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Factors Influencing Integration of Geographic Information System, Community Coping Strategies, and Local Knowledge in Flood Management in Narok Town, Kenya

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ABSTRACT

Kenya is vulnerable to natural disasters like floods, which are expected to become more common as a result of climate change. Flooding is one of the natural hazards that is catastrophic in nature and affects human settlements, infrastructure and livelihoods. The objective of the study was to To investigate the factors influencing integration of GIS, community coping strategies, and local knowledge in flood management in Narok Town, Kenya. This study adapted analytic cross-sectional study design and exploratory approach. The study population comprised of households within Narok Town. Sampling unit was a single household while the household head was the unit of analysis. Stratified random sampling technique was used to select 385 households from the different zones in the town. A structured flood coping mechanism questionnaire was used to collect data from the household head while Key informant interview guide and focus group discussion was used to gather qualitative information. Descriptive statistics included the mean, standard deviation, percentages, chi-square test were used to analyze data. Analysis was done using SPSS version 24.0 and Quantum Geographic information System to generate data and information on community coping mechanisms, geo– spatial patterns of floods and perception about floods in Narok town. Qualitative analysis was analyzed through the use of secondary literature while quantitative data was analyzed through the inferential statistics Fisher's exact test, Analysis of variance, correlation, and logistic regression. The study findings showed that there is low integration of household knowledge, coping strategies and Geographic information System in flood management among residents of Narok Town. The study finding established that education, Income and government policies influenced integration of local knowledge, coping strategies and GIS integration in flood management. The finding implied that households' heads education, income and awareness of existing government policy on flood disaster management significantly strengthened integration of local knowledge, coping mechanism, GIS integration in flood management.

1. Introduction

According to Dogulu et al., (2015) flood risk specialists are supposed to have a specified level of experience and appropriate awareness of these concerns. Flood Risk Management (FRM) is intrinsically problematic in a variety of ways due to the dynamic and interrelated nature of a flood risk system. As a result, flood risk managers and specialists face a variety of difficulties. In this regard, implementing training and education programs is critical not just for strengthening current flood risk professionals' knowledge and abilities, but also for building capacity through educating future flood risk experts. Unfortunately, the value of such training and education has not been adequately recognized at both the undergraduate and graduate levels. Incorporating a consistent comprehensive and integrated strategy to FRM teaching is still needed over the world.

Furthermore, in recognition of the fact that there is an increasingly significant demand for qualified staff in the field of FRM, there have been initiatives to serve for the purpose of providing training and education, especially in the recent years. An overview of various examples of FRM training and education practices in the world. Among the examples listed are master degrees, short course(s), workshops, and games. The rainy season in Ghana runs from April through July, with heavy rainfall and thunderstorms typically in May. The storm hydrograph can be affected by high rainfall intensities. Heavy rains cause more water to reach the drainage basin, resulting in a larger discharge and a longer period of flooding (Samuel et al., 2015). The flood that struck Accra in July 1995 has a 50-year return time. The majority of these practices are based in Europe, as can be shown.

Using multi-regression analysis and spatial analysis, Kawasaki et al., (2020) discovered that poor individuals tend

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to dwell in flood-prone locations, and that floods can both cause and exacerbate poverty. Spatial distribution results showed that the people who suffer most from floods are those who live in the worst conditions. The study concluded that the resettlement of communities as an option for countering the effects of floods and alleviating poverty. The study finding demonstrate that level of income can influence the integration of flood management practices such as GIS, Coping strategies and adoption of local knowledge in flood management.

Low-income challenges in floodplain management are little understood. Knowledge management improves the overall performance of the long-term disaster management endeavor. People, process, technology, and goal-oriented implications of Knowledge Management (KM) methods in disaster management are considerable. Floods, on average, generate more losses in the United States than any other natural disaster. The extent to which flood control code initiatives reach disadvantaged populations and minorities, a critical metric of program fairness, is partly determined by income and ethnic group. Flood insurance is generally unavailable to disadvantaged groups, and the damage to the poor is sometimes irreversible. Indeed, if the poorest people are the ones who are most affected by floods, more effective methods for coordinating local, state, and federal responses are required.

