



UNDERSTANDING WATER CONFLICTS IN RIVER RONGAI CATCHMENT: NATURE, PATTERNS, EXTENT AND THE ROLE OF SURFACE WATER VARIABILITY

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ABSTRACT

Globally, freshwater scarcity has emerged as one of the greatest environmental and development challenges of the twenty-first century. This study sought to understand the nature, patterns and extend of water conflicts and the influence of surface water variability on water related conflicts in River Rongai Catchment. A cross- sectional study was conducted where primary data were obtained using structured questionnaires, Focus Group Discussion and Key Informant interviews. Proportionate stratified sampling technique before a simple random sampling was employed to select respondents from the Upper, middle and lower catchment areas. Most of the respondents perceived unequal water distribution as a major cause of water conflicts. Findings from respondents across the three study locations indicated that water conflicts intensify during the dry season when reduced surface water availability is insufficient to meet the increasing demand for freshwater within the catchment. Additionally, the discussions from the FGDs further revealed that serious cases of water conflict are commonly experienced between January and March, which corresponds with a period of low streamflow in the catchment. Pearson correlation analysis between seasonal surface water variability and water conflicts occurrence revealed a very weak positive relationship ($r = 0.011$, $p = 0.916$) which was statistically insignificant ($p > 0.05$). The study recommends that other factors influencing water access in the catchment should be considered for sustainable water management. The community should adopt an integrated method of conflict management rather by looking beyond the seasonal variations of the river. Community awareness on water policies and should be strengthened in River Rongai catchment.

Key words: Water, Surface Water Variability, Nature, Extent, Pattern, Community Awareness

1 INTRODUCTION

Water is a vital natural resource for human life, it plays an important role in socio-economic development and maintenance of an overall ecosystem health [1]. Fresh water resources provide essential ecosystem services including; domestic water supply, agricultural production, industrial development, and biodiversity conservation, thereby

supporting the livelihoods of millions of people worldwide [2]. Sustainable management of freshwater resources is particularly important because crop and livestock productivity largely depend on adequate water availability [3]. However, freshwater resources are increasingly under pressure due to rapid population growth, unsustainable human activities and climate change, all of which have altered the quantity and quality of available water resources [4]. Generally, dry seasons are associated with a reduction of the available water from various sources for withdrawal and human consumption. Seasonal water shortages, particularly during prolonged dry periods further intensify competition.

Globally, freshwater resources are limited, accounting for only approximately 2.5–2.7% of the total water available on Earth. Moreover, the distribution of these freshwater resources is uneven, with Africa accounting for about 29%, Russia 20%, North America 21%, and the remaining regions collectively accounting for only 14% [5]. This uneven spatial distribution, coupled with increasing water demand underscores the need for sustainable water resource management to ensure equitable allocation and long-term availability.

In Africa, rainfall and river flow exhibit considerable spatial and temporal variability contributing to recurrent water shortages, flooding and substantial socio-economic losses across many river basins [6]; [7]. While rainfall variability remains the primary determinant of surface water fluctuations, these hydrological changes are further intensified by land use land cover change, water abstraction, reservoir development and other anthropogenic interventions. Rapid land use land cover change in many developing countries, particularly the conversion of forests and natural vegetation into agricultural land and settlements has accelerated the degradation of water, soil and vegetation resources. Such changes alter key hydrological processes, including interception, infiltration, evapotranspiration, groundwater recharge and surface runoff ultimately modifying both surface and subsurface water flows [8].

Surface water variability is influenced by both natural and anthropogenic factors. Climate variability, particularly fluctuations in rainfall and the increasing frequency of droughts, has been identified as a major driver of changes in surface water availability, especially in arid and semi-arid lands (ASALs) [9]. However, although climatic factors are widely acknowledged as the dominant drivers of hydrological variability, growing evidence suggests that human-induced land use change increasingly modify catchment hydrology by altering the magnitude, timing, and distribution of surface water resources. Surface water variability is commonly manifested through increased flood frequency during periods of intense rainfall and reduced water availability during prolonged dry seasons. Flash floods are frequently associated with expanding built-up areas, declining forest cover, degradation of riparian ecosystems and the loss of natural infiltration capacity within catchments [10]. Conversely, reduced dry season flows often result from declining groundwater recharge, increased water abstraction and catchment degradation. These findings demonstrate that changes in land use not only influence the quantity of available water but also affect the seasonal reliability of water resources thereby increasing the vulnerability of communities that depend on rivers for domestic, agricultural and livestock production.

