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PROPOSED FRAMEWORK FOR SUSTAINABILITY MANAGEMENT OF THE RECOMMENDED QUALITY AND QUANTITY OF DRINKING WATER IN MALAWI

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ABSTRACT

For over a decade now, there has been an advice in the literature that all the factors that affect sustainability of the quality and quantity of drinking water (drinking water supply services) have to be managed in order for the drinking water supply services to be sustainable. However, the existing frameworks only manage some of the factors. This study was conducted to develop a framework for managing all the factors that affect sustainability of drinking water supply services in Malawi. The developed framework identifies the combined effects of the factors that affect sustainability of drinking water supply services, and the root causes that trigger the combined effects. The framework then facilitates development as well as implementation of the strategies and tactics for managing the identified combined effects and the associated root causes. The framework is based on the concept that a problem is only solved completely when it is the root causes that are addressed. As such, use of the framework is expected to improve sustainability of drinking water supply services in Malawi.

Keywords: drinking water supply, interaction of factors, Malawi, root causes, sustainability factors

INTRODUCTION

At 90%, drinking water supply (DWS) coverage in Malawi is quite good compared to the other countries in the Sub-Saharan Africa. Actually, Malawi is one of the only twelve countries in the Sub-Saharan Africa (out of 49 countries) where the DWS coverage is 90% and above (UNICEF/WHO, 2015). The other countries where the DWS coverage is 90% and above are Mauritius, Sao Tome and Principe, Botswana, Seychelles, Gabon, South Africa, Cape Verde, Namibia, Comoros, Djibouti, and Gambia. The high DWS coverage in Malawi is due to the effort made to achieve the Millennium Development Goal (MDG) number 7c which required countries to halve by the year 2015, the percentage of people who did not have sustainable access to safe drinking water in 1990 (UNGA, 2000; IOB and UNICEF, 2011). However, despite the high DWS coverage, the cases of waterborne diseases in Malawi account for 3% of all illnesses recorded in the health facilities. It should be noted that 3.0% average prevalence rate of water-borne diseases signals a problem with the safety and adequacy of the water used in Malawi. Results from a worldwide study by Pruss-Ustun et al (2008) show that water-borne diseases, where 100% of the people use unsafe water, account for an average of 3.5% of all illnesses. Based on this finding, the average prevalence rate of water-borne diseases in Malawi, where 90% of the people have access to improved water sources, should have been about 0.4% and not 3.0%. The study by Ungwe and Morton (2014) links the high prevalence rate of waterborne diseases in Malawi to the unsustainability of the quality and quantity of drinking water that is supplied to the people. DWS can only accomplish its main purpose of maintaining and/or improving public health (Bostoen, 2005; UNICEF and WHO, 2012) if the supplied drinking water is safe and adequate all the time (Sanders and Fitts, 2011). If safe and adequate water is not available all the time, even where supply interruptions are occasional, public health cannot be maintained nor improved (Hunter et al, 2009). This is the case because during water supply interruptions some people are forced to use unsafe and/or inadequate water.

In Malawi, the quantity and quality of the drinking water that is supplied to the people, deteriorate as time passes after commissioning of the water supply systems (Ungwe and Morton, 2014). The deterioration continues to the extent that in some water supply systems, the quantity and/or quality of the drinking water becomes too little and/or too poor to maintain and/or improve public health. However, the DWS practitioners in Malawi have not done much about this situation. This has been the case partly because MDG 7c did not put much emphasis on the quantity and quality of water supplied but on the number of people who had access to improved water sources (UNICEF/WHO, 2012). Lack of emphasis that drinking water should always be adequate and safe for human consumption contributed to construction of water supply systems (during the era of the MDGs) that did not have, and some of them still do not have, the capacity for continued supply of adequate and safe drinking water. However, people who consume water which is too little and/or too poor to maintain and/or improve public health suffer from waterborne diseases (Malawi Ministry of Health, 2015). This problem can be solved if people are provided with drinking water of the recommended quality and quantity in a sustainable manner.

