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COMBINED EFFECTS OF THE FACTORS THAT AFFECT SUSTAINABILITY OF DRINKING WATER SUPPLY SERVICES IN MALAWI: A VALIDATED PERSPECTIVE

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ABSTRACT

The factors that affect sustainability of drinking water supply services (i.e. quality and quantity of drinking water) do so by triggering some combined effects which in turn affect sustainability of the drinking water supply services. This study was conducted to identify such combined effects. The combined effects were identified by conducting a cause-and-effect analysis in a focus group discussion, and validated through a descriptive survey and multiple case studies conducted in Malawi. The respondents of the survey were 40 drinking water supply practitioners while the multiple case studies involved ten drinking water supply systems. The finding is that the factors trigger seven combined effects. The paper argues that all the seven combined effects should be managed if all the aspects required for sustainability of drinking water supply services are to be maintained; and the drinking water supply services sustained.

Keywords: Drinking Water Supply, Service Sustainability Factors, Interaction of Factors, Combined Effects Of Factors, Categorisation Of Factors, Malawi

INTRODUCTION

The concept of sustainable development requires that all human needs should be available to both the present and future generations (United Nations World Commission on Environment and Development, 1987). A drinking water supply (DWS) service, which is one of the human needs, accomplishes its main purpose of maintaining and/or improving public health when the drinking water is of a certain quality and quantity (Bostoen, 2005; UNICEF and WHO, 2012). However, in Malawi, these parameters (quality and quantity of drinking water) deteriorate with time, which is in sharp contrast with sustainable development. For example, some rural piped DWS systems that used to supply safe water to all the users, no longer do so (World Bank, 2011). For instance, the results from the water quality surveillance conducted in 2009 in 10 rural DWS systems show that, on average, 86% of the samples collected from different places in the 10 areas were of contaminated water (Malawi Ministry of Irrigation and Water Development, 2009). As regards the situation in the individual DWS systems, it was noted that all the samples (100%) from 8 of the 10 DWS systems were of contaminated water, while 80% and 64% of the samples from the ninth and tenth DWS systems respectively were of contaminated water. The 10 DWS systems are located in different parts of Malawi.

In terms of the quantity of water supplied, information from 167 piped DWS systems in Malawi (19 piped DWS systems out of a total of 186 systems in 2014 were not studied because they were only about 2 years old) shows that the quantity of water available for supply to the users in 85% of the systems was less than the Government of Malawi recommended quantity of 36 litres per person per day. Consequently, water supply to the users was either intermittent or the flows from the taps were so low that it took a long time to fill a container. Low water flows from the taps occurred mostly in the rural areas.

For the urban areas, the challenge was mainly water supply intermittency. The average number of hours per day that water was available to the users in the urban areas was less than the planned 24 hours (World Bank, 2011). The results from a consumer survey conducted by the Ministry of Water Development and Irrigation in 2013 in 8 areas show that, on average, water was available to the users for 13 hours per day (Malawi Ministry of Water Development and Irrigation, 2013). In some areas, water was available only for 6 hours per day.

The challenge with the above situations was that people were forced to complement the inadequate safe water with the available contaminated water (Harvey and Reed, 2006). The result was that people contracted water-borne diseases despite having access to some safe water (Malawi Ministry of Health, 2011). There was, therefore, a need to ensure that the quality and quantity of drinking water were sustained. This study was part of a larger research aimed at finding ways for ensuring sustainability of the quality and quantity of drinking water in Malawi. In this study, sustainability of DWS services (quality and quantity of drinking water) is continued flow of water at the same rate and quality as per the design of the supply system.

FACTORS THAT AFFECT SUSTAINABILITY OF DWS SERVICES

The authors of this paper conducted an extensive review of the literature to identify the factors that affect sustainability of the quality and quantity of drinking water. Forty three (43) studies, conducted from 1960s to date (2014), were reviewed. The review was done following holistic and life cycle approaches, and as such, all possible factors that can affect service sustainability at any stage of a project were noted. The review resulted in the identification of 76 factors that affect or can potentially affect sustainability of DWS services. The identified factors are in Appendix A. Appendix A shows that a number of studies have been conducted to identify the factors that affect sustainability of DWS services. When the factors from different studies are put together, the list is long and almost exhaustive.

RECOMMENDED FACTORS FOR SUSTAINABILITY OF DWS SERVICES

The researchers and practitioners recommend that, when managing sustainability of the quality and quantity of drinking water, concentration should be on some of the factors. The factors on which concentration is recommended are referred to by different names such as main factors (Binder, 2008), key factors (McConville and Mihelcic, 2007), and critical factors (Sugden, 2003). The number of these factors varies. For example, Binder (2008) identified 3 factors while WaterAid (2010) identified 13 factors. The researchers and practitioners consider the main, key or critical factors important because:

a. The factors are listed in the best-practice guidelines (McConville and Mihelcic, 2007);
b. The factors are cited frequently in the literature (Lockwood, 2003; WaterAid, 2010);
c. The factors are given more weight than other factors by the authors (Lockwood, 2003);
d. The factors are observed to affect sustainability of water supply facilities (Masduqi, Soedjono, Endah and Hadi, 2009);
e. Personal experience of the authors and practitioners suggests that the factors are important (McConville and Mihelcic, 2007; WaterAid, 2010); and
f. The factors are identified and given more weight than other factors by the respondents.