Water conflicts remain a persistent challenge in Kenya due to increasing pressure on limited freshwater resources. In many parts of the country, available water supplies are insufficient to meet the growing demands of domestic, agricultural, industrial, and environmental water users making water scarcity a major source of resource competition [11]. The unequal spatial distribution of water resources coupled with seasonal variability in water availability and increasing socio-economic demands has further intensified competition among water users. Consequently, water-related conflicts are particularly prevalent in the arid and semi-arid lands (ASALs) where water availability is naturally limited and highly variable.

Several studies have documented the occurrence of water conflicts in different parts of Kenya indicating the diverse factors driving these conflicts. For example, Lake Naivasha has experienced recurrent disputes because it supports multiple economic activities, including commercial agriculture, fisheries, tourism, and domestic water supply making it one of the most contested freshwater resources in the Rift Valley region [12]. According to [13], water conflicts in Lamu are influenced by socio-economic inequalities, governance challenges and religious differences demonstrating that water conflicts are not solely a consequence of physical water scarcity but are also shaped by social and institutional factors. Similarly, [14] found that increasing irrigation demands resulted in excessive water abstraction, reducing downstream river flows and intensifying competition among water users.

Collectively, these studies demonstrate that water conflicts in Kenya arise from the interaction of multiple factors, including water scarcity, increasing demand, governance challenges, and competing livelihood activities. However, most previous studies have examined these drivers independently, focusing either on water abstraction, governance, or socio-economic conditions with limited attention to the combined influence surface water variability on the occurrence and intensity of water conflicts. Seasonal fluctuations in river flows influence the reliability of water resources available to competing users. Understanding these interactions is therefore essential for explaining the complex nature of water conflicts within river catchments.

The occurrence and intensity of water-related conflicts are closely linked to changes in water availability, which are influenced by both natural and anthropogenic factors. Among the human-induced drivers, LULCC, water abstraction, irrigation expansion and increasing water demand significantly alter hydrological processes and the availability of freshwater resources [15]. As global populations continue to grow and demand for water increases, understanding these interacting drivers has become essential for promoting sustainable water resource management and reducing conflict. Water scarcity remains one of the principal drivers of water-related conflicts. The nature and intensity of these conflicts often vary according to the severity, duration and spatial distribution of water shortages [16]. Increasing frequencies of drought associated with climate change and global warming coupled with weak freshwater governance have further intensified competition over limited water resources [17]. These observations suggest that water conflicts are not solely a consequence of declining water availability but also reflect deficiencies in governance, planning and equitable resource allocation.

Therefore, this study seeks to understand the nature, pattern and extent of water related conflicts and the role of surface water variability. The findings provide empirical evidence to inform sustainable water resources management and policy interventions aimed at reducing water conflicts at the grassroot levels and beyond.

2 MATERIALS AND METHODS

2.1 Study area

The study was conducted in Rongai sub-county in Nakuru County, it lies 30Km west of Nakuru town and covers an area of 1049.1 Km² according to the Nakuru County Integrated Development plan (NCIDP) of 2018-2022. This study area has a total of five administrative wards namely, Mosop, Soin, Visoi, Menengai West and Solai. The study focused on River Rongai that flows through Mosop, soin and Visoi wards.