FACTORS THAT AFFECT SUSTAINABILITY OF DWS SERVICES

Sustainability of the quantity and quality of drinking water, which is the continued flow of water at the same rate and quality as per the design of a water supply system, is affected by a number of factors. A study conducted by Ungwe and Morton (2014) identified 67 factors that affect sustainability of DWS services in Malawi (Appendix A). The author of this paper

found out that the practitioners in DWS management in Malawi do not use systematic methods to manage sustainability of DWS services. As a result, not all the factors are managed. Consequently, DWS services are not sustained because of failure to manage some of the factors. The author, therefore, looked for the existing frameworks that can be used to manage the factors in order to sustain the quality and quantity of drinking water. Three frameworks were identified, namely; framework for sustainable rural water supply services by WaterAid (2010), sustainability model of rural water supply systems by Masduqi et al, (2009), and sustainability snapshot by Sugden (2003). Review of these frameworks by the author revealed that the frameworks would not address all the issues that affect sustainability of the DWS services in Malawi. Some of the frameworks would address certain issues while other frameworks would address other issues; with none of them being able to address all the issues. For example, the framework by WaterAid (2010) would not be able to address the issue of continued safety and adequacy of water because while the framework talks of monitoring of compliance of the services to the standards, it does not indicate concrete actions that need to be taken, when and by who, in order to address the shortfalls that would be identified during the monitoring. The framework by Masduqi et al (2009) would not address the issues of continued safety and adequacy of water because these issues are not covered in the framework. On its part, the sustainability snapshot by Sugden (2003) would not address the issues of the quantity and quality of raw water as well as continued safety and adequacy of water provided to the users. This would be the case because the framework only deals with the functionality level of water supply infrastructure by ensuring that maintenance of the infrastructure is carried out in the recommended manner.

The three frameworks would not be able to address all the issues because they only manage some of the factors that affect sustainability of DWS services. While this is the case with the existing frameworks, the literature states that each of the factors has to be managed for DWS services to be sustainable (Nkambule and Peter, 2012). This is important because all the aspects required for sustainability of DWS services have to be maintained, otherwise failure of any one of them renders the DWS services not sustainable (Abrams, 1998; Khan, 2000; Lockwood and Smits, 2011). To simplify management of all the factors, Belassi and Tukel (1996); Clarke (1998) and King (1996) advise that it is the interactions of the factors that should be managed. By conducting cause-and-effect analysis, Ungwe and Morton (2014) established the interactions of the factors that affect sustainability of DWS services. These authors established that there are 26 root causes that kick-start interactions of the factors in Malawi (Appendix B). The interactions of the factors affect sustainability of DWS services by triggering seven combined effects. The seven combined effects that are triggered are:

a. Quantity of available raw water;
b. Quality of available raw water;
c. Capacity of infrastructure to produce and supply adequate water continually;
d. Capacity of infrastructure to produce safe water continually;
e. Continuity of infrastructure to function as required at the design stage;
f. Capacity to operate the infrastructure; and
g. Realisation of service provider expectations

(Ungwe and Morton, 2014).

This study was conducted to develop a framework for holistic management of all the factors that affect sustainability of DWS services in Malawi. This was to be achieved by managing the interactions of the factors.

THE REQUIRED FRAMEWORK

Having noted from the literature that interactions of the factors that affect sustainability of DWS services are kick-started by the root causes (Ungwe and Morton, 2014), and that a problem is only solved completely when it is the root causes that are addressed (Dew, 1991; Doggett, 2005), the author of this paper postulates that a framework that can facilitate sustainability of the DWS services should address the root causes.

THE 6-STEP 7-STRATEGY FRAMEWORK FOR SUSTAINABLE DWS SERVICES IN MALAWI

The 6-step 7-strategy framework has been developed to facilitate sustainability of DWS services in Malawi. The framework has been developed based on what works in practice to sustain the quality and quantity of drinking water. The graphical representation of the 6-step 7-strategy framework for sustainable DWS services in Malawi is in figure 1.