The situation in Malawi was not different. Only financial self-sufficiency and decentralised day-to-day management of the DWS systems were considered as the factors that needed to be managed for sustainability of DWS services (World Bank, 2007).

The result of concentrating on a few factors was that the other factors were not managed. Consequently, DWS services were unsustainable not only in Malawi but also other countries (Khan, 2000; Saucer, Reilly and Shenhar, 2009). Examples of such other countries included Mauritania, Madagascar, Niger, DR Congo, Rwanda and Mozambique, among others (UNDP-WSP, 2006).

Gbadegesin and Olorunfemi (2007) state that for DWS services to be sustainable, there is need to adopt a holistic approach whereby all the factors should be considered rather than focussing on a few factors. Abrams (1998), Khan (2000) and Lockwood and Smits (2011) explain that it is important that all the factors should be managed otherwise management of some factors and not other factors, results in certain aspects required for sustainability of DWS services not being maintained; and that failure of any one aspect renders DWS services unsustainable. This, however, does not necessarily mean each and every factor should be managed in isolation. The factors could be grouped so that it is the interactions of the grouped factors that should be managed (King, 1996). After all, it is the combined effects of the factors that matter to achieve service sustainability, and not individual factors (King, 1996).

COMBINED EFFECTS OF THE FACTORS NOT IDENTIFIED

With the recommendation that it is the combined effects of the factors that should be managed for sustainability of DWS services, and that this recommendation had been made about two decades earlier, one expected the combined effects to have been identified and documented in the literature. However, literature review showed that the combined effects of the factors had not yet been identified. As such, the factors were not managed to address the combined effects but for the reasons mentioned in the preceding section. Consequently, only some of the factors were managed. Failure to manage all the factors resulted in certain aspects required for sustainability of DWS services not being maintained, which led to unsustainable DWS services (Abrams, 1998; Khan, 2000; Lockwood and Smits, 2011).

This study was, therefore, conducted to identify the combined effects of the sustainability factors for DWS services in Malawi.

RESEARCH METHODOLOGY

Having noted the above problem, one of the researchers in the current study facilitated a focus group discussion in Malawi in which a cause-and-effect analysis of the factors was conducted. The objective of the analysis was to identify the combined effects of the factors that affect sustainability of DWS services. Five participants took part in the analysis. The five participants were people who worked at Northern Region Water Board and had between 5 and 15 years experience in DWS management. The cause-and-effect analysis was done based on the experience of the participants and the descriptions in the literature.

After identifying the combined effects in the focus group discussion, a descriptive survey was conducted to assess if the combined effects identified from the cause-and-effect analysis affected sustainability of the DWS services in Malawi. In addition, the survey was conducted to establish the extent to which the combined effects facilitated and impeded sustainability of DWS services in Malawi. Three questions, which were part of a larger questionnaire, were dedicated to the present research. One question required the respondents to identify from a given list of the combined effects, the combined effects that were important for sustainability of DWS services in their water supply systems. The other two questions sought perceptions of the respondents on the extent that each of the combined effects facilitated or impeded sustainability of the DWS services in Malawi.

The respondents in the descriptive survey were people who worked in the organisations that provided DWS services in Malawi. The total number of the possible respondents in the survey was 50. Since this number is small, it was decided that data would be collected from all the possible respondents and that all the data would be analysed. A questionnaire was e-mailed to all the 50 possible respondents, and 40 completed questionnaires were returned. This represents 80% response rate, which is much higher than the acceptable minimum range of 30-40% for surveys (Moser and Kalton, 1971).

The participants in the focus group discussion as well as the respondents in the descriptive survey were people who worked at middle management level, and were involved in project design, implementation, operation, maintenance, and undertook monitoring and evaluation of the DWS systems, which are key activities that affect sustainability of DWS services (Gosling, 2010; Griffiths, 2007; Khan, 2000). People at middle management level were considered to be appropriate respondents for the focus group discussion and descriptive survey because they were the ones who either undertook the above activities in person or supervised implementation of the activities directly. As such, these people had adequate knowledge of the management of the DWS services in Malawi.

Multiple case studies were also conducted in the research. There were two objectives for the case studies. One, to identify the factors that affected sustainability of the quality and quantity of drinking water in Malawi, and two, to establish how those factors affected the sustainability of the two parameters i.e. quality and quantity of drinking water. Ten piped DWS systems in Malawi were studied. Purposive sampling was used to select the cases that were studied based on the criteria that ensured that the selected DWS systems were representative of all the piped DWS systems in Malawi. The criteria that were used related to the types of water sources, types of the institutions that managed the water supply systems, means of supplying water, and the administrative regions where the water supply systems were located, among others. The names of the selected case DWS systems are in table 1 and their locations in Malawi are shown in figure 1.

Interviews, document analysis, and observation were used to collect data from the case DWS systems. The interviewees were the senior managers from the institutions that managed the case DWS systems. In order to get a comprehensive and varied account of the key issues in the case DWS systems, at least three senior managers were interviewed from each of the five institutions that managed the case DWS systems. A total of 17 respondents were interviewed. The five institutions that managed the case DWS systems were the Department of Water Supply Services, Blantyre Water Board, Central Region Water Board, Northern Region Water Board and Southern Region Water Board. Considering their positions, educational qualifications, work experience, and professional background, the senior managers were considered to have adequate knowledge of DWS management in their organisations (Saqib, Farooqui and Lodi, 2008).

