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**TRANSFORMATION TOWARDS SUSTAINABLE
AND RESILIENT WASH SERVICES**

**Decision support system tool for the evaluation of
sustainability of rural water supply services**

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This study formulates a DSS tool that can aid the rural water supply engineer and planner in decision making regarding the sustainability of rural water supply services. Three modules that comprises functionalities for data input, data analysis and display of results are employed in the computer program, developed by the author using visual basic. The DSS tool identifies the sustainability status of a particular water supply service and further goes to identify the factors behind it. The DSS tool further scrutinizes between different water supply sources in a district to decide which type of water source is sustainable in that particular district. The DSS tool is applied on specific sites at Ethiopia. The results show increased social participation contributing to increased sustainability, schemes with distribution are more sustainable than isolated on spot schemes and increased cost recovery of the services contributing to increased sustainability of the rural water supply services.

Introduction

Sustainability has emerged as a major issue as the global rally of the Millennium Development Goals ended in 2015. World attentions are turned towards the post-2015 agenda to deliver the Sustainable Development Goals (SDGs), sustainability being a global concern. The transformation of the globe's rally from the MDGs to the SDGs is no surprise because; it is the lack of sustainable development that endangers the world right now and the world tomorrow.

It was in 2000 that the MDGs were officially established following the Millennium Summit, where all 189 United Nations member states adopted the United Nations Millennium Declaration, from which the development goals were derived, with eight international development goals, 21 targets, and a series of measurable indicators for each target., the MDGs have been a platform of a global effort towards improving social and economic conditions in the world's poorest countries (United Nations General Assembly, 2001).

Halving, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation was the third target from the MDG-7 (ensure environmental sustainability) and the tenth target out of all the 21 targets of the MDGs. Being so, sustainability of water supply and sanitation has remained a top priority in improving the livelihood of the rural poor (United Nations General Assembly, 2001).

From the seventeen goals of the SDG, the one that describes the goal of water and sanitation-goal 6 thrives to achieve universal and equitable access to safe and affordable drinking water for all by 2030. It further outline the importance of integrated water resource management at all levels which this thesis tries to incorporate (United Nations General Assembly, 2015).

A DSS is a computer-based information system where models and data are combined in order to solve semi-structured and some unstructured problems with extensive involvement of a user (Averweg, 2012).DSS is a methodology where decision making is supported through an interactive, flexible, adaptable computer based information system (CBIS) easily developed to supporting a solution (Waghmode & Jamsandekar, 2014).

Existing decision support systems regarding rural water supply services

There are many Decision Support system tools in the rural water supply sector. Some of the DSS tools that are reviewed and resemble the DSS tool developed are discussed here under.

Sustainability Assessment Tool (SAT)

Developed by the Swiss community of practice, AGUASAN, the SAT is a tool for reviewing existing interventions of programs and helps to support future WASH programs planning. With 22 indicators that have each 2 to 8 sub indicator questions, the SAT assesses the economic, environmental, institutional, knowledge, social, and technological aspects of a WASH program intervention. The tool was pilot tested during an assessment of rural water schemes in Kosovo in 2010. The SAT's strengths include: its comprehensiveness to cover the assessment of social, economic, environmental, knowledge, institutional and technological aspects, it shows in what ways should a sector must be developed to increase sustainability. The SAT's weaknesses are: its limited application and its high number of indicators and sub-indicators (22 and 110) (Schweitzer, et al., 2014).

Water Aid's Sustainability Snapshot Tool

The water aid sustainability snapshot tool is a simple screening tool of sustainability, developed by the International NGO, Water Aid in 2003. This tool assesses the general technical, financial and equipment-spares parts aspect of a rural water supply service in a brief but comprehensive manner to produce a score that represents a quick image of the sustainability status of a rural water supply service (Sugden, 2003). Its weakness is its lack of depth and lack of integration of sectors other than technical and financial aspects. Its strength is, its speed to quickly screen the sustainability status of a rural water supply service.