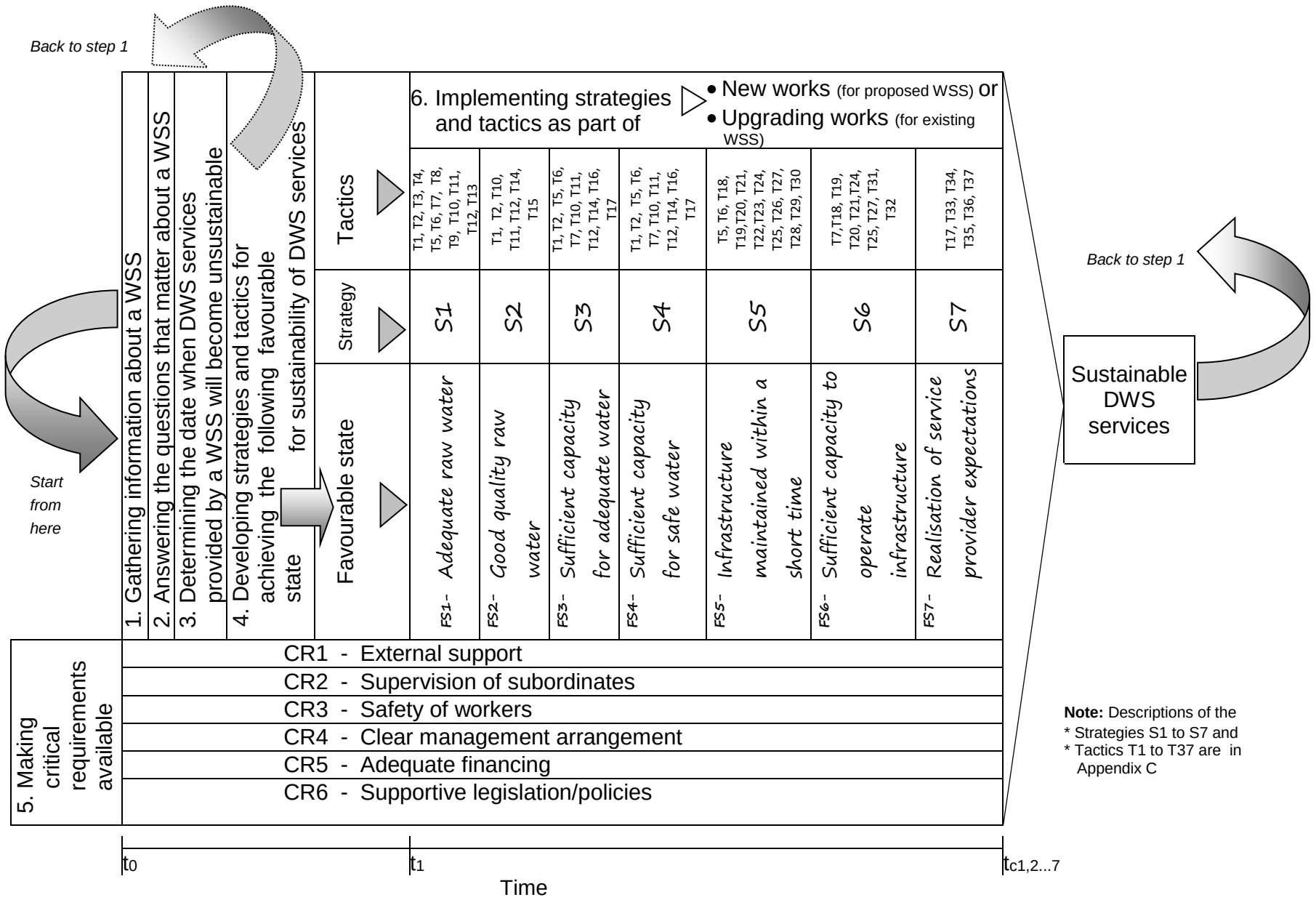

Figure 1: The 6-step 7-strategy framework for sustainable DWS services in Malawi

Source: Author

The framework in figure 1 is known as '6-step 7-strategy framework for sustainable DWS services in Malawi' to reflect the number of steps that need to be followed, and the maximum number of strategies that need to be employed to achieve sustainable DWS services. The 6 steps are as follows:

Step 1: Gathering information about a water supply system (WSS)

To identify the combined effects that affect or have potential to affect sustainability of DWS services in a WSS, there is a need to collect some information. The information to be collected should relate to the time a WSS was being designed, at present and in the future. This is supported by Sanders and Fitts (2011) who state that data for a WSS should be gathered at the time of design and throughout the life of a WSS. For this to be achieved, the practitioners in DWS in Malawi need to change their tendency of not collecting and storing correct data. Sugden (2003) notes that, at the time of his study, data related to drinking water supply in Malawi was limited, inaccurate and dissipated.