Table 1: Overview of the case DWS systems for the current research

Case No.	Name of piped DWS system	Administrative region in Malawi	Period of operation (years)	Type of managing institution	Type of water source	Sustainability of		Means of water supply
						Minimum required quantity of water supplied per capita	Quality of water supplied	
1	Chintheche	North	29	Water Board	Lake	√	√	Pumping
2	Chipoka rural	Central	23	Community	River	X	X	Gravity
3	Chipoka town	Central	29	Water Board	Lake	√	√	Pumping
4	Chiradzulu	South	49	Water Board	River	√	√	Gravity
5	Chitipa	North	46	Water Board	Boreholes	√	√	Pumping
6	Ighembe	North	40	Community	River	X	X	Gravity
7	Mudi	South	61	Water Board	Dam	√	√	Pumping
8	Mzuzu	North	74	Water Board	Dam	√	√	Pumping
9	Nkhamanga-Lunyina	North	36	Community	River	X	X	Gravity
10	Salima	Central	39	Water Board	Boreholes	√	√	Pumping

Key: √ ~ sustained X ~ not sustained

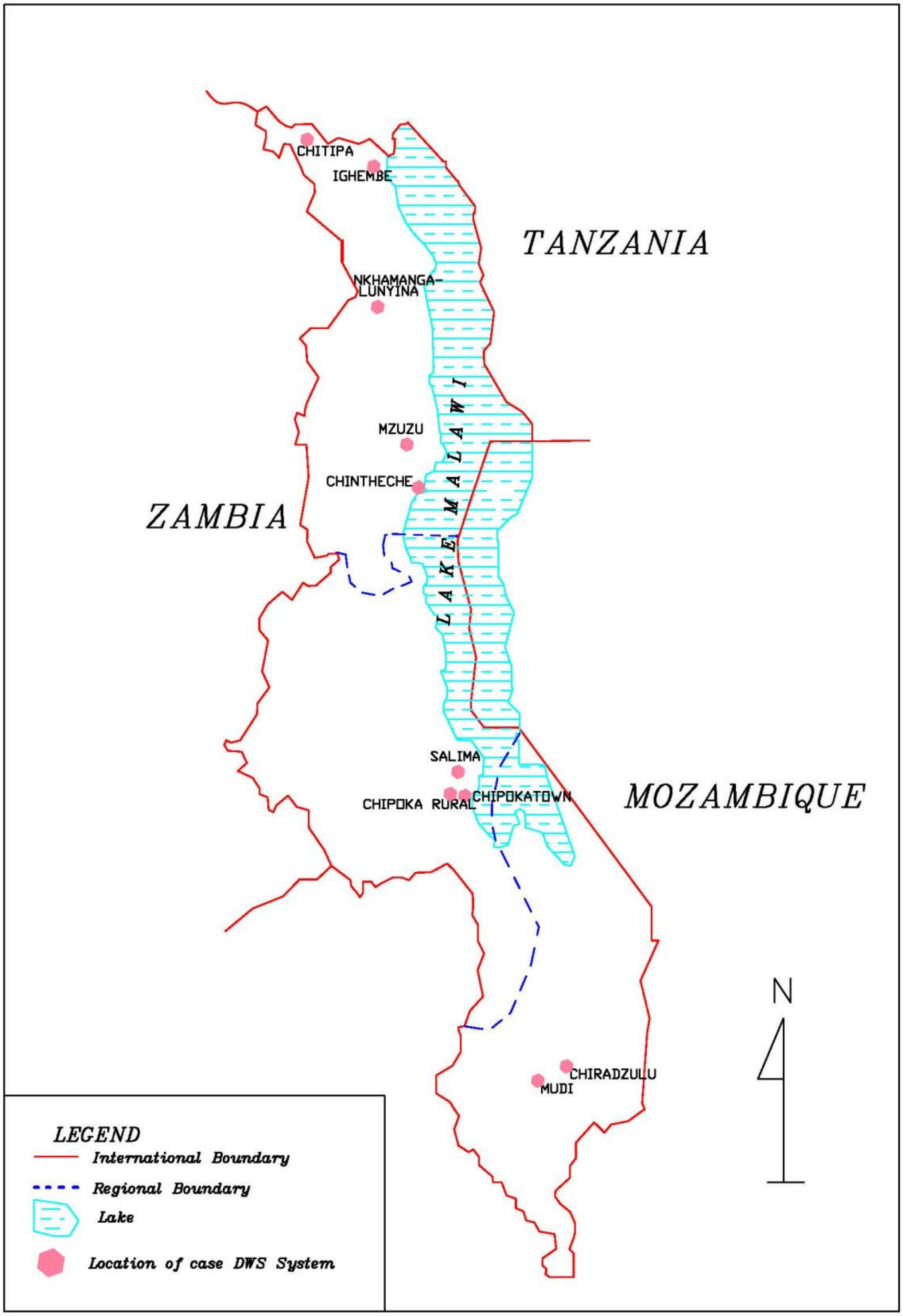

Figure 1: Map of Malawi showing locations of the case DWS systems

RESULTS, ANALYSIS AND DISCUSSION

Results from the multiple case studies revealed that different combinations of the factors in Appendix A affected sustainability of DWS services in the particular case DWS systems. Overall, 61 of the 64 factors (the number of the factors in Appendix A drops to 64 from 76 when the factors that refer to one main factor are combined) affected sustainability of the quality and quantity of drinking water in Malawi. This shows that the majority of the factors identified from the literature, as having potential to affect sustainability of the quality and quantity of drinking water, were applicable in practice in Malawi. The three factors which were not applicable in practice in the case DWS systems are organisational culture, demand-responsive approach, and inter-community competitions. The respondents felt that these factors did not have influence on the sustainability of DWS services in Malawi.

The factors that were applicable in Malawi were then subjected to a cause-and-effect analysis in a focus group discussion. The results of the analysis show that the interactions of the factors led to seven combined effects which in turn affected sustainability of DWS services. The seven combined effects are:

1. Quantity of available raw water;
2. Quality of available raw water;
3. Capacity of infrastructure to produce and supply adequate water continually;
4. Capacity of infrastructure to produce safe water continually;
5. Continuity of infrastructure to function as required at the design stage;
6. Capacity to operate the infrastructure; and
7. Realisation of service provider expectations.

The above findings from the cause-and-effect analysis are supported by the results from the case studies which showed that all the factors that contributed to the sustainability failure of the DWS services in the ten case DWS systems led to either:

a. Inadequate raw water;
b. Poor quality raw water;
c. Insufficient capacity of infrastructure to produce and supply adequate water;
d. Insufficient capacity of infrastructure to produce safe water;
e. Prolonged breakdown of infrastructure;
f. Insufficient capacity to operate the infrastructure; or
g. Failure to realise service provider expectations.

The seven combined effects and the factors under them are presented in table 2. Table 2 has been prepared based on a fish-bone diagram (which cannot fit on a page like this one because the factors are many) for unsustainable DWS services which has been drawn based on the results of the cause-and-effect analysis carried out in this study.