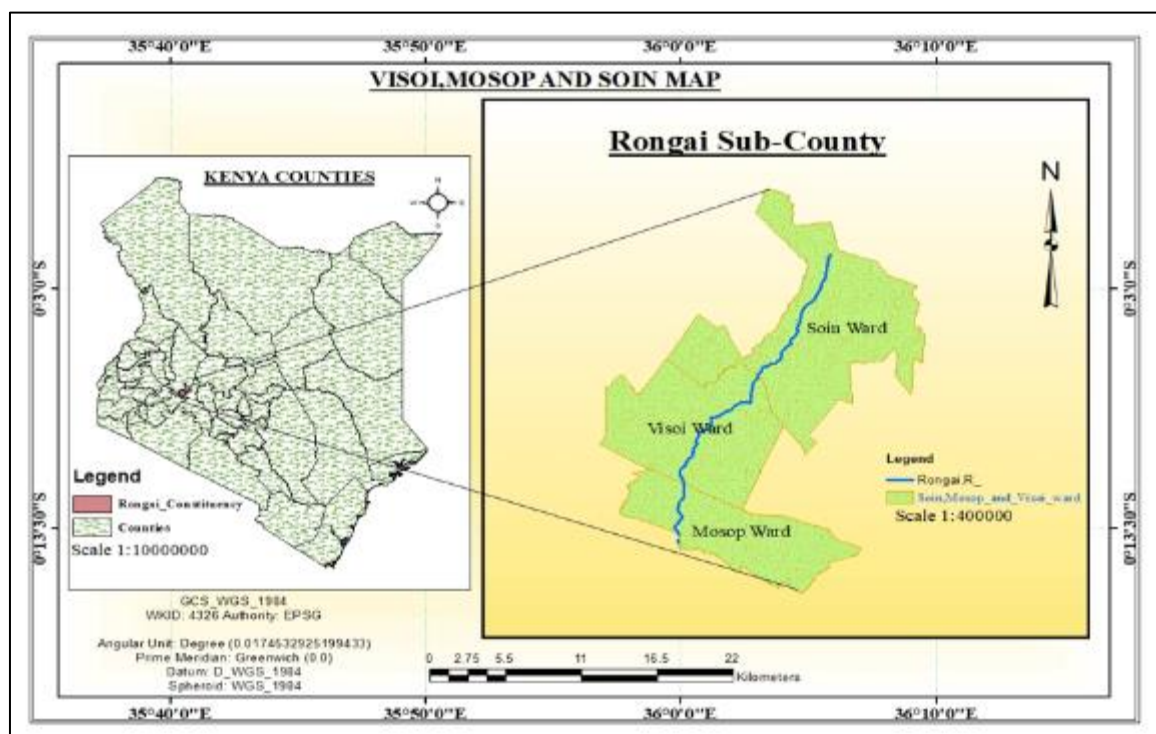


Figure 1: The Map of the study area

2.2 Research design

This study adopted a cross-sectional research design. Data were collected between April and June 2025. The design was appropriate because it enabled obtainment of the current prevailing conditions in the River Rongai (RR) catchment without the need to monitor the changes in the same households over time. In addition, the cross-sectional design was cost-effective and time-efficient as data were collected only once from each participant, unlike longitudinal studies which require repeated observations over an extended period. Consequently, the design was suitable for assessing the nature, pattern and extent of water conflicts as well as the current status surface water variability in relation to water conflicts in the catchment.

2.3 Target population

The target population for this study were the household heads and key stakeholders in RR catchment. The respondents were drawn from Mosop, Visoi and Soin wards to represent the upper, middle and the lower catchment respectively.

2.4 Sampling procedure and Sampling size

The population was heterogeneous (Upper, middle and lower catchment) based on LULC characteristics, hydrological conditions and socio-economic activities. Therefore, Proportionate stratified sampling was employed before a simple random sampling method was used to select household heads within the three locations for interviewing.

2.5 Data collection methods

2.5.1 Household Interviews

Primary data was collected using a semi-structured online questionnaire using the Kobo collect toolbox. A simple random sampling of respondents was done from each stratum.

2.5.2 Focus Group Discussions

Recruitment for the FGD was done using the door-to-door canvassing method to identify respondents depending on the ability and capacity of the individuals to provide information. The unforeseen circumstances of participants failing to turn up for discussion was controlled by over recruitment of participants. One FDG comprising of ten members was conducted in each location.

