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ROOT CAUSE ANALYSIS OF RECURRENT IRRIGATION SYSTEM DESTRUCTION IN JOWHAR DISTRICT, MIDDLE SHABELLE REGION, SOMALIA

Mohamed Mohamud ABDI[1], Bashir Ahmed MAOW[2]*

[1]*Department of Irrigation and Agrometeorology, Ministry of Agriculture and Irrigation, Mogadishu, Somalia*
[2]*Department of Water and Environmental Engineering, Odoros Research Center, Mogadishu, Somalia*

Abstract: Governments have historically considered irrigated agriculture as a way to stabilize rural communities, increase rural incomes, and meet the growing population's requirements for food and fiber. In Somalia, irrigation development started during the Italian colonization era of 1920s for the purpose of banana cultivation. The majority of these infrastructural investments were made in Middle Shabelle. The central government's fall in 1991 left the Somali government become weak financially and unable to finance the maintenance and operation of the irrigation infrastructure. The main objective of this research is to identify the root causes of recurrent irrigation system destruction after their rehabilitation in the Jowhar district of the Middle Shabelle Region, Somalia. Two sub-objectives of the study were to assess how insufficient institutional capacity and financing affected the failure of irrigation canals in the Jowhar District. In the study, 28 participants participated. A mixed-methods strategy was used to conduct the research, which included surveys, field observations, and interviews. The questionnaire is divided into three sections, each of which has a question about management, design, and financing. The final section investigates how inadequate institutional capability contributes to canals failure. This study examined the relationship between finance availability and institutional capacity with regard to canal failures and concluded that finance availability is positively correlated to the failure of irrigation canal and also low institutional capacity have moderately positive correlation with failures of irrigation canal.

Keywords: Irrigation, Canals, Jawhar, Middle Shabelle, Somalia

***Corresponding author:** Department of Water and Environmental Engineering, Odoros Research Center, Mogadishu, Somalia
E mail: Qaalla49@gmail.com (B. A. MAOW)
Mohamed Mohamud ABDI https://orcid.org/0000-0002-8809-3840
Bashir Ahmed MAOW https://orcid.org/0000-0002-5717-7232

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1. Introduction

Governments have historically considered irrigated agriculture as a way to address the growing population's requirements for food and fiber, boost rural incomes, and stabilize rural populations (Malano and Robertson, 2003). According to FAO data, the world's net cultivable area rose by 12% between 1961 and 2009, primarily at the expense of wetlands, grasslands, and forests. At the same time, the world's irrigated area doubled (FAO, 2011). Earth's agricultural land area has grown by 159 Mha since 1961. However, throughout the same time span, more land has been put under cultivation while less previously used land has been taken out of use. Irrigated cropping was responsible for the whole net gain in the cultivated area over the past 50 years, while rainfed systems exhibited a very minor drop (FAO, 2011).

According to a study by (Omar et al., 2019), evaporation, seepage through canal bunds, overtopping the bunds, overflow losses, and overwatering are the most common ways irrigation water is lost from canals and canal bunds, with an average field application efficiency of 25% and an average conveyance efficiency of 30%. When these considerations are taken into account, the scheme's calculated irrigation efficiency is 7.5%, which is low for surface irrigation, which is the prevalent method in the research area.

In Somalia, irrigation development started during the Italian colonization era of the 1920s for the purpose of banana cultivation when they constructed barrages in the Middle Shabelle region to divert more water for banana cultivation (Mbara et al., 2007). Middle Shabelle is the region that received the majority of these infrastructure investments. Major irrigation infrastructure was still being built and established by the Somali government after colonization in the 1960s, but it was abandoned after the central government was overthrown in 1991(Mbara et al., 2007).

Since the fall of the central government in 1991, the Somali government has deteriorated financially and in terms of its administrative capabilities (World Bank, 2018). Since 2000, the country has been recovering from protracted periods of government inefficiency. The government has been unable to support the operation and maintenance of the irrigation system because the

security situation prevents it from leaving the cities and accessing the rural areas where the irrigation system is located.