In the descriptive survey, the respondents were asked “What aspects of your piped DWS systems should be maintained for the DWS services to be sustainable?” A list of the seven combined effects was provided. The respondents were supposed to tick the combined effects that were important for sustainability of DWS services in their piped DWS systems. It is noted that the respondents ticked different combinations of the seven combined effects as the aspects that needed to be maintained for sustainability of DWS services in their water supply systems in Malawi. Overall, each of the seven combined effects was ticked. This further validates the finding from the cause-and-effect analysis that there are seven combined effects that directly affect sustainability of DWS services. The percentages of the respondents who ticked each combined effect are shown in table 3.

Table 2 : Categorisation of the factors that affect sustainability of DWS services based on the combined effects

Combined effect 1

Factors								
Combined effect	Quantity of available raw water							
Level 1	Perennial source of water			Efficiency of using water resources				Equity in distribution of water resources
Level 2	Climate change impacts	Capacity of water catchment area		Water demand management	Level of water loss			Extent of abiding with water rights provisions
Level 3		Natural condition of water catchment area	Social/economic activities in water catchment area		Timeliness of maintaining leaking water supply infrastructure			Enforcement of water rights provisions
Level 4			Protection of water catchment area		Availability of spare parts	Availability of maintenance tools	Human resource management	

Combined effect 2

Factors			
Combined effect	Quality of available raw water		
Level 1	Natural condition of water catchment area	Social/economic activities in water catchment area	Climate change impacts
Level 2		Protection of water catchment area	
Level 3			
Level 4			

Combined effect 3

Factors							
Combined effect	Capacity of infrastructure to produce and supply adequate water continually						
Level 1	Growth of water demand		Quality of raw water		Level of water loss		
Level 2	Population increase	Increase in non-domestic activities that use water	Natural condition of water catchment area	Social/economic activities in water catchment area	Timeliness of maintaining leaking water supply infrastructure		
Level 3				Protection of water catchment area	Availability of spare parts	Availability of maintenance tools	Human resource management
Level 4							

Combined effect 4

Factors							
Combined effect	Capacity of infrastructure to produce safe water continually						
Level 1	Growth of water demand		Quality of raw water		Level of water loss		
Level 2	Population increase	Increase in non-domestic activities that use water	Natural condition of water catchment area	Social/economic activities in water catchment area	Timeliness of maintaining leaking water supply infrastructure		
Level 3				Protection of water catchment area	Availability of spare parts	Availability of maintenance tools	Human resource management
Level 4							

Combined effect 5

Factors													
Combined effect	Continuity of infrastructure to function as required at design stage												
Level 1	Capacity to carry out proper maintenance of infrastructure								Climate change impacts	Type of technology			Quality of infrastructure
Level 2	Preventative maintenance	Troubleshooting	Rate of breakdown	Extent of breakdown		Availability of spare parts	Availability of maintenance tools	Involvement of motivated personnel		Performance of designers	Project owner requirements	Project sponsor requirements	Performance of contractor
Level 3	Availability of spare parts	Involvement of trained personnel	Vandalism of infrastructure	Age of infrastructure	Vandalism of infrastructure			Level of remuneration			Project owner's flexibility to change its predetermined requirements based on expert advice	Project sponsor's knowledge of local situation versus dictation of requirements	
Level 4		Continued training of staff	Supply of water to people living close to the infrastructure		Supply of water to people living close to the infrastructure								