2.5.3 Key Informant Interviews

Key Informant Schedule was used to collect data from 4 key informants during the study including stakeholders from; Ministry of Water, Sanitation and Irrigation, WRA, local administration and Kenya Forest service.

2.6 Data Analysis

Descriptive statistics was used to analyse the demographic nature of the respondents. Content analysis was used to analyse the qualitative data obtained from the FGDs and KII. The themes included were those related to; Nature of water conflicts, Patterns of the conflict and the extent of conflicts in the catchment. The interview was transcribed to gain a comprehensive understanding of the participants' responses. The next step involved coding the data by assigning labels to statements that conveyed similar ideas. Related codes were then grouped into broader categories from which key themes were developed based on the objectives of the study. Finally, the identified themes were interpreted and supported with selected summarized narratives from the participants. The relationship between surface water variability and water conflicts was determined using Pearson's correlation analysis method since both variables (surface water variability and water conflicts were treated independently). Surface water variability was measured based on the perception of the respondents on stream flow (fluctuated, increased, decreased). Water conflicts was measured by the respondent's perception on whether the changes in surface water contributed to water related disputes. The responses were coded numerically and the score combined to obtain an overall score for each variable.

3 RESULTS AND DISCUSSIONS

3.1 Gender Distribution of the respondents given age

Male respondents constituted the majority in the age groups of 26-34, 45-54, and 55-64 years. The age group of 65 years and above was relatively balanced while the 35-44 age group had a nearly equal representation of both genders. The female respondents were the majority of the younger age group.

Figure 2 illustrates the gender distribution amongst the six age groups.