Policy failures and flood disasters may have also influenced flood management policies. The findings of Haque et al., (2019) demonstrated that policy adjustments were predominantly impacted by the structural intervention paradigm's dominance and catastrophic flood disasters. Multiple interest groups served as contributors to, as well as impediments to, flood prevention strategies, resulting in nonlinear shifts. Policy arguments over environmental issues aided in the transition from a primarily structural approach to a mixed approach that included a variety of non-structural measures. Furthermore, our findings suggest that changes in flood management policies have resulted in a greater reliance on a "people-centered" approach rather than solely on a "engineering coalition," which emphasizes the critical role of community members in decision-making and flood policy and program implementation.

2. Research methodology

2.1 Research design

In order to meet the study's objective, the researcher used an analytic cross-sectional study design that included qualitative and quantitative data collection approaches. This approach is appropriate for the study's nature because it incorporates analytics and necessitates the description, recording, analyzing, and interpreting of existing conditions. It also entails various comparisons and contrasts in order to uncover relationships (Cooper and Schindler, 2011).

2.2 Study area

The research was carried out at Narok town, which is the administrative center of Narok County in Kenya's south west. It is bordered on the north by Nakuru County, on the east by Kajiado County, on the south by Republic of Tanzania, and on the west by Bomet and Migori. Narok is located between latitudes 1°0'0" 'S and 2°0'0" 'S, and longitudes 35°0'0" East and 37°0'0" East, with an elevation ranging from 1827 to 2138 meters above sea level. Narok is a town with a total area of 215.4 km2 (KNBS, 2019) Figure 2.1.

2.3 Sample Size and Sampling Techniques

To determine the number of households' heads, Fischer's formula was used based on simple random sampling.

$$n = \frac{Z^2 pqN}{e^2(N-1) + Z^2 pq} \quad \text{.....Eq. 2.1}$$

Where

n denotes the sample size and N denotes the whole population.

Z= the z score corresponding to a significance level of =0.05,

E stands for Expected Error.

p = interest probability,

q denotes the likelihood of non-interest.

However, because N is a large number, 11,776 households, the formula reduce the to;

$n = (Z^2 * p * q) \div e^2$

Which normal approximation to binomial where

P=0.5, q=0.5, Z0.025=1.96, e=0.05, and substituting these values in the formula3.2, the sample size result is,

Sample size

385 = n = (1.962*0.5*0.5)/0.052 household heads.

As a result, 385 households were sampled for the study in order to obtain the necessary primary data. Narok was purposefully chosen because of its continued vulnerability and the high magnitude of recurrent floods. Key informants were purposively selected which included Sub–County disaster management committee members, stakeholders involved in emergency services (Kenya Red Cross), Kenya Meteorological department and community elected leaders because they had in depth understanding of the research variables.

This study used Stratified Random Sampling. The numbers of households were identified per stratum based on the perpendicular distance of Household location from the river. The first zone is 0-100 meters from, second is for Households within 100-150 Meters and finally above 150 Meters from the river formed the three zones because they are at different risk profiles-high risk, moderate risk and low risks respectively. As shown in Table 2.1, the sample of 385 household heads was proportionately divided among the three categories.

Because of the variation in the number of household units in the risk areas, a stratified-sampling strategy was used to determine the number of household units that were sampled per risk area in order to obtain proportions (Barreiro and Albandoz, (2001).

$$nh = \left(Nh \big/ N\right) n \quad \text{.....Eq. 2.2}$$

nh = sample size of stratum

Nh = Population size of the stratum

N = Total population size

n = Total sample size

In this study, samples of 133, 131 and 121 household heads were sampled from the three strata.In addition, one (1) member of the Sub-County disaster management committee, one (1) emergency service officer, and six (6) community leaders were purposefully chosen for the study.