The information that is required, hence should be collected under this framework, is:

a. Quantity of available raw water;
b. Quality of available raw water;
c. Capacity of infrastructure to produce and supply adequate water;
d. Capacity of infrastructure to produce safe water;
e. Continuity of infrastructure to function as per design;
f. Capacity to operate the infrastructure; and
g. Realisation of service provider expectations.

Once collected, the information should be analysed and trends established.

Step 2: Answering the questions that matter about a WSS; and

Step 3: Determining the date when DWS services will become unsustainable

Using the information collected in step 1, sustainability of DWS services in a WSS should be assessed. Assessment of the sustainability of DWS services in a WSS is important because the results from the assessment enlighten the authorities whether or not the DWS services are or will be sustainable. Assessment of the sustainability of DWS services also assists to identify sustainability-related challenges so that corrective measures can be taken on time (Khan, 2000).

The assessment of DWS sustainability should be conducted by answering the following questions:

a. Is raw water adequate for the demand? If yes, when will it become inadequate?
b. Is the quality of raw water good? If yes, when will it become poor?

c. Is the capacity of the infrastructure sufficient to produce and supply adequate water? If yes, when will the capacity of the infrastructure become insufficient to produce and supply adequate water?
d. Is the capacity of the infrastructure sufficient to produce safe water? If yes, when will the capacity of the infrastructure become insufficient to produce safe water?
e. Are the broken down parts of the infrastructure maintained within a short time? If yes, when will the broken down parts of the infrastructure not be maintained in a short time?
f. Is there adequate capacity to operate the infrastructure? If yes, when will the capacity not be adequate to operate the infrastructure?
g. Are the service provider expectations being realised? If yes, when will the service provider expectations not be realised?

The first parts of the above 7 questions will assist to find out whether the DWS services are sustainable or not. The answer 'No' to any of the first parts of the 7 questions means that the combined effect is in the unfavourable state for sustainability of DWS services (the opposite of FS1 to FS7 presented in step 4). Therefore, the DWS services would not be sustainable.

For each question where the answer is 'No', the root causes of the unfavourable state of the combined effects should be identified. A list of the root causes of unsustainable DWS services in Malawi is in Appendix B.

The second parts of the 7 questions will assist to find out when the DWS services are likely to become unsustainable i.e. time $t_{c1,2...7}$, where t_{c1} is the date when the combined effect 1 will be in the unfavourable state for sustainability of DWS services, t_{c2} is the date when the combined effect 2 will be in the unfavourable state for sustainability of DWS services etc. The DWS services will become unsustainable at the time the state of any one combined effect will become unfavourable (see step 4).

Step 4: Developing strategies and tactics for achieving the favourable state

For the combined effects whose state is already unfavourable and/or those whose unfavourable state will occur in future as per the assessment in steps 2 and 3, appropriate strategies and tactics should be developed. Development of strategies and tactics is supported by Carter and Rwamwanja (2006) who advise that to achieve service sustainability, there should be plans on the required activities. The strategies and tactics should be for changing the unfavourable state of the combined effects to favourable state for sustainability of DWS services. Where the combined effects are in the favourable state, the strategies and tactics should be for preventing the favourable state from slipping into unfavourable state. The favourable state for each of the combined effects as shown in figure 1 is:

FS1 - Adequate raw water (Abrams, 1998);

FS2 - Good quality raw water (Abrams, 1998);

FS3 - Sufficient capacity to produce and supply adequate water (Lockwood, 2003);

FS4 - Sufficient capacity to produce safe water (Lockwood, 2003);

FS5 - Maintenance of infrastructure within a short time when it breaks down (Carter et al,1999);

FS6 - Sufficient capacity to operate the infrastructure (Lockwood, 2003); and

FS7 - Realisation of service provider expectations (Al-Tmeemy et al, 2011).

Generic strategies and tactics have been developed as part of the larger research of which this study forms part. The developed generic strategies and tactics are in Appendix C.