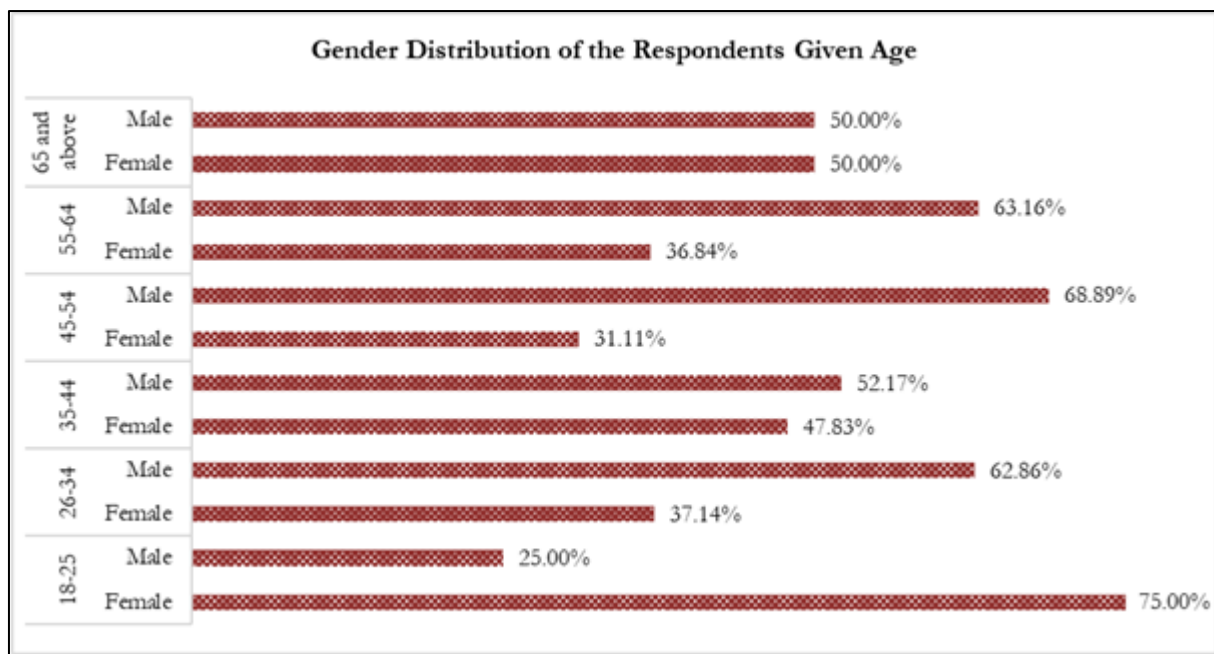


Figure 2: Gender Distribution of the respondents in different age groups

3.2 Education level of the respondents

The majority of respondents had attained secondary education as their highest level of education across the three study areas (57.38%), followed by those with tertiary education (19.46%). Respondents with primary education accounted for 21.48% of the sample, while only 1.68% had no formal education. Figure 3 distribution of respondents according to their levels of education.

3.3 Nature, Pattern and Extent of Water Conflicts in River Rongai Catchment

3.3.1 Nature of Water Conflicts in the Catchment

There are three main water related conflicts manifesting along River Rongai Catchment area as mentioned by the respondents. The community relies on the river for various purposes including; watering animals, large- and small-scale irrigation and for the typical household purposes. Most of the respondents perceived unequal water distribution as a major cause of water conflicts in the catchment during the dry season when streamflow is significantly reduced. This may be attributed to increased water abstraction activities in the upper and middle catchment areas which leave the lower catchment with reduced water flows. These findings are comparable to those of studies conducted in the Upper Ewaso Ng'iro catchment, which revealed a persistent reduction in water availability in the lower catchment despite an increase in rainfall. The reduction was attributed to increased water abstraction during the dry season which consequently escalated water conflicts during this period [18].

Table 1: Nature of water conflict in River Rongai catchment

Responses	Frequency	Percentages
Competition over water resources use	80	27
Unequal distribution of water	128	43
Water scarcity	90	30

3.3.2 Water conflicts Patterns in the Catchment

According to respondents across the three catchment locations, water conflicts intensify during the dry season when limited surface water is insufficient to meet the growing demand for freshwater in the catchment. Water conflicts related to the unequal distribution of water had the highest potential of occurring during the dry season (39.53%). However, although less frequent than during the dry season, conflicts arising from the unequal distribution of water still showed a relatively high potential of occurring during other seasons of the year (3.49%). This may be attributed to

widespread commercial riparian farming involving tomatoes, leafy green vegetables and cereals which occurs throughout the year and is highly dependent on irrigation.

Findings from respondents across the three study locations indicated that water conflicts intensify during the dry season when reduced surface water availability is insufficient to meet the increasing demand for freshwater within the catchment. Conflicts associated with the unequal distribution of water were reported to have the highest likelihood of occurring during the dry season (39.53%). Although the likelihood of such conflicts occurring during other seasons was considerably lower (3.49%), their occurrence throughout the year suggests that unequal access to water is not solely a seasonal challenge but may also be influenced by persistent water use practices and management challenges within the catchment.

The occurrence of water conflicts beyond the dry season may be associated with widespread commercial riparian farming involving; tomatoes, leafy green vegetables and cereals. These agricultural activities are undertaken throughout the year and are highly dependent on irrigation thereby creating sustained pressure on the available surface water resources. The findings align with those of [19] who identified agricultural land conversion as a widespread trend in developing countries where cropland has expanded at the expense of shrub lands and grasslands. Consequently, water demand may remain high even during periods of relatively increased water availability. This suggests that seasonal water scarcity alone may not adequately explain the occurrence of water conflicts as continuous water abstraction for irrigation may contribute to unequal water access across different sections of the catchment.

Additionally, the discussions from the FGDs further revealed that serious cases of water conflict are commonly experienced between January and March, which corresponds with a period of low streamflow in the catchment. This finding reinforces the relationship between reduced water availability and increased competition among water users. However, the escalation of conflicts during this period may not be attributed solely to reduced streamflow but may also reflect increased water demand, continued upstream abstraction and inadequate regulation of water use. Although a nine-member peace committee has been established within the catchment and includes a community representative, participants in the FGDs reported poor enforcement of water related laws and inadequate knowledge of water policies among community members. These findings suggest that the existence of local conflict resolution structures may not necessarily translate into effective water governance where institutional enforcement and public awareness of water resource management strategies remain limited.