The researcher assisted by the research assistants conducted mapping to identify all the target population mainly households within the three zones from the river. A Sampling frame was then generated after the mapping, which contained all the households within the study area. The

study included every fifth household until all 385 respondents were located and their contact information was submitted to the research assistants.

3. Results and Discussions

3.1 Influence of education and income on integration of local knowledge in flood management

This section presents the influence of level of education and income level on integration of GIS, coping strategies and local knowledge on flood management in Narok Town in Kenya.

Table 3.1 shows that household knowledge and household education were both significant predictors of flood management. Therefore, household education could be used as a predictor variable of flood management besides being a moderating variable. On the other hand, household incomes was insignificant, hence household income could only act as a moderating variable of the relationship between household knowledge and flood management. In step shown in Table 3.2 the study includes the interaction between household knowledge and household education and Income.

Flood risk experts are expected to have a specific level of expertise and suitable understanding into these issues, according to Dogulu *et al*., (2015). Given the dynamic and interdependent character of a flood risk system, FRM is inherently difficult in a variety of ways. As a result, flood risk managers and specialists frequently confront challenges. In this regard, developing training and education programs is crucial not only for improving the present knowledge and abilities of existing flood risk professionals, but also for increasing capacity through educating future flood risk experts. Unfortunately, the value of such training and

The results show that interaction variables household knowledge*Education and household knowledge*Income were statistically significant at 0.05. The findings implied that household education and household income significantly moderated the relationship between household knowledge and flood management in Narok Town.

The findings of the study backed up those of Dogulu *et al*., (2015), who indicated that flood risk specialists must have a specific level of expertise and awareness into these topics.

The survey also discovered that flood risk managers and professionals encounter numerous challenges. In this regard, developing training and education programs is crucial not only for improving the present knowledge and abilities of existing flood risk professionals, but also for increasing capacity through educating future flood risk experts. The findings of the survey also revealed that there is an increased demand for community flood management training.

The findings backed up those of Kawasaki *et al*. (2020), who concluded that community resettlement is a viable alternative for mitigating flood damage and decreasing poverty. The findings of the study show that socioeconomic status has an impact on the integration of flood management measures such as GIS, coping mechanisms, and the use of local knowledge in flood management.

3.2 Influence of education and income on integration of coping strategies in flood management

The study's goal in this part was to see if household education/income had a moderating effect on the link between flood control outcomes and community coping techniques. Similarly, the two-step strategy advocated by Baron and Kenny (1986) was used.

Table 2.1. Proportional Allocation by risk areas

Stratum	Total Number of Households (Nh)	Sample size $nh = \left(Nh/N\right)n$
Within 100 meters (High Risk)	4,077	133
100-150 meters (Moderate risk)	3,990	131
Over 150 meters (Low Risk)	3,709	121
Total	11,776	385

Source: GoK, 2019 and Researcher (2021)

Table 2.2. Summary of study population units, sample methods and sample size

Population Units	Sample size	Sampling strategy
Households	385	Stratified
County Disaster committee member	1	Purposive
Emergency Service providers	1	Purposive
Community leaders	6	Purposive
Focus Group Discussions	3	Quota Sampling

Source: Researcher (2021)

Table 3.1. Influence of Education and Income on Integration of Local Knowledge in Flood Management

	B	Std. Error	Beta	t	Sig.
Constant	2.486	0.077		32.082	0.000
Local Knowledge	0.24	0.023	0.463	10.235	0.000
HH Education	0.032	0.014	0.101	2.232	0.026
HH Monthly Income	0.024	0.017	0.064	1.437	0.152
Model	1				
R	.501a				
R Square	0.251				
Adjusted R Square	0.245				
Std. Error of the Estimate	0.34205				
F-statistics	42.537				
Sig.	.000b				