Following the civil war (1998–1999), the United Nations' humanitarian agencies started to step in and take over the government's responsibilities. They also started projects to support Somalia's national food security system, which included the rehabilitation of the country's main irrigation canals. In the past ten years, the irrigation system that had been restored by the humanitarian organization with the help of foreign partners once more failed. The purpose of this study is to improve our knowledge of the main factors that lead to irrigation canal failures that occur repeatedly and to learn more about the factors that influence the success—or lack thereof—of irrigation canals in the Jowhar district in the middle Shebelle region.

This study is very significant as the Somali government, especially the Ministry of Agriculture and Irrigation, will benefit from the research output as it will contribute to the knowledge and information level of the government at both national and state levels regarding irrigation systems, and how to support more efficient and sustainable services for the people. It will also benefit the humanitarian organizations that collect the funds for the rehabilitation of these infrastructures to know the tangible causes of the recurrent destruction of these canals to not go back to the works completed earlier. This will contribute to the improvement of functionality and sustainability while reducing duplication of efforts.

The target audiences of this research were both levels of government (national and state levels), civil society organizations, farmer cooperatives, international non-governmental organizations, and their local non-governmental organizations and implementation partners.

2. Materials and Methods

2.1. Participants

Participants in the study were the irrigation committee of the Jowhar district, lower Shabelle Region, where selected committee members were used as information sources on the main causes of irrigation canal failures in the Jowhar area. 28 members of the irrigation committee responded to the survey. In the Jowhar district, the researcher also did field observations and conducted 20 interviews with local residents in order to learn more about the irrigation system there.

2.2. Instruments of Data Collection

The study combined field observations, a structured interview, and a questionnaire. Members of the irrigation committee of Jowhar were asked to fill out questionnaires that the researchers had prepared. The main purpose of the questionnaire was to collect information on major factors leading to the destruction of irrigation canals in the Jowhar area. There are three sections included in the questionnaire. All responses were rated using Likert scales: (1) strongly disagree (2) disagree (3) neither agree nor disagree (4) strongly agree (5) agree. The structured interview and field observations were conducted in order to obtain additional information in support of the data collected within the questionnaire. During the interview, the researcher raised open issues related to the causes of irrigation canal failure at Jowhar. During the observation process, the researcher also observed the status and physical condition of the irrigation canals.

2.3. Data Collection

The questionnaire was distributed to the members of the irrigation committee in Jowhar. The respondents were given an explanation of the questionnaire so that they could comprehend the goal of the study. This was done to prevent arousing suspicion, as well as to enable the researchers to provide impartial feedback on the questions asked. In addition, the researcher conducted interviews with other irrigation specialists, discussed the primary causes of canal failure, and observed the canals' current status and physical condition.

2.4. Data Analysis

The gathered data were statistically evaluated using Statistical Package for Social Sciences (SPSS version 20) software. To simplify and expedite data interpretation, tables were utilized, and responses were reported as percentages and evaluated for consistency. The obtained data were encoded for use with the Statistical Package for the Social Sciences (SPSS) because this is the most efficient way to identify, compare, and describe relative frequencies, means, and standard deviations. Using this strategy, accurate and reliable data will be gathered and a conclusion will be reached. Using a Pearson correlation coefficient, the relationship between the two variables was also determined.

2.5. Research Limitations

Due to the existence of Covid-19, the study was completed in a short timeframe of four months. As a result of the pandemic, the movement of the irrigation canal committee was hampered by the spread of the virus, and the researcher and a number of key knowledge figures perished.

Due to the scarcity of Somalia-specific irrigation literature, the majority of this study's references came from outside of the country. Due to the lack of clarity in the irrigation canal committee organization and the inability to establish it effectively, as well as the presence of Covid-19, the sample size was extremely small.

Due to the instability in Somalia, security is a key concern, as the project location is located outside of secure zones, the researcher was only permitted to move within the safe zones in the Jowhar area of the middle Shabelle region.

2.6. Data Interpretation

The Table 1 shows the data interpretation values used during the study.