Triangulation of findings from the household surveys, FGDs and KIIs indicated that water conflicts predominantly originate in the lower catchment and are largely driven by frustrations among local community members regarding limited and unequal access to water. The lower catchment may be particularly vulnerable because upstream and middle catchment water abstraction potentially reduces the volume of water available downstream. This spatial pattern reveals the interconnected nature of water use within the catchment where water abstraction in one section may affect water availability and access in other sections. The findings therefore suggest that water conflicts are influenced not only by seasonal variability but also by the spatial distribution of water use and the effectiveness of water governance mechanisms.

Furthermore, respondents reported experiencing water related challenges during nearly all seasons. This may be partly explained by negative community perceptions regarding the physicochemical quality of river water which contribute to a preference for alternative water sources even during periods of relatively high-water availability. The findings imply that water availability alone may not adequately determine water security since its suitability and perceived quality of available water also influence its accessibility and use. This results are consistent with those of [19] and [20] that submits that water security will not only be determined by its variability but also by other factors including water quality. Therefore, water related conflicts in the catchment may result from the interaction between seasonal water scarcity, unequal water distribution, continuous irrigation demand, water-quality concerns and weaknesses in the enforcement of water governance regulations. Figure 4 shows the nature of conflict and the probability of occurrence during the dry season and all seasons (dry and wet).

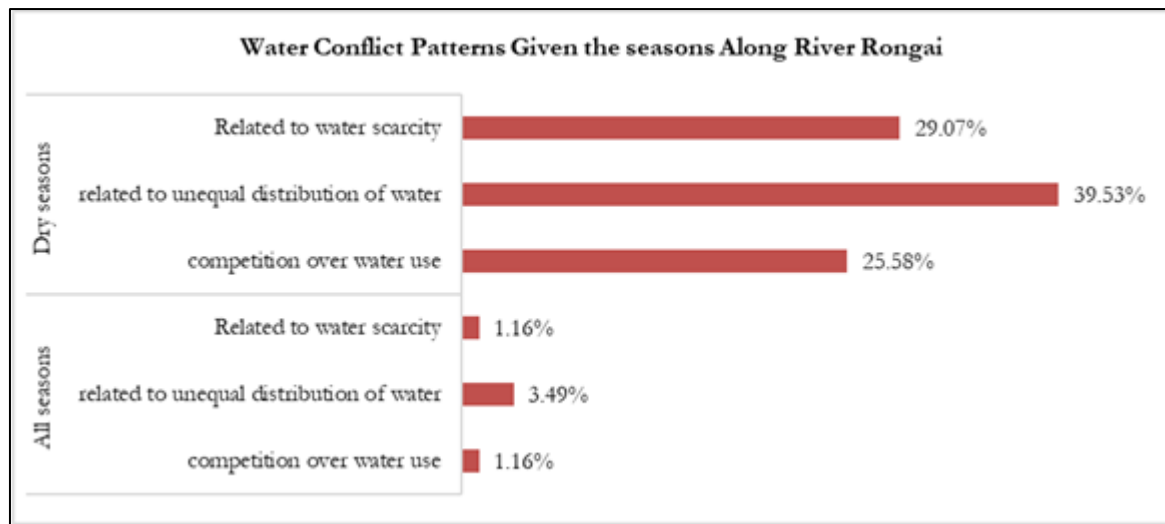


Figure 3: Seasonal patterns of water conflicts

3.3.3 The Extent of Water Related Conflicts in the Catchment Area

Most of the respondents felt that water conflicts largely impact the lower catchment compared to the upper and the middle catchments water conflicts related to unequal distribution of water resources. However, KII in the three locations revealed that water users in the upper and the middle catchment are also affected in the sense that angry residents storm their farms, destroy crops and other valuable equipment and sometimes the conflicts may escalate to death of the victims pursued.

FGD established that the community in all the catchment areas have resolved to using alternative water sources. The high variability of water levels in the river and human influenced nature of the water has led to the poor water quality parameters resulting to the lower preference of the river as their source of water even though it be a natural water source.