Table 3.2. Influence of Education and Income on Integration of Local Knowledge in Flood Management

	B	Std. Error	Beta	t	Sig.
Constant	2.463	0.049		50.024	0.000
Household Knowledge	0.261	0.036	0.504	7.219	0.000
HH knowledge*Education	0.253	0.052	0.271	4.883	0.000
HH knowledge*Income	0.215	0.05	0.242	4.288	0.000
Model	1				
R	.490a				
R Square	0.24				
Adjusted R Square	0.234				
Std. Error of the Estimate	0.34445				
F-statistics	40.181				
Sig.	.000b				

a Dependent Variable: Flood Management At household

The results show that education significantly (β=0.057, p=0.001) predicted flood management while the effect of income was insignificant (β=0.037, p=0.055) at level of significance of 0.05. The finding implied that household education could be used as a predictor variable of flood management besides being used as a moderating variable. On the other hand, income was a good moderating variable of the relationship between flood management outcomes and community coping strategies since it directly has an effect on flood management.

Second steps in the test for a moderating influence of education/income on the link between Flood Management Outcomes and Coping Strategies are presented in Table 3.4.

In this model, the regression analysis includes interaction variables (Coping mechanism* Education and Coping mechanism* Income).

Samuel *et al*. (2015),furthermore, in recognition of the fact that there is an increasingly significant demand for qualified staff in the field of FRM, there have been initiatives to serve for the purpose of providing training and education, especially in the recent years. An overview of various examples of FRM training and education practices in the world. Among the examples listed are master degrees, short course(s), workshops, and games. The rainy season in Ghana runs from April through July, with heavy rainfall and thunderstorms typically in May. The storm hydrograph can be affected by high rainfall intensities. Heavy rains cause more water to reach the drainage basin, resulting in a larger discharge and a longer period of flooding. The flood that struck Accra in July 1995 has a 50-year return time. The majority of these practices are based in Europe, as can be shown.

Coping mechanism* Education and Coping mechanism* Income were statistically significant at the 0.05 level of significance, according to the findings. According to the findings, education and income had a substantial influence on the association between community coping mechanisms and flood management.

Table 3.3 Influence of Education and Income on Integration of Coping Strategies in Flood Management

	B	Std. Error	Beta	t	Sig.
Constant	3.207	0.18		17.781	0.000
Coping mechanism Score	0.07	0.051	0.068	1.353	0.177
HH Education	0.057	0.016	0.176	3.498	0.001
HH Monthly Income	0.037	0.019	0.097	1.928	0.055
Model	1				
R	.223a				
R Square	0.05				
Adjusted R Square	0.042				
Std. Error of the Estimate	0.38529				
F-statistics	6.616				
Sig.	.000b				

a Dependent Variable: Flood Management

Table 3.4. Influence of Education and Income on Integration of Coping Strategies in Flood Management

	B	Std. Error	Beta	t	Sig.
Constant	3.163	0.173		18.258	0.000
Coping mechanism Score	-0.06	0.056	-0.058	-1.061	0.289
Coping mechanism*HH Education	-0.016	0.005	-0.182	-3.447	0.001
Coping mechanism*HH Income	0.012	0.006	0.11	2.113	0.035
Model	1				
R	.226a				
R Square	0.051				
Adjusted R Square	0.044				
Std. Error of the Estimate	0.38495				
F	6.858				
Sig.	.000b				

a Dependent Variable: Flood Management At HH

The findings of the study backed up those of Dogulu *et al*. (2015), who indicated that flood risk specialists must have a specific level of expertise and awareness into these topics. The survey also discovered that flood risk managers and specialists encounter numerous challenges while dealing with floods. In this regard, developing training and education programs is crucial not only for improving the present knowledge and abilities of existing flood risk professionals, but also for increasing capacity through educating future flood risk experts. The findings backed up those of Kawasaki *et al*. (2020), who concluded that community resettlement is a viable alternative for mitigating flood damage and decreasing poverty. The findings of the study show that socioeconomic status has an impact on the integration of flood management measures such as GIS, coping mechanisms, and the use of local knowledge in flood management.