WASH Life-Cycle Assessment

It was developed by McConville as part of a master thesis and is used to evaluate completed water and sanitation projects. Its framework is composed of a matrix that consists five sustainability factors (Socio-cultural respect, community participation, political cohesion, economic sustainability, environmental sustainability) and five project life stages (needs assessment, conceptual design and feasibility, design and action planning, implementation, operation and maintenance) (McConville, 2006).

The methods of scoring include a checklist consisting 100 sustainability recommendation questions (4 per matrix element), a rating (0-4) for each matrix element that provides an overall sustainability score on a scale of 0-100 and a score for each project life stage and each sustainability factor (out of possible 20 points) presented on a radar diagram.

The tool has been applied in completed water and sanitation projects at Mali, Honduras, Benin and Uganda. The tool's strengths include it's easy to use, useful to assess post implementation of a project, uses a life cycle thinking approach to assess the sustainability of a project across each stage of its life. The tool's limitations are that it plans each life stage separately and weighting of sustainability factors are not incorporated in the scoring.

Tool for Planning, Predicting & Evaluating Sustainability (TOPPES)

TOPPES was developed in Ghana by the WSA (Water and Sanitation in Africa). The TOPPES predicts service delivery sustainability for WSA projects from socio-economic, service delivery, water resources /quality/ and environmental needs, technical, financial, O& M and institutional contexts where each factor has a number of indicators, totaling 23, which are scored by answering 92 yes/no sub-indicator questions. Scores are then weighted according to perceptions of importance that resulted from the field test (Schweitzer, et al., 2014).

As a methodology, a case study approach is used and judgmental sampling technique where a comprehensive list of communities with interventions is used to identify communities where data will be collected. After that Data is collected through focus group meetings with water committees, physical inspections, and in some cases information from district level is incorporated. TOPPES produces outputs that comes from sustainability score results labeled as sustainable, moderately sustainable or not sustainable. The tool's strengths are its comprehensive assessment of the different sustainability factors, it can also be used at the post project period as an evaluation tool or on the pre-project stage as a planning tool. The tool's limitation is its condensed application to water supply only excluding sanitation aspects.

Sustainability Index Tool (SIT)

In 2012 the USAID and Rotary International developed the SIT. The SIT assesses sustainability of WASH services from institutional, management, financial, technical and environmental point of view. Each factor consists sub-questions but without a weighting. Data is collected through site inspections, household and key informant interviews, focus group discussions at various levels (service, district, national), review of policy documents and technical standards and norms. After data is collected, results are presented as aggregate scores, graphically. It includes both urban and rural intervention and provides a rigorous quantitative assessment which makes it potential for scalability (Rotary International, USAID, 2012).

With a pdf guiding document and excel spread sheets the SIT assesses sustainability factors of services under the category of Water Supply, Sanitation and Hygiene and sub category of community reticulated systems, community hand pumps, utility water systems, water source protection, water pan systems, rain water harvesting, institutional sanitation, household sanitation, hygiene and hand washing promotion, household water treatment. The SIT's strengths are its detailed assessment framework that incorporates the different administrative (national, regional or district) levels and its incorporation of water supply, sanitation and hygiene in the sustainability assessment. Its limitations are-high cost for assessment:

- complexity in terms of application
- complexity in terms of the indicators used.
- continuous requirement of the indicators used to be modified according to the country's context where the tool is applied.

Decision Support System Development

DSS Tool Design

The preferred computer programming language to design the DSS tool is visual basic because it is a method simple for building user interfaces, flexible to apply and efficient in that it can interface with codes written in C++ or #C programming language. The visual basic programming language is written by the integrated development environment of Visual Studio 2013. Since it is intended to make the DSS tool a windows desktop application, it is created by windows forms application part of visual basic.

The software is designed by integrating the required information, tools, models and decision-making procedures in a user-friendly interface system. The software consists three main levels of process which comprises functionalities for data input, data analysis (data query) and display of results.