Combined effect 6

Factors						
Combined effect	Capacity to operate the infrastructure					
Level 1	Human resource management	Involvement of trained personnel	Involvement of motivated personnel	Adequacy/availability of supplies e.g. power supply		
Level 2		Continued training of staff	Level of remuneration	Type of technology		Performance of suppliers
Level 3				Performance of designers	Project sponsor requirements	
Level 4					Project sponsor's knowledge of local situation versus dictation of requirements	

Combined effect 7

Factors						
Combined effect	Realisation of service provider expectations					
Level 1	Realistic objectives	Continued use of supplied water as expected at design stage				
Level 2	Integrity in project appraisal	User satisfaction with service	Realisation of benefits by users			Availability of alternative water sources
Level 3	Political interference on where a project should be implemented	User involvement in decision-making	Quantity of potable water used		Quality of water used	Political will on the need for people to use safe water
Level 4		Amount of information shared with the users	Capacity of infrastructure to produce adequate water	Economic status of users	Capacity of infrastructure to produce safe water	

Source: Cause and effect analysis conducted under this study based on works of the authors shown in Appendix A

Table 3: % of respondents who identified the seven combined effects as important

Combined effect	Percentage of respondents
Adequacy of raw water	98
Quality of raw water	85
Continuity of infrastructure to functions as required	85
Capacity of infrastructure to produce and supply adequate water	83
Capacity of infrastructure to produce safe water	78
Capacity to operate infrastructure	78
Realisation of service provider expectations	60

Table 3 indicates that some combined effects affected sustainability of DWS services in almost all the piped DWS systems where the respondents worked, while other combined effects affected sustainability of DWS services in only some of the piped DWS systems where the respondents worked. To check whether or not the differences in the proportions of the piped DWS systems affected by each of the seven combined effects (based on the percentages of the respondents who identified the combined effects as important) were statistically significant, a one-sample t-test statistical analysis was conducted. The results of the analysis show that the differences were statistically significant. This implies that some of the seven combined effects were widespread in Malawi while other combined effects were not. This is supported by the results from the multiple case studies which show that, out of the ten case DWS systems:

a. Quantity of available raw water affected sustainability of DWS services in 4 case DWS systems;
b. Quality of available raw water affected sustainability of DWS services in 4 case DWS systems;
c. Capacity of infrastructure to produce and supply adequate water continually affected sustainability of DWS services in 4 case DWS systems;
d. Capacity of infrastructure to produce safe water continually affected sustainability of DWS services in 3 case DWS systems;
e. Continuity of infrastructure to function as required at the design stage affected sustainability of DWS services in 3 case DWS systems;
f. Capacity to operate the infrastructure affected sustainability of DWS services in 5 case DWS systems; and
g. Realisation of service provider expectations affected sustainability of DWS services in 1 case DWS system.

Overall, each of the seven combined effects affected at least one case DWS system.

The respondents were also requested to rate the extent of influence of each of the seven combined effects on sustainability of DWS services in Malawi. The rating was done on a scale of 0 to 5, where 0 is no influence and 5 is maximum influence. For each combined effect, total scores were calculated against each score point (i.e. 0, 1, 2, 3, 4 and 5), and the results are presented in tables 4 and 5.

Table 4: Total scores on how the seven combined effects facilitate DWS service sustainability in Malawi

Combined effect	Total scores against each score point					
	0	1	2	3	4	5
Adequacy of raw water	0	1	0	0	28	150
Quality of raw water	0	1	2	21	32	110
Continuity of infrastructure to functions as required	0	1	6	3	52	100
Capacity of infrastructure to produce and supply adequate water	0	0	0	9	60	95
Capacity of infrastructure to produce safe water	0	0	2	18	44	105
Capacity to operate infrastructure	0	0	12	21	20	90
Realisation of service provider expectations	0	1	10	30	32	75

Table 5: Total scores on how the seven combined effects impede DWS service sustainability in Malawi

Combined effect	Total scores against each score point					
	0	1	2	3	4	5
Adequacy of raw water	0	0	2	9	12	130
Quality of raw water	0	4	0	21	40	60
Continuity of infrastructure to functions as required	0	2	6	15	20	95
Capacity of infrastructure to produce and supply adequate water	0	3	2	6	28	75
Capacity of infrastructure to produce safe water	0	0	6	21	32	75
Capacity to operate infrastructure	0	5	8	9	16	60
Realisation of service provider expectations	0	3	8	30	20	45

Using the total scores in tables 4 and 5, two one-way analyses of variance (ANOVA) were conducted, one where the combined effects were considered to be facilitating sustainability of DWS services in Malawi, and the other where the combined effects were considered to be impeding sustainability of DWS services in Malawi. The results show that the level of influence of the seven combined effects on sustainability of DWS services in Malawi was not statistically different. This means that statistically the combined effects had the same level of influence on the sustainability of DWS services in Malawi. This finding implies that there were no trivial combined effects amongst the seven combined effects. Each combined effect was as important as the other combined effects in influencing sustainability of DWS services in Malawi. It was noted in the case studies that, depending on the severity of the unfavourable state of the combined effects, each combined effect has capacity on its own to affect sustainability of the quality and/or quantity of drinking water. For example, supply of water completely stopped for some time in some of the case DWS systems due to either unavailability of raw water, or poor quality raw water or unavailability of water purification chemicals, among others.