Depending on the length of the period between the time the strategies and tactics are developed, t_1 and when the DWS services are projected to become unsustainable ($t_{c1,2...7}$), implementation of the strategies and tactics can commence immediately, or can wait for some time. If implementation of the strategies and tactics will wait, then the process should start all over again beginning with gathering new information.

Step 5: Making critical requirements available

It is noted in the literature that there are 6 critical requirements which may be required in all the 6 steps for sustainability of DWS services in Malawi (Ungwe and Morton, 2014). The 6 critical requirements are external support, supervision of subordinates, safety of workers, clear management arrangement, adequate financing, and supportive legislation/policies. The availability of the 6 critical requirements will ensure that the strategies and tactics are implemented effectively. As such, mechanism should be put in place to ensure that all the 6 critical requirements are available at the required level.

Step 6: Implementing strategies and tactics

The strategies and tactics developed in step 4 should be implemented before time, $t_{c1,2...7}$ otherwise the DWS services will become unsustainable. The strategies and tactics should be implemented as part of new works where the concerned WSS is yet to be established or as part of upgrading works where the concerned WSS has been in existence for some time.

The cycle of the framework (step 1 to step 6 and back to step 1, or step 1 to step 4 and back to step 1) should be repeated continually including during implementation of strategies and tactics. This will assist to check if all the combined effects of the factors are in the favourable state for sustainability of DWS services (FS1 to FS7). If some combined effects are in the unfavourable state (the opposite of FS1 to FS7), or are likely to be in the unfavourable state in the future, the activities in the next cycle of the framework should identify the root causes, and appropriate strategies and tactics should be implemented accordingly.

WHO SHOULD CARRY OUT THE ACTIVITIES OUTLINED IN THE FRAMEWORK

An institution that manages a WSS and wants to use the 6-step 7-strategy framework for sustainable DWS services should assign a staff member or establish a unit (depending on the number of WSSs and/or their complexity) to be collecting information outlined in step 1. The collected information should be submitted to the head office for the WSS. At the head office, there should be a unit to establish the trends of consumption figures for each water user, quantity and quality of raw water, water demand growth, and magnitude of floods, among others. The unit should analyse the established trends, and other information received from the WSSs.

After analysing the information, the unit should answer the questions that matter about a WSS, determine the date when the DWS services are likely to become unsustainable, and develop strategies and tactics i.e. steps 2, 3 and 4. Mechanism for ensuring availability of the 6 critical requirements should be proposed.

The above details should be contained in a report which should be submitted to the senior managers of the institution that manages a WSS under review. After reviewing the report, the senior managers should submit the report to the DWS Services Regulator with a copy to the ministry responsible for DWS. At the Regulator's office, the unit responsible for sustainability of DWS services should review the report and satisfy itself that the report is correct. If not correct, the report should be sent back to be corrected. Once the report is correct, the unit responsible for sustainability of DWS services at the DWS Services Regulator should have keen interest and follow up with the institution that manages a particular WSS to ensure that the strategies and tactics outlined in their report are implemented on time.

The above discussions show that there should be staff at individual WSSs to gather information. Then there should be a unit at the head office which should compile a report for submission to senior management. In turn, the report should be submitted to the DWS Services Regulator which should have a unit responsible for sustainability of DWS services.

UNIQUENESS OF THE DEVELOPED FRAMEWORK

The framework developed in this study is different from the existing ones in that:

a. It is holistic i.e. it includes 7 strategies and 37 tactics that address all the 7 combined effects and the related root causes respectively;
b. It includes practical steps that need to be followed in the process of implementing the framework; and
c. It includes critical requirements necessary for effective implementation of the strategies and tactics.

One key advantage of using the proposed framework is that works for sustaining the DWS services can be planned well in advance. Such works can be staggered to fit the available financing contrary to the current practice in Malawi where the required works are only determined after encountering challenges with sustainability of DWS services or when funds are sourced. For example, the biggest segment of the respondents in the descriptive survey (36%) conducted by Ungwe and Morton (2014) stated that an analysis for checking whether or not the quantity of raw water that will be available in future will be adequate for the demand was only conducted after a problem was experienced. To solve a problem which was already being faced, all the required works were supposed to be implemented at once. However, implementation of all the required works at once, and after a long break, requires a lot of funds which may not be easy to source, as observed by the respondents.