Respondents also indicated that the initial installation costs of the available piped tap water were costly and only a few residents were able to afford. One respondent from the upper catchment mentioned that; *“we no longer benefit from our river, its polluted most of the time because of the large flower farm along the river valley, the water levels varies a lot and during the rainy seasons it becomes dangerous because of flashflood”*. This implies to the preferences shifting towards the use of boreholes and rain water through roof catchment. These findings were consistent with those of [22] that reported that communities prefer alternative sources of water to increase water availability especially in catchments with pronounced seasonal variability. Water use preference is also determined by the geographical locations and natural water accessibility by the community members and this might have influenced their choices in the current study as well.

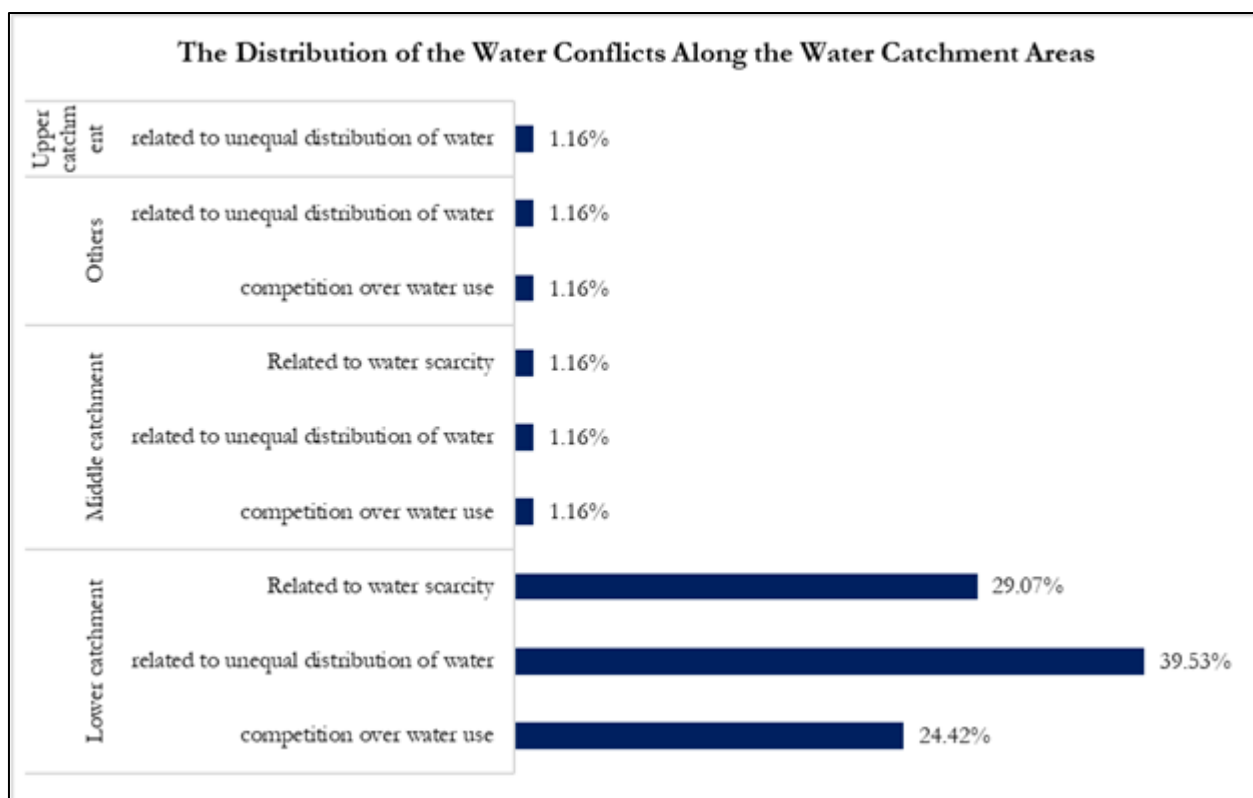


Figure 4: Water conflicts distribution in the three catchment areas

3.4 The Relationship between Surface Water Variability and Water Conflicts

This study objective sought to determine whether there was a significant relationship between surface water variability, which was treated as the independent variable and water conflicts which constituted the dependent variable. Surface water variability was measured based on respondents' perceptions of seasonal water availability while water conflicts were measured based on respondents' experiences of whether variations in surface water availability resulted in water related conflicts within the catchment. The responses were coded and treated as continuous values and Pearson's product moment correlation analysis was conducted using 212 valid paired responses out of the total sample of 298 respondents. The remaining responses were excluded from the analysis due to missing or incomplete data for one or both variables.

Although the catchment experiences considerable seasonal variations in surface water availability, pearson correlation analysis between seasonal surface water variability and water conflicts occurrence revealed a very weak positive relationship ($r = 0.011$, $p = 0.916$) which was statistically insignificant because the $p > 0.05$. This finding suggests that seasonal variations in surface water availability did not have a statistically significant relationship with the nature of water conflicts experienced in the River Rongai catchment. Therefore, other factors may have a greater influence on the occurrence and nature of water conflicts in the catchment.

These results are comparable to the results reported by [23] who associated water demand factors such as population pressure, agricultural activities and economic development with an increased likelihood of water conflicts as opposed to water supply factors within a catchment. Similarly, findings by [24] supports the findings of our study by indicating that river flow diversions (dams), boundary demarcations associated with transboundary water resources, food production and political instability are the major factors influencing water conflicts. These findings support the argument that water conflicts are influenced by multiple social, economic, political and institutional factors rather than by variations in water availability.