The benefit of having identified the seven combined effects is that these will form a much simpler starting point for identifying the root causes of DWS service sustainability failure, as opposed to when the 76 factors identified from the literature are scattered all over. For example, where one is not sure as to what is causing failure of the sustainability of DWS services, a question needs to be asked whether or not all the seven combined effects in table 2 are responsible for the failure. Based on expert knowledge, and/or knowledge that people have about a water supply system, and/or by observing a water supply system, the combined effects that are responsible for the failure can be identified. Then the factors that contribute to the unfavourable state of the identified combined effects (e.g. inadequate quantity of available raw water) can be identified (factors in the lower rows of table 2 can be a starting point), and should be placed under each of the identified combined effects. By analysing the interactions of the factors under each combined effect, the root causes can be identified.

Conversely, the proposed categorisation of the factors based on the seven combined effects can assist to confirm or exonerate a factor suspected to be the root cause of undesirable state of the combined effects. For example, a speculation that high population increase is the root cause of sustainability failure of DWS services can be systematically investigated using table 2. It will be noted from combined effect 3 in table 2 that population increase affects the growth of water demand which has an impact on the capacity of the infrastructure to produce and supply adequate water continually. Working downwards through combined effect 3 in table 2, questions like; is it high population increase that leads to inadequacy of water, or fast developmental improvements, or failure to develop additional water supply system in time, or delays in upgrading the infrastructure, may be asked. By analysing the interactions of these factors, high population increase could either be exonerated or confirmed as a root cause of the insufficient capacity of infrastructure to produce and supply adequate water continually in a particular situation.

Table 2 was used to identify root causes for the undesirable state of the seven combined effects that affect sustainability of DWS services in Malawi. This was done in a larger research of which this is a part.

Once the root causes are identified, corrective measures will be taken on them. By taking corrective measures on the root causes as opposed to managing the factors which are not the root causes, the problem of drinking water supply service sustainability failure will be solved completely (Doggett, 2005).

Lastly, it should be mentioned that apart from the factors under the seven combined effects in table 2, the participants who conducted the cause-and-effect analysis under this study, also noted other important factors. The other factors are six in number and are:

a. External support;
b. Supervision of subordinates;
c. Safety of workers;
d. Clear management arrangement;
e. Adequate financing; and
f. Supportive legislation/policies.

The above factors are neither combined effects nor root causes or the factors that fall in between. These factors are also not the strategies or the tactics. These are factors that are required for effective implementation of the strategies and tactics for sustainability of the quality and quantity of drinking water in Malawi. Further discussion of these factors is beyond the scope of this paper.

CONCLUSIONS AND RECOMMENDATIONS

There are seven combined effects of the factors that affect sustainability of DWS services in Malawi. The seven combined effects are quantity of available raw water, quality of available raw water, capacity of infrastructure to produce and supply adequate water continually, capacity of infrastructure to produce safe water continually, continuity of infrastructure to function as required at the design stage, capacity to operate the infrastructure, and realisation of service provider expectations.

Some of the seven combined effects are widespread in Malawi while others are not. On the other hand, the level of influence of the combined effects on the sustainability of DWS services in Malawi is the same. Each of the seven combined effects is as important as the other combined effects. It is, therefore, recommended that the Government of Malawi should develop a policy that will require that the criteria to be used in the appraisal and monitoring and evaluation of DWS projects should take into account all the seven combined effects. This will ensure that DWS services are sustainable, as all the aspects required for sustainability of DWS services will be maintained. Sustainable DWS services will show that sustainable development is achieved in DWS. This will be different from the current situation whereby the factors that are recommended to be managed for sustainability of the DWS services in Malawi (i.e. financial self-sufficiency and decentralised day-to-day management of the DWS systems) do not directly address any of the seven combined effects. This has a consequence that the DWS services are not sustainable. The DWS services need to be sustainable because sustainable development in most of the other sectors cannot be achieved without sustainable DWS services (Kataoka, 2002; Mwanza, 2003).

The seven combined effects are also the names of the categories of the sustainability factors for DWS services proposed in this study (table 2). This categorisation ensures that all the factors that affect a particular combined effect fall under one category. This is important for analysing interactions of the factors so that root causes of the unfavourable state of the combined effects (e.g. inadequate quantity of available raw water) can be identified.

It should be noted, however, that since this study was conducted in Malawi only, the findings cannot be generalised to other countries. However, the findings could be considered as a guide to conduct similar studies in other countries.

There is also a need to conduct studies to find out why the respondents in this study stated that organisational culture, demand-responsive approach, and inter-community competitions did not have influence on the sustainability of DWS services in Malawi. Such studies will be important considering that previous studies noted that these factors affected sustainability of DWS services in other countries.