CONCLUSIONS AND RECOMMENDATIONS

The framework for sustainable drinking water supply services in Malawi, presented in this paper, addresses all the factors that affect sustainability of drinking water services. This is the case because by managing the root causes, all the factors that are triggered by the root causes are automatically addressed. Further, by managing the root causes, sustainability of drinking water supply services is expected to improve because a problem is solved completely when it is the root causes that are addressed (Dew, 1991; Doggett, 2005). The framework is furthermore expected to improve sustainability of drinking water supply services because it has been developed based on what works in practice to sustain the quality and quantity of drinking water. It is, therefore, recommended that the Government of Malawi should develop a policy that will require water utilities to use the framework developed in this study to improve sustainability of drinking water supply services in Malawi. This will ensure that drinking water is not only supplied to the increased number of people but also that the supplied drinking water is always of the recommended quality and quantity. In addition to Malawi, the framework presented in this paper, is expected to improve sustainability of DWS services in other countries with similar contexts.

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Appendix A: Factors that affect sustainability of the recommended quality and quantity of drinking water in Malawi

1.	Type of technology	23.	Continued training
2.	Quality of infrastructure	24.	Involvement of motivated personnel
3.	Proper handover of new infrastructure	25.	Human resource management
4.	Infrastructure that works as required	26.	Realistic objectives
5.	Continuous upgrading of infrastructure e.g. extension of pipe network	27.	Stability of economic status of users
6.	Preventative maintenance	28.	Supportive legislation/policies
7.	Rate of breakdown of infrastructure	29.	Population growth rate
8.	Extent of breakdown of Infrastructure	30.	Developmental improvements
9.	Performance by consultants	31.	Equity in distribution of water resources
10.	Performance by contractors	32.	Natural condition of water catchment area
11.	Capacity to maintain infrastructure	33.	Protection of water source
12.	Capacity to operate infrastructure	34.	Quantity of raw water
13.	Performance by suppliers	35.	Quality of raw water
14.	Use of alternative water sources	36.	Perennial source of water
15.	Efficiency of using water resources	37.	Social/economic activities in water catchment area
16.	Vandalism of infrastructure	38.	Involvement of appropriate stakeholders
17.	Growth of water demand	39.	User involvement
18.	Age of infrastructure	40.	User satisfaction with a service
19.	Availability/adequacy of supplies e.g. power supply	41.	Continued use of supplied water as expected at the design stage
20.	Leaking water supply facilities	42.	Achievement of benefits by users e.g. health and economic benefits
21.	Rewards to all people involved in provision of DWS services	43.	Availability/use of adequate financial resources
22.	Involvement of trained personnel	44.	Spare parts supply

Appendix A: continued

45. Management arrangement (type) of water supply system	60. Realisation of service provider expectations
46. Maintenance tools supply	61. Integrity in project appraisal
47. Climate change impacts	62. Project owner's flexibility to change its predetermined requirements based on expert advice
48. Lessons from past projects/ organisational learning	
49. Troubleshooting	
50. Safety of workers	63. Project sponsor's knowledge of local situation versus dictation of requirements
51. Involvement of senior managers in a project	
52. External support	64. Quantity of potable water used
53. Project owner requirements	65. Quality of water used
54. Project sponsor regulations	66. Supply of water to the people living close to the water supply infrastructure
55. Supervision of subordinates	
56. Level of water loss	
57. Wasteful usage of water	67. Amount of information shared with the water users
58. Water demand management	
59. Political support/interference	

Source: Ungwe and Morton (2014)

Appendix B: Root causes of unsustainable drinking water supply services in Malawi