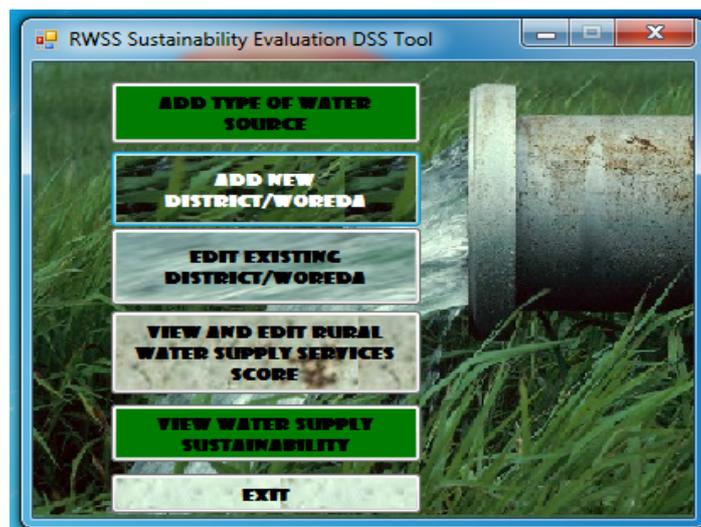


Figure 1. The user interface applied as home page in the RWSS Sustainability Evaluation DSS Tool

Three premises were used in the design of the DSS tool architecture. Firstly, the system is built based on forty two significant indicators of sustainability: Service functionality, working hours, system defect,

breakdowns per year, leakage, assigned person, water loss design consideration, minimum water pressure, break pressure tank/pressure reducing valves, minimum head loss in system, electricity availability, water metered, water metered versus water consumed, unaccounted for water, maximum pressure in system tariff cost, tariff setting, differential tariff, punitive measures, financial book keeping system, bank account, tariff per m³, tariff versus household income community consultation, community contribution, women in WASHCO, community satisfaction, tariff level perception, willingness to pay, days without repair, spare parts availability, construction supervision form, water technician availability, training on operation and maintenance, training on procurement management, seasonal water availability, chlorine addition, contamination risk, lpcd consumption, waiting time, water source conservation and residual chlorine. These indicators that are based on literature from (Sara & Katz, 1998) are divided into five factors called: Technical, Financial, Social, Institutional and Environmental.

Secondly, the system has the capacity to analyze the sustainability indicators scores and the weighting factors and automatically generate an overall sustainability score. The overall sustainability score for a rural water supply service is obtained by multiplying the indicator score comprising three kinds of scores (0,0.5 and 1) in which 1 represents likely sustainable rural water supply services, 0.5 represent less likely sustainable and 0 represents unlikely sustainable rural water supply services. Adapting a weighting factor from (Lockwood, et al., 2003), the Overall sustainability score is computed by this equation.

Equation of Overall Sustainability Score Computation

Overall Sustainability Score =Sustainability Indicator Score ×Weighting factor

Based on the overall sustainability score, the DSS tool analyze and decide a rural water supply service to be **“likely sustainable”** if the sustainability score is above 66% , **“less likely sustainable”** if the scheme is between 33%-66% and **“unlikely sustainable”** if the rural water supply service is below 33%.

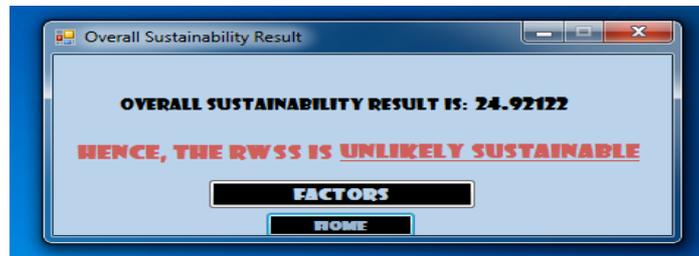


Figure 2. The RWSS Sustainability Evaluation DSS Tool presenting the overall sustainability score result

Thirdly, the system has the capacity to compare between the different factors and rank in order the factors that influence the overall sustainability score of the rural water supply service. The factor that score least among the five factors shows the sector of rural water supply service where more work needs to be done.