3.3 Influence of education and income on integration of GIS in flood management

Finally, the researcher wanted to see if education and income had a mitigating influence on the association between GIS integration and flood control in Narok Town. The mean of all the statements used to determine the extent of GIS integration was used to calculate the GIS integration score in the study. The score was used to calculate interaction factors (GIS Integration* Education and GIS Integration* Income) in the moderating effect test.

Table 3.5 shows that GIS integration score and education were both significant predictors of flood management. The finding implied that household education could be used as a predictor variable of flood management besides being a moderating variable. On the other hand, incomes were insignificant, implying that household income could only act as a moderating variable of the relationship between GIS integration and flood management. In step shown in Table 3.6 the study includes the interaction between GIS integration and education and income.

GIS integration* Education and GIS integration* Income were statistically significant at the 0.05 level of significance, according to the findings. The findings implied that education and Income significantly moderated the relationship between GIS Integration and flood management.

The findings of the study backed up those of Dogulu *et al*. (2015), who indicated that flood risk specialists must have a specific level of expertise and awareness into these topics. The survey also discovered that flood risk managers and professionals encounter numerous challenges. In this regard, developing training and education programs is crucial not only for improving the present knowledge and abilities of existing flood risk professionals, but also for increasing capacity through educating future flood risk experts.

The findings backed up those of Kawasaki *et al*. (2020), who concluded that community resettlement is a viable alternative for mitigating flood damage and decreasing poverty. The results of the study show that income has an impact on the integration of flood management measures including GIS, coping mechanisms, and the use of local knowledge in flood management.

3.4 Influence of government policies on integration of GIS, local knowledge and coping strategies in flood management

The goal of this phase of the study was to see how government policies affected the integration of GIS, local knowledge, and coping techniques in flood management. Figure 3.1 shows that just 31% of respondents indicated that they were aware of national and county flood management policies. The data suggest that community understanding of government flood management strategies is quite low. This explains why residents of Narok Town are often hesitant to hold government officials accountable for the recurring floods that have destroyed property worth millions of dollars.

The findings were consistent with those of Haque *et al*. (2019), who found that policy transitions were predominantly driven by the structural intervention paradigm's dominance and catastrophic flood events.

Table 3.5. Influence of Education and Income on Integration of GIS in Flood Management

	B	Std. Error	Beta	t	Sig.
Constant	2.635	0.075		35.314	0.000
GIS Integration	0.308	0.036	0.394	8.524	0.000
Education	-0.047	0.015	-0.147	-3.177	0.002
Monthly Income	0.027	0.018	0.07	1.517	0.130
Model	1				
R	.445a				
R Square	0.198				
Adjusted R Square	0.192				
Std. Error of the Estimate	0.35394				
F-statistics	31.334				
Sig.	.000b				
a Dependent Variable: Flood Management At					

Table 3.6. Influence of Education and Income on Integration of GIS in Flood Management

	B	Std. Error	Beta	t	Sig.
Constant	2.584	0.044		58.52	0.000
GIS Integration	0.320	0.062	0.408	5.188	0.000
GIS Integration* Education	0.032	0.013	0.140	2.387	0.017
GIS Integration* Income	0.149	0.049	0.152	3.013	0.003
Model	1				
R	.436a				
R Square	0.19				
Adjusted R Square	0.184				
Std. Error of the Estimate	0.3557				
F-statistics	29.779				
Sig.	.000b				

Table 3.7. Results for Influence Integration of GIS, Local knowledge and coping strategies in Flood Management