RC1 - Failure to protect water catchment areas;
RC2 - Wasteful usage of water;
RC3 - Unavailability of spare parts;
RC4 - Unavailability of appropriate maintenance tools;
RC5 - Number of personnel that does not consider amount of work to be carried out;
RC6 - Failure to issue and regulate water rights for some water users;
RC7 - Poor natural condition of water catchment areas;
RC8 - Climate change impact - decrease in rainfall;
RC9 - Increased population;
RC10 - Increased non-domestic activities that use water;
RC11 - Limited continued training of staff;
RC12 - Low remuneration;
RC13 - Water not supplied to people living close to the water supply infrastructure;
RC14 - Use of infrastructure beyond its useful life span without refurbishment;
RC15 - Poor performance of designers;
RC16 - Project owner's refusal to change its predetermined requirements in spite of the experts' advice;
RC17 - Project sponsors who do not have adequate knowledge of local situation but insist to prescribe requirements;
RC18 - Poor performance by contractors;
RC19 - Climate change impact - extreme floods;
RC20 - Poor performance by suppliers;
RC21 - Political interference on where a project should be implemented;
RC22 - Limited information shared with water users;
RC23 - Limited capacity of infrastructure to produce and supply adequate water;
RC24 - Limited capacity of infrastructure to produce safe water;
RC25 - Poor economic status of water users; and
RC26 - Lack of political will on the need for people to use safe water.

Source: Ungwe (2015)

Appendix C: Generic strategies and tactics

C1: Generic strategies

S1 - Ensuring that raw water for DWS is always in sufficient quantity to satisfy the demand and is at a place from where it can be supplied in a cost-effective way;
S2 - Ensuring that raw water for DWS is always of a quality that can be treated by the existing infrastructure in a cost-effective way;
S3 - Ensuring that infrastructure for DWS always has sufficient capacity to produce and supply adequate water for the demand;
S4 - Ensuring that infrastructure for DWS always has sufficient capacity to produce water which is safe for human consumption;
S5 - Ensuring that broken down infrastructure is maintained within a short time;
S6 - Ensuring that there is always sufficient capacity to operate DWS infrastructure in the required manner; and
S7 - Ensuring that there is always conducive environment for all people to use adequate quantities of potable water in order to realise health benefits and that there is adequate funds for managing the WSSs in the required manner.

C2: Generic tactics

T1 - Declare water catchment area as a protected area;
T2 - Manage water catchment area;
T3 - Monitor water consumption figures for users;
T4 - Maintain leaking facilities;
T5 - Prepare a list of required spare parts and appropriate maintenance tools;
T6 - Prioritise and enforce purchase of spare parts and appropriate maintenance tools;
T7 - The number of staff should be based on the amount of work to be carried out
T8 - DWS service providers should be proactive in ensuring that their water rights are not violated;
T9 - Monitor the trend of the quantity of available raw water;
T10 - Develop and use alternative/additional water source;
T11 - Authorities responsible for land development should be advised not to allow additional people and developments in the affected area;
T12 - Relocate the affected settlement to a new area
T13 - Government should provide financing for DWS systems which are not cost-effective;
T14 - Construct water impoundment structures;
T15 - Monitor the trend of the quality of available raw water;
T16 - Upgrade existing water supply infrastructure in time;
T17 - Monitor the trend of the water demand growth;
T18 - Prepare a training schedule for all staff members;
T19 - Implement training schedule;
T20 - Lobby training institutions in the country to introduce courses for staff working in water utilities;
T21 - Remuneration should not be substantially less than that offered by other water supply utilities in the country;
T22 - All people living close to water supply infrastructure should be supplied with water;
T23 - Refurbish infrastructure before expiry of its useful life time;
T24 - Foreign consultants should partner with local consultants;
T25 - Deliverables of designers should be critically evaluated;
T26 - A clause shifting blame of the cause of infrastructure failure from consultants to project owner should be included in consultancy contracts;
T27 - DWS service providers must not accept requirements prescribed by project sponsors which are likely not to work;
T28 - DWS service providers should assess the constructed facilities thoroughly to ensure compliance with the specifications;
T29 - Monitor the trend of the magnitude of the floods that occur;
T30 - Reconstruct infrastructure which is located across the rivers;

T31 - Use different supplier;
T32 - Use different supplies;
T33 - The ministry responsible for DWS and the DWS service providers should organise meetings to brief the politicians the consequences of implementing projects which do not satisfy appraisal criteria;
T34 - DWS service providers should share with water users information that affects the water users;
T35 - The ministry responsible for DWS and the DWS service providers should lobby the government to provide subsidies for the poor people to use adequate quantities of potable water;
T36 - DWS service providers should encourage water users to pay for water in small but frequent amounts; and
T37 - The ministry responsible for DWS and the DWS service providers should organise meetings to brief the politicians the dangers of people using unsafe water.

Source: Ungwe (2015)

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