Additionally, these results were in accord with the results by [25] who established that there was no direct relationship between variations in water availability and the occurrence of armed conflicts. The study emphasized the need to examine other factors that influence water resource availability. Spatial configurations of landscapes and topographic features influences water resources of a catchment or a basin impacting water at different scales [26]. Other studies highlighted socio-economic factors such as religion, migration and poverty as being linked to water related conflicts during water scarcity [16]. However, the lack of a statistically significant relationship does not mean that seasonal changes in surface water availability is less important in the catchment but rather suggest that changes in water availability alone may not necessarily lead to water conflicts. The occurrence of conflicts may depend on how the

available water is accessed, shared and managed among different users. During periods of low water availability, increased demand for irrigation, unequal water distribution and challenges in how water is governed may contribute to water related conflicts.

Table 2: Relationship between surface water variability and water conflicts

		Surface Water Variability	Nature of Water conflict
Surface water variability	Pearson Correlation	1	.011
	Sig. (2-tailed)		.916
	N	212	212
Nature of conflict	Pearson Correlation	.011	1
	Sig. (2-tailed)	.916	
	N	212	212

4 CONCLUSION

The study revealed that the community perceived the unequal distribution of water as the predominant type of water conflict, although other forms of water-related conflicts were also reported within the catchment. These conflicts were reported to intensify during the dry season when streamflow is low and the available water is insufficient to meet the growing demand among different water users. The conflicts predominantly originate in the lower catchment, where limited access to water may lead to frustrations and confrontations between downstream water users and those in the middle and upper catchment areas. In some cases, these conflicts escalate into violent confrontations resulting in loss of life and destruction of property. Furthermore, the findings revealed that variations in river flow between the dry and wet seasons were not significantly associated with the occurrence of water conflicts when surface water variability was treated as an independent variable. This suggests that changes in river flow alone may not adequately explain the occurrence of water conflicts within the catchment and that other factors may contribute to the emergence and escalation of water related conflicts in River Rongai.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Disclosure of conflict of interest

There is no conflict of interest declared by the authors regarding the publication of this paper.

Statement of ethical approval

Ethical Clearance was sought from Egerton University Ethics Committee. A research permit was obtained from National Commission for Science, Technology and Innovations (NACOSTI) before the commencement of the data collection in River Rongai Catchment, Kenya

Statement of informed consent

Informed consent was obtained from all individual participants included in the study

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