The RWSS Sustainability Evaluation DSS tool also shows which water source is more sustainable than other water sources presented in a woreda/district. This is useful in identifying the most sustainable water source in a woreda/district by analyzing the different water sources in type and in quantity.

The RWSS Sustainability Evaluation DSS tool is designed for engineers and planners that are involved in the planning and implementation of rural water supply services. It is designed to be used as both a post project evaluation tool and a pre project planning tool.



Figure 3. The RWSS Sustainability Evaluation DSS Tool showing the factors that affect the sustainability of rural water supply services in descending order

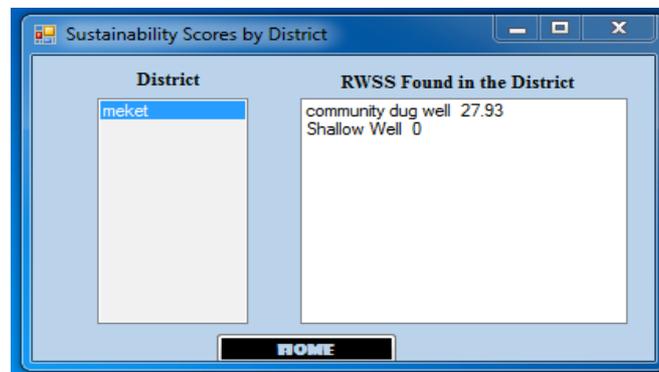


Figure 4. Sustainability scores of every water supply source categorized by their type in a sample district

DSS Tool test and result

The RWSS Sustainability Evaluation DSS Tool was applied on different areas of Ethiopia that have different rural water supply services. After primary and secondary data collection (through the structured indicator questionnaires and observation checklist of the WHO sanitary inspection form) was made, the data were entered in the DSS tool for a real time analysis.

A total of eleven rural water supply schemes categorized into four types of water sources were tested using the DSS tool. Ten of the RWSS are found in North Wollo Zone of Amhara region and one is at Arsi Zone, Oromia region of Ethiopia. Out of The Ten RWSS found in North Wollo Zone Seven of the schemes are hand dug wells with hand pump, two shallow wells and one spring at spot. One RWSS (Multi-village water supply scheme) is located at Arsi zone of Oromia region, Hitosa Woreda/District.

From the real time analysis of the DSS tool, it is found out that increased social scores which represents community contribution and social participation contributing to increased sustainability scorings. This is similar with the findings of (Sharma, 2012) and (Hurst & Moges, 2013) where increased involvement and social participation of the community and increased community contribution majorly contributing to the sustainability of rural water supply services.

From the studied RWSS, it is found out that schemes with distribution are more sustainable than isolated on spot schemes. This is similar with the finding of (Gebrie, 2012) which remarks that a shift is needed from isolated source scheme to rural water schemes with distribution, to ensure sustainability in Ethiopia.

It is found that ensuring cost recovery of the services highly contribute to the sustainability of the rural water supply services which is a similar finding with (Gebrie, 2012) that concludes tariff models should ensure cost recovery of rural water supply services and not only operation and maintenance costs.

Conclusion

The formulated DSS Tool's distinctive features include its user friendliness, easy to use and apply, and a very low cost of application compared to other DSS tools. Its application not only points out the sustainability scores of RWSS but also identifies the factors behind the failure to achieve the likely sustainability scores. The DSS Tool further answers which water supply source in a district is most feasible in terms of sustainability and hence is preferable for construction. The flexibility of the software makes it easy to analyse the sustainability of RWSS at district level, zone level, region level or even national level. Future development of the DSS tool is needed to incorporate more rural sanitation and hygiene sustainability assessment features into the DSS tool.

From the real time analysis of the DSS tool and its finding, it is concluded that increasing community contribution and social participation, ensuring cost recovery and developing services with distribution schemes than isolated spot schemes increases sustainability of rural water supply services.

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