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Appendix A: Factors that affect or can potentially affect sustainability of drinking water supply services drawn from works of various authors

No.	Sustainability factors	Authors																																										
		Avots, 1969	Kerzner, 1987	Morris and Hough, 1987	Pinto and Slevin, 1988	Roark et al, 1989	UNCHS-Habitat, 1989	Sanvido et al, 1992	Hodgkin, 1994	Clarke,1995	Abrams, 1998	Sara and Katz, 1998	ADB-ADF, 1998	Lopes and Flavell, 1998	WSP, 1998	Carter et al, 1999	Fowler and Walsh, 1999	WSSCC, 2000	Aini et al, 2001	Parry-Jones et al, 2001	Sonuga, et al, 2002	Mwanza, 2003	Harvey and Reed, 2003	Lockwood, 2003	Mukherjee and van Wik, 2003	Sugden, 2003	Harvey and Reed, 2004	WHO and UNICEF, 2004	Abdullah and Ramly, 2006	Butler and Memon, 2006	Carter and Rwamwanja, 2006	UNDP-WSP, 2006	Aini et al, 2007	Bhandari and Grant, 2007	Morita-Lou and Waters, 2008	Montgomery et al, 2009	Rietveld et al, 2009	Hunter et al, 2010	WaterAid, 2010	Yigitcanlar and Dur, 2010	Harvey, 2011	Man et al, 2011	Al-Tmeemy et al, 2011	Mimrose et al, 2011
1	Quality of project designs i.e. specifications from designs								√							√									√									√							√			
2	Type of technology e.g. water supply system that the benefiting community can sustain					√			√														√			√	√								√	√					√			
3	Quality of infrastructure								√			√				√									√																			
4	Proper handover of new infrastructure																																	√										
5	Spare parts supply																									√	√					√			√									
6	Infrastructure that works as required						√																																					
7	Continuous upgrading of infrastructure												√																															
8	Preventative maintenance						√																																					
9	Rate and extent of breakdown of infrastructure					√										√																												
10	Performance by consultants																									√									√	√								
11	Performance by contractors																									√									√	√								
12	Capacity to maintain infrastructure					√			√						√	√				√					√	√	√								√	√					√			
13	Capacity to operate infrastructure					√			√						√	√				√					√	√	√								√	√					√			

No.	Sustainability factors	Authors																																										
		Avots, 1969	Kerzner, 1987	Morris and Hough, 1987	Pinto and Slevin, 1988	Roark et al, 1989	UNCHS-Habitat, 1989	Sanvido et al, 1992	Hodgkin, 1994	Clarke,1995	Abrams, 1998	Sara and Katz, 1998	ADB-ADF, 1998	Lopes and Flavell, 1998	WSP, 1998	Carter et al, 1999	Fowler and Walsh, 1999	WSSCC, 2000	Aini et al, 2001	Parry-Jones et al, 2001	Sonuga, et al, 2002	Mwanza, 2003	Harvey and Reed, 2003	Lockwood, 2003	Mukherjee and van Wijk, 2003	Sugden, 2003	Harvey and Reed, 2004	WHO and UNICEF, 2004	Abdullah and Ramly, 2006	Butler and Memon, 2006	Carter and Rwamwanja, 2006	UNDP-WSP, 2006	Aini et al, 2007	Bhandari and Grant, 2007	Morita-Lou and Waters, 2008	Montgomery et al, 2009	Rietveld et al, 2009	Hunter et al, 2010	WaterAid, 2010	Yigitcanlar and Dur, 2010	Harvey, 2011	Man et al, 2011	Al-Tmeemy et al, 2011	Minrose et al, 2011
14	Performance by suppliers																									√									√	√								
15	Use of alternative water sources																													√														
16	Efficiency of using water resources																																		√									
17	Rewards for good operation																																	√										
18	Rewards for good maintenance																																	√										
19	Involvement of trained personnel					√			√			√	√											√	√							√			√									
20	Involvement of motivated personnel					√			√			√	√											√	√							√			√									
21	Organisational structure adaptation to a project		√																																									
22	Organisational culture adaptation to a project		√																																									
23	Human resources management																												√															
24	Realistic objectives									√																																		
25	Stability of operating environment e.g. economic status																						√			√	√																	
26	Population growth rate																											√																
27	Developmental improvements																											√																
28	Equity in distribution of water resources																	√																										
29	Environmental considerations													√																														
30	Protection of water source															√																			√									
31	Perennial source of water						√																																					

