nile_MLA.pdf

- **Deep Seepage Assessment in Small Reservoirs**. Develop a simple methodology to estimate seepage losses through the bottoms of small reservoirs. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IIb%2003%20Seepage%20Assessment_ML.pdf

- E**vaporation Losses from Small Reservoirs.** Observe evaporative losses in small reservoirs. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IIb%2004%20Evaporation%20Losses_MLA.pdf

- **Water Quantity Assessment of Silted-Up Small Reservoirs**. Estimate water stored in silted-up small reservoirs. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IIb%2005%20Silted%20up%20Reservoirs_ML.pdf

- **137Cs Radionuclide Tracer Method to Quantify Soil Erosion and Sedimentation at Hillslope and Reservoir Scale**. Estimate the amount of sediment eroded from the field, redistributed downstream and accumulated in reservoirs. This tool uses measurements of 137Cs concentration of collected soil samples in the watershed. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IIb%2006%20137Cs%20Radionuclide%20Tracer%20Method_MLA.pdf

- **Small Erosion Modeling at Small Reservoir Scale by WaTEM/ SEDEM**. Simulate soil erosion and sedimentation rates at the catchment scale; produce soil erosion hazard maps. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IIb%2007%20Soil%20Erosion%20Modeling_MLA.pdf

- **Bathymetric Survey by Depth Sonar and Lake Sediment Coring by Beeker Sampler to Identify Sediment Badges and Siltation Rates of Small Reservoirs**. Monitor changes in reservoir morphology, measure the thickness of accumulated soil particles and calculate siltation rates. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IIb%2008%20Bathymetric%20Survey_MLA.pdf

3. **Ecosystem and Human Health Toolkit.** Aims to reduce health risks and increase health benefits from small reservoirs. Surveys are conducted for general health inquiry, epidemiological and vector studies and other related contamination or quality assessments.

   Examples:

- **Participatory Health Impact Assessment.** Identify relevant health issues associated with small reservoirs and to improve their operation to mitigate health risks. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/III%2001%20Participatory%20Health%20Impact%20Assessment_MLA.pdf

- **Health Questionnaires**. Assess the prevalence of water-related diseases at the reservoir cluster or river basin level. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/III%2002%20Health%20Questionnaires_MLA.pdf

- **Epidemiological Survey**. Determine infection rates of key water-related diseases. This tool uses standard biomedical methodologies. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/III%2003%20Epidemiological%20Survey_MLA.pdf

- **Vector Studies**. Understand the ecological preferences of vector organisms in relation to small reservoirs. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/III%2004%20Vector%20Studies_MLA.pdf

- **Water Quality Assessment**. Assess the suitability of reservoir water quality for different uses. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/III%2005%20Water%20Quality%20Assessment_MLA.pdf

- **Cyanobacteria, Cyanotoxins and Potential Health Hazards in Tropical Small Reservoirs**. This tool is a documentation of the algal bloom observations in Burkina Faso. Use this to better understand the issues and risks. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/III%2006%20Cyanobacteria_ML.pdf

- **Agricultural Intensification and Ecological Threats around Small Reservoirs**. Analyze the

impact of anthropological and agricultural activities near the reservoir. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/III%2007%20Pesticides%20and%20Agricultural%20Intensification_ML.pdf

- **Small Reservoir Water Quality Monitoring Using Plankton Abundance and Diversity**. Assess reservoir water quality through changes in the abundance and diversity of organisms. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/III%2008%20Water%20Quality%20Assessment%20Plankton%20Limpopo_ML.pdf

- **Indicators.** Identify impact indicators. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/III%2009%20Indicators_MLA.pdf

4. **The Institutions and Economics Toolkit.** Deals with water allocation application, which includes financial accounting models. It aims to estimate the effects on yield of climate and weather deviations and the effects on yield and water consumption of improved irrigation practices. This toolkit also deals with governance of water resources and with visualizing, discussing, monitoring, evaluating and improving situations in which many different actors influence outcomes.

   Examples:

   Water Allocation

- **Water Evaluation and Planning (WEAP)**. Use this model to plan water allocation schemes. This model is linked with groundwater model MODFLOW, water quality model QUAL2K and socio-economic models for tracking changes in livelihood over time. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IVa%2001%20WEAP_ML1.pdf

- **Financial Accounting Model.** Use this model to estimate initial and recurring farm-level costs of water-related infrastructure and to estimate price and income consequences of increased crop production. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IVa%2002%20Financial%20Accounting%20Model_ML.pdf

- **Water-Limited Yield Model**. Use this model to estimate the effects on yield of climate and weather and to estimate the effects on yield and water consumption of improved irrigation practices. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IVa%2003%20Water%20Limited%20Yield_ML.pdf

- **Small Reservoir Water Allocation Strategy**. Use this model to estimate water productivity and social values to make informed decisions on the allocation of scarce water resources. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IVa%2004%20Water%20Productivity%20Limpopo_ML.pdf

   Institutions and Governance

- **Institutions and Governance of Small Reservoir Water Resources**. Use this tool to describe the indigenous practices, legal frameworks and institutions that are most conducive to equitable, win-win and pro-poor investments. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IVb%2001%20Institutional%20Governance_ML.pdf

- **Net-Map (Influence Network Mapping).** Use this tool to understand, visualize, discuss, monitor, evaluate and improve situations in which many different actors influence outcomes. For more information, visit http://

www.smallreservoirs.org/full/toolkit/docs/IVb%2002%20Networking%20Mapping_MLA.pdf

- **Social Capital.** Use this tool to assess and analyze social networks within a community to determine how cooperation in that community influences "who participates, and how" in the development of a collective good such as a small reservoir. For more information, visit http://www.smallreservoirs.org/full/toolkit/docs/IVb%2003%20Social%20Capital_ML.pdf

Key findings

The key findings from SRP require follow—through from the community, local, national and, if relevant, international partners. Some key findings include the following:

1. Results show that evaporation from small multi-use reservoirs in the savanna setting was under half of what was assumed on the basis of an analogy with oases in deserts and was less than that from cropped areas of similar size. The social and production advantages of storing water in community reservoirs nearer to where it is used by individual households need not be balanced against worries about excessive evaporative losses.
2. Combined satellite and field measurements show that the downstream impact of small reservoirs can be minimal. For instance, in the Volta Basin, quadrupling the number of small reservoirs would result in the consumption of less than one percent of the total available water.
3. Small reservoirs are less costly to operate and maintain than pumped systems and do not require recurrent expenditures for parts and fuel. Fish production, recreational and other non-consumptive uses are supported by small reservoirs. Groundwater mining results in escalating costs of extraction and eventual depletion of available supply.
4. Small reservoirs are managed by traditional leaders, local communities, NGOs and local governments. Therefore, technical and financial assistance from various organizations may be required.
5. Surface water in the small reservoirs is rarely suitable for human consumption; yet, it is often used for drinking without treatment. This risky behavior will continue to be an issue.
6. Most small dams are supposed to be built according to recommended design, construction and maintenance guidelines. Their current physical condition is poor because of lack of maintenance and unclear lines of responsibility among the government, NGOs and the communities.

Conclusion

Small reservoir systems are sustainable, cost-effective solutions to increase yield and improve livelihoods in semi-arid communities. The project showed that strengthening ties between donor agencies, government and traditional leadership is key to the improved design, use and governance of small reservoirs.

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Global Change and Hydrological Cycle (GLOWA) Volta Project
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Tags: PN46; Small Multi-purpose Reservoir Planning

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