Table 1. Data Interpretation of the values

Mean Range	Interpretation
1-1.8	Agree
1.9- 2.6	Strongly agree
2.7-3.4	Neither Agree nor Disagree
3.5-4.2	Disagree
4.3-5.0	Strongly disagree

3. Results

3.1. Demographic Information of the Participants

Table 2 outlines the demographic characteristics of the respondents. Within the sample size of 28 respondents, males dominated the respondents compared to females. 4 respondents were female, with a percentage of 14.3%, while 85.7% were men. This can be due to the reason that there are more male workers in the irrigation sector than female workers in Somalia. Additionally, the study showed that 46.4% of respondents had nonformal education, while 25% of the respondents had primary school qualifications, and other 25% of the respondents had graduate-level qualifications from an agricultural university which illustrates the fact that farmers lack qualified personnel to carry out the day-to-day activities of the sector.

With regard to the marital status of the respondents, the study found that most of the respondents, 89.3%, were married. In contrast, 7.1 % were single and 1 was divorced. This indicates that the percentage of respondents who are married is high. According to the age distribution of respondents, 39.3% of respondents are between 41-50 years old, 21.4% are between 31-40 years old, 17.9% are between 20-30 years old, 14.3% are between 51-60 years old, and 7.1% are over 60 years old.

Table 2. Demographic Information

Gender of Respondents	n	%
Male	24	85.7
Female	4	14.3
Total	28	100.0
Qualification of respondents		
Non-formal	13	46.4
Primary	7	25.0
Secondary	2	7.1
Graduate	6	21.4
Total	28	100.0
Marital status		
Single	2	7.1
Married	25	89.3
Divorced	1	3.6
Age		
20-30	5	17.9
31-40	6	21.4
41-50	11	39.3
51-60	4	14.3
>60	2	7.1

3.2. Descriptive Analysis to Measure Factors Causing the Failure of Irrigation Canals

Tables 2 and 3 illustrate the descriptive study of how independent variables (institutional capacity and financial availability) affect the dependent variables (canal failure) as the relationship between these variables was measured in the study. Both the independent and dependent variables contained nine and five questions, respectively. For each question, a Likert scale was utilized: strongly disagree, disagree, uncertain, agree, and strongly agree.

Table 3. Descriptive analysis of measures of the canal failure factors

Items	n	Mean	Std. Deviation	Interpretation
A Financing availability	28	1.57	0.573	Agree
Technical support	28	1.75	0.928	Agree
Low market access to the farm products	28	1.79	1.101	Agree
Low farm production	28	1.54	0.881	Agree
B Week institutional capacity	28	2.36	1.420	Strongly agree
Availability of Irrigation policy and regulation	28	1.82	1.090	Agree
Flood diversion/ projection mechanism	28	1.50	0.745	Agree
Availability of adequate irrigation expertise	28	1.79	1.197	Agree
Irrigation research center/institute and extension services	28	1.54	0.576	Agree
Availability of adequate irrigation expertise	28	1.79	1.197	Agree
Irrigation research center/institute and extension services	28	1.54	0.576	Agree

Table 4. Descriptive analysis measures of canal failure

Items	n	Mean	Std. Deviation	Interpretation
Management	28	2.61	1.166	Strongly agree
Poor design	28	1.86	1.079	Strongly agree
Seepage and leakage	28	1.82	1.124	Agree
Erosion and siltation	28	1.64	0.989	Agree
Frequency overtopping	28	1.64	1.062	Agree

The study interpreted the results of both variables using the mean and standard deviation for each question using SPSS (Tables 3 and 4).

Table 4 illustrates how the lack of management, poor design and related variables are causing the canal failures in Jowhar. The table shows that lack of management and poor design during canal rehabilitation was the most causing factors followed by seepage and leakage, Erosion and siltation and frequency overtopping.

3.3. Correlation Coefficient

In this study, the Pearson correlation was used to examine the relationship between finance availability and institutional capacity for canal failure. According to Table 5, there is a significant correlation between finance availability and canal failure (r=0.437*, P=0.02). However, institution capacity was moderately correlated with canal failure (r=0.355, P=0.064).

Table 5. Pearson's correlation of canal failure factors

Pearson's correlation		Canal failure
Finance availability	Pearson Correlation	0.437*
	Sig. (2-tailed)	0.020
Institutional capacity	Pearson Correlation	0.355
	Sig. (2-tailed)	0.064

*= correlation is significant at the 0.05 level (2-tailed).