No.	Sustainability factors	Authors																																										
		Avots, 1969	Kerzner, 1987	Morris and Hough, 1987	Pinto and Slevin, 1988	Roark et al, 1989	UNCHS-Habitat, 1989	Sanvido et al, 1992	Hodgkin, 1994	Clarke,1995	Abrams, 1998	Sara and Katz, 1998	ADB-ADF, 1998	Lopes and Flavell, 1998	WSP, 1998	Carter et al, 1999	Fowler and Walsh, 1999	WSSCC, 2000	Aini et al, 2001	Parry-Jones et al, 2001	Sonuga, et al, 2002	Mwanza, 2003	Harvey and Reed, 2003	Lockwood, 2003	Mukherjee and van Wijk, 2003	Sugden, 2003	Harvey and Reed, 2004	WHO and UNICEF, 2004	Abdullah and Ramly, 2006	Butler and Memon, 2006	Carter and Rwamwanja, 2006	UNDP-WSP, 2006	Aini et al, 2007	Bhandari and Grant, 2007	Morita-Lou and Waters, 2008	Montgomery et al, 2009	Rietveld et al, 2009	Hunter et al, 2010	WaterAid, 2010	Yigitcanlar and Dur, 2010	Harvey, 2011	Man et al, 2011	Al-Tmeemy et al, 2011	Minrose et al, 2011
32	Quantity of raw water																																						√					
33	Quality of raw water																																						√					
34	Stakeholder participation								√																√										√									
35	Gender and poverty focus					√																			√										√									
36	Social considerations													√																														
37	User involvement																√																											
38	Demand-responsive approach											√													√											√								
39	User satisfaction with a service					√			√							√									√																			
40	Equity in distribution of water supply services																																		√									
41	Achievement of benefits by users e.g. health and economic benefits					√																																						
42	Community participation																				√																							
43	Full cost recovery tariffs												√																															
44	Collection of all generated revenue												√																															
45	Operation cost																																		√									
46	Maintenance cost																																		√									
47	Institutional set-up								√																																√			
48	Management type of water supply system e.g. decentralised management, autonomous entity								√			√											√			√	√							√	√						√			

No.	Sustainability factors	Authors																																										
		Avots, 1969	Kerzner, 1987	Morris and Hough, 1987	Pinto and Slevin, 1988	Roark et al, 1989	UNCHS-Habitat, 1989	Sanvido et al, 1992	Hodgkin, 1994	Clarke,1995	Abrams, 1998	Sara and Katz, 1998	ADB-ADF, 1998	Lopes and Flavell, 1998	WSP, 1998	Carter et al, 1999	Fowler and Walsh, 1999	WSSCC, 2000	Aini et al, 2001	Parry-Jones et al, 2001	Sonuga, et al, 2002	Mwanza, 2003	Harvey and Reed, 2003	Lockwood, 2003	Mukherjee and van Wijk, 2003	Sugden, 2003	Harvey and Reed, 2004	WHO and UNICEF, 2004	Abdullah and Ramly, 2006	Butler and Memon, 2006	Carter and Rwamwanja, 2006	UNDP-WSP, 2006	Aini et al, 2007	Bhandari and Grant, 2007	Morita-Lou and Waters, 2008	Montgomery et al, 2009	Rietveld et al, 2009	Hunter et al, 2010	WaterAid, 2010	Yigitcanlar and Dur, 2010	Harvey, 2011	Man et al, 2011	Al-Tmeemy et al, 2011	Minrose et al, 2011
49	Assessment and addressing of risks			√																																								
50	Lessons from past projects/organisational learning																											√																
51	Involvement of senior managers				√																																							
52	Troubleshooting				√																																							
53	Continual evaluation and improvement								√																		√									√								
54	Post-project implementation external support								√							√												√				√			√	√								
55	Project owner requirements	√																																										
56	Project sponsor regulations								√														√																					
57	Health and safety measures							√																																				
58	Supervision by superiors e.g. district authorities, government ministry																																	√										
59	Water loss that is within acceptable levels												√																															
60	Water demand management																													√														
61	Climate change impacts																																							√				
62	Continued use of supplied water											√																																
63	Growth of water demand																																									√		
64	Age of infrastructure																																									√		

No.	Sustainability factors	Authors																																										
		Avots, 1969	Kerzner, 1987	Morris and Hough, 1987	Pinto and Slevin, 1988	Roark et al, 1989	UNCHS-Habitat, 1989	Sanvido et al, 1992	Hodgkin, 1994	Clarke,1995	Abrams, 1998	Sara and Katz, 1998	ADB-ADF, 1998	Lopes and Flavell, 1998	WSP, 1998	Carter et al, 1999	Fowler and Walsh, 1999	WSSCC, 2000	Aini et al, 2001	Parry-Jones et al, 2001	Sonuga, et al, 2002	Mwanza, 2003	Harvey and Reed, 2003	Lockwood, 2003	Mukherjee and van Wijk, 2003	Sugden, 2003	Harvey and Reed, 2004	WHO and UNICEF, 2004	Abdullah and Ramly, 2006	Butler and Memon, 2006	Carter and Rwamwanja, 2006	UNDP-WSP, 2006	Aini et al, 2007	Bhandari and Grant, 2007	Morita-Lou and Waters, 2008	Montgomery et al, 2009	Rietveld et al, 2009	Hunter et al, 2010	WaterAid, 2010	Yigitcanlar and Dur, 2010	Harvey, 2011	Man et al, 2011	Al-Tmeemy et al, 2011	Minrose et al, 2011
65	Continued training																							√																				
66	Incentives for stakeholders															√																												
67	Political support/ interference																							√																				
68	Geographic focus																														√													
69	Supply of maintenance tools											√																																
70	Institutional set-up								√																																			
71	Availability/adequacy of supplies e.g. power supply																																				√							
72	Appropriateness of policies																																					√						
73	Wasteful usage of water																		√																									
74	Leaking water supply facilities																																√											
75	Activities taking place in water catchment area																																											√
76	Realisation of service provider expectations																																										√	

Source: Compiled by the authors of this paper

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