3.4. Interview and Filed Observation

The study interviewed 20 respondents in Jowhar districts who had experience in the irrigation system in Jowhar. It was discussed in the study what the respondents perceived as the major causes of the recurrent failure of the irrigation system in Jowhar, what can be done to prevent the recurrent destruction of irrigation canals, the frequency of operation and maintenance, and finally, who is responsible for the operation and maintenance of irrigation canals? Despite their differences, the study grouped their responses and analyzed their responses to determine a common outcome. After collecting the answers from 20 respondents, the responses of the respondents were summarized below.

Operations and maintenance of the established or rehabilitated canals is a must to continue the work of the canals, Respondents that there is a lack of operation and maintenance of the canals is the main cause of the destruction of the canals in Jawhar district as the farmers and the irrigation committees do not have enough finance the maintenance and operations of the canals. On the other hand, respondents also noted that recurrent Shabelle River flooding during the wet season is another adding cause to the destruction of the canals (Figure 1). As the governments also struggle with financial problems, they do not have the budget to support these operations. Poor management of the canals is also another factor in the destruction of the canals.

As the factors that are contributing to the destruction of the canals were identified, respondents were also asked their perspectives regarding the solutions they are recommending to avoid the recurrent destruction of the canals (Figure 2). The respondents recommended that continues rehabilitation of the canals was the best option to keep the functioning of the canal, according to respondents, Management and monitoring of the canals are also crucial to avoid destruction of the canals. In addition, continuous improvements in the functionality of irrigation committees through capacity building and technical support and increasing the availability of financial support for canal rehabilitation projects are also part of the recommended solutions.

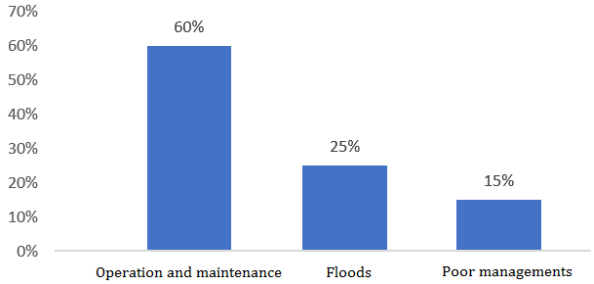

Figure 1. Analysis of the factors causing the failure of the irrigation canals.

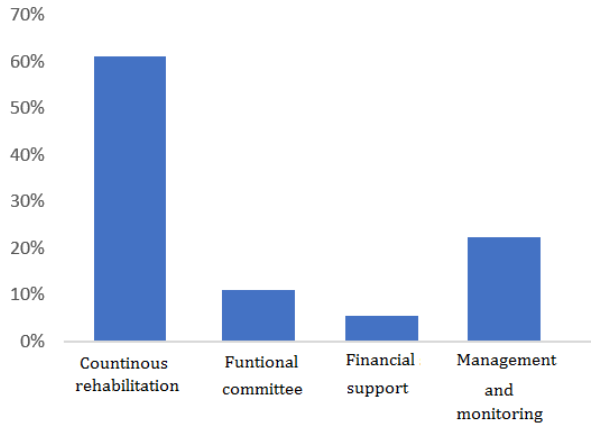

Figure 2. Proposed solutions for the destruction of the irrigation canals.

As continuous operation and maintenance was the most solution recommended by the respondents, the frequency of the maintenance was asked. 65% of the respondents suggested conducting the operation and maintenance of the irrigation canal twice a year while 35% recommended conducting the operation and maintenance once a year (Figure 3).

Most of the time, Government establishes new canals or rehabilitates the existing canals, but as these projects are finalized the maintenance of the operation of the canals is a must. For that reason, we asked the respondents who should take responsibility for the newly established or rehabilitated canals regarding their operation and maintenance after the project is finalized and the respondents indicated that Irrigation committees and farmers are mostly responsible for the operations and

maintenance of the canals, although some of the canals are maintained with the support of local and International NGOs (Figure 4). They stated that the government's role is the initial establishment or rehabilitation of the canals but canal operations are for the farmers themselves.

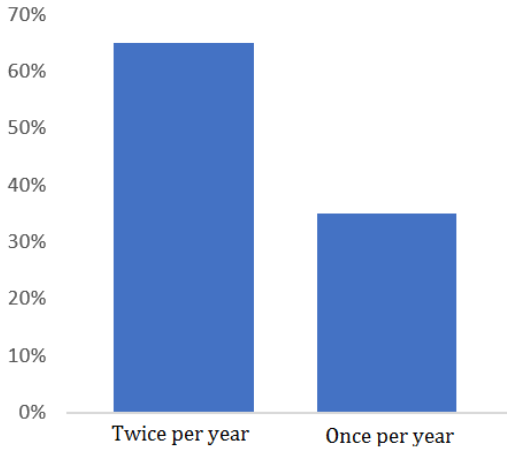

Figure 3. Recommended operation and maintenance intervals.

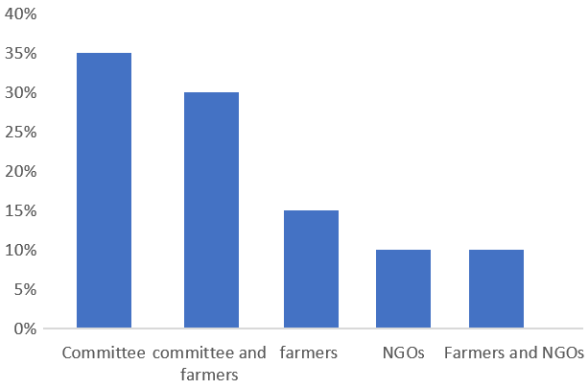

Figure 4. Recommended operation and maintainance intervals and the responsiblity of the operation and maintainance of the canals.

4. Discussion and Conclusion

Since the collapse of the central government in 1991, the Somali government's financial and administrative capabilities have worsened. As a result, the government has been unable to fund the irrigation system's management and maintenance, but humanitarian organizations have begun to step in and take over the government's responsibilities. They also began programs to help Somalia's national food security system, such as the rehabilitation of the country's primary irrigation canals. In the last ten years, the humanitarian organization's irrigation system, which had been rehabilitated with the assistance of foreign partners, has once again failed. This study was conducted to examine the major factors that cause irrigation canal failures in Jowhar and concluded that finance availability is positively correlated to irrigation canal failures and that low institutional capacity has a moderately positive correlation with irrigation canal failures, implying that if there is a gap in finance available for canal rehabilitation, the irrigation canal will not function due to a gap in operation and maintenance.

5. Recommendations

Since the study found that a lack of funding, a lack of policy and regulations, gaps in expertise, and the ineffectiveness of irrigation committees were the main causes contributing to the deterioration of repaired canals, the study suggests the following:

- Allocation of additional funds for the rehabilitation and operation and maintenance of irrigation canal systems: The government, humanitarian organizations, and farmers themselves must allocate funds for restoration at an early stage to avoid deterioration of the system. This will contribute to increased food security and farm income.
- Increase institutional capacity at both the government and farmer levels including capacity injection, awareness raising, and local knowledge enhancement through capacity building and field demonstrations of how the irrigation system is effectively administered and maintained. This will result in the irrigation system's sustainability and a reduction in recurring irrigation system failures.
- Improve agricultural water management policy and regulation, which can have a significant impact on water production and ultimately serve as a solution to lower water costs.
- Establishment of a nationwide agricultural water management platform that collects information for end users and provides it to government institutions to help with decision-making and to help researchers base their analyses.
- Increasing the number of studies addressing the irrigation sector and agriculture in general to understand the gaps and solutions to the difficulties faced by farmers.

Author Contributions

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

	M.M.A.	B.A.M.
C	90	10
D	70	30
S	60	40
DCP	80	20
DAI	60	40
L	70	30
W	70	30
CR	50	50
SR	20	80
PM	60	40

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

A permission letter was obtained from the regional office of the Ministry of Agriculture and Irrigation, Somalia (date: May 10, 2021 and protocol code: 2021/013).

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