	Not at all	Rarely	Sometimes	Often	Always	Mean	Std Dev
The government has inculcated awareness on occurrence of floods to the local population	36.1%	27.5%	29.9%	3.6%	2.9%	1.10	1.03
There exist monitoring systems set by the government on flooding	32.5%	28.3%	31.9%	4.9%	2.3%	1.16	1.01
Early warning systems to alert people on flooding exist in the community	31.2%	30.6%	32.2%	2.1%	3.9%	1.17	1.02
Government awareness policies on floods allow me to respond quickly to threats of floods	30.4%	28.3%	34.5%	4.2%	2.6%	1.20	1.01
Existence of accurate monitoring systems allow me to escape from floods	33.0%	29.1%	30.1%	2.6%	5.2%	1.18	1.08
Early flood warning systems enable me to reconstruct my livelihood quickly	33.8%	28.6%	30.9%	3.6%	3.1%	1.14	1.03

Source: Survey Data (2020)

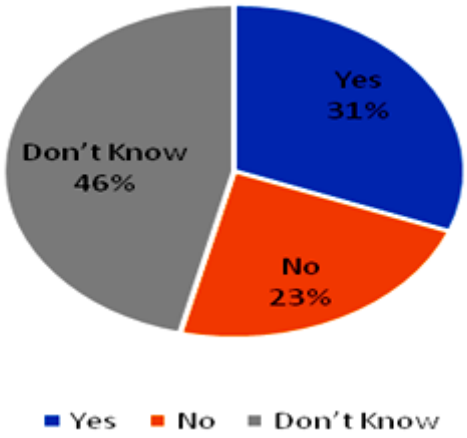

Figure 3.1. Whether Existing Policies Influence Integration of GIS, Local knowledge and coping strategies in Flood Management.

This section sought to find out from the respondents whether existing policies influence integration of GIS, local knowledge and coping strategies in flood management in Narok Town. The study sought to establish whether the local communities in Narok town have used government policies in coming with effective coping mechanism in flood management.

The respondents were asked if the government, including the national and county governments, had done public awareness programs in Narok about floods and how the local community could manage floods. Table 3.7 shows that the majority of respondents said they only did it occasionally or never did it at all. The findings implied that despite the fact that Narok Town has been experience destructive floods for decades, the government rarely take initiative of conducting public awareness campaigns where local communities are trained on various coping mechanisms or are made aware on flood hotspots and periods that floods are likely to occur. Lack of such awareness reduces community level of preparedness leading to maximum impacts on floods.

The researchers also wanted to know if there were any early warning systems in place to warn people about flooding. According to the findings, the majority of respondents stated that such early warning systems did not exist or were only utilized infrequently to advise local people about probable floods. Despite the fact that floods occur on a regular basis in Narok town, the findings of this study indicated that the government still does not provide early warning to local communities to assist households living in flood-prone areas in early preparedness. The findings also suggest that the majority of respondents believe that the government's flood awareness policies, early warning systems, and monitoring systems in Narok Town are insufficient and do not support the local people in responding quickly to flood risks.

The findings of the study back with Kiptim's (2019) finding that humanitarian relief organizations frequently utilize the phrase "early warning, early response" to confront an impending disaster. Early warning is the most effective way of approaching a crisis, according to the scientific community. This gives affected communities time to prepare and/or avoid disaster. For example, an early warning of impending heavy rain in a flood-prone area will allow residents to evacuate the area before the rains arrive. People who live in flood plains, on the other hand, should leave the area well before the rains arrive. Floods in Marigat Sub County have occurred as a result of the towns' failure to implement an early warning system. According to Okaka and Odhiambo (2019), the majority of households have implemented some adaptation steps, the majority of which were temporary, owing to budgetary constraints, a lack of knowledge, and government support.

4. Conclusion

The study concluded that educated household and those household with better income, tend to have better knowledge and coping mechanism during floods. Education and availability of resources enables households to be proactive in seeking relevant information which in necessary in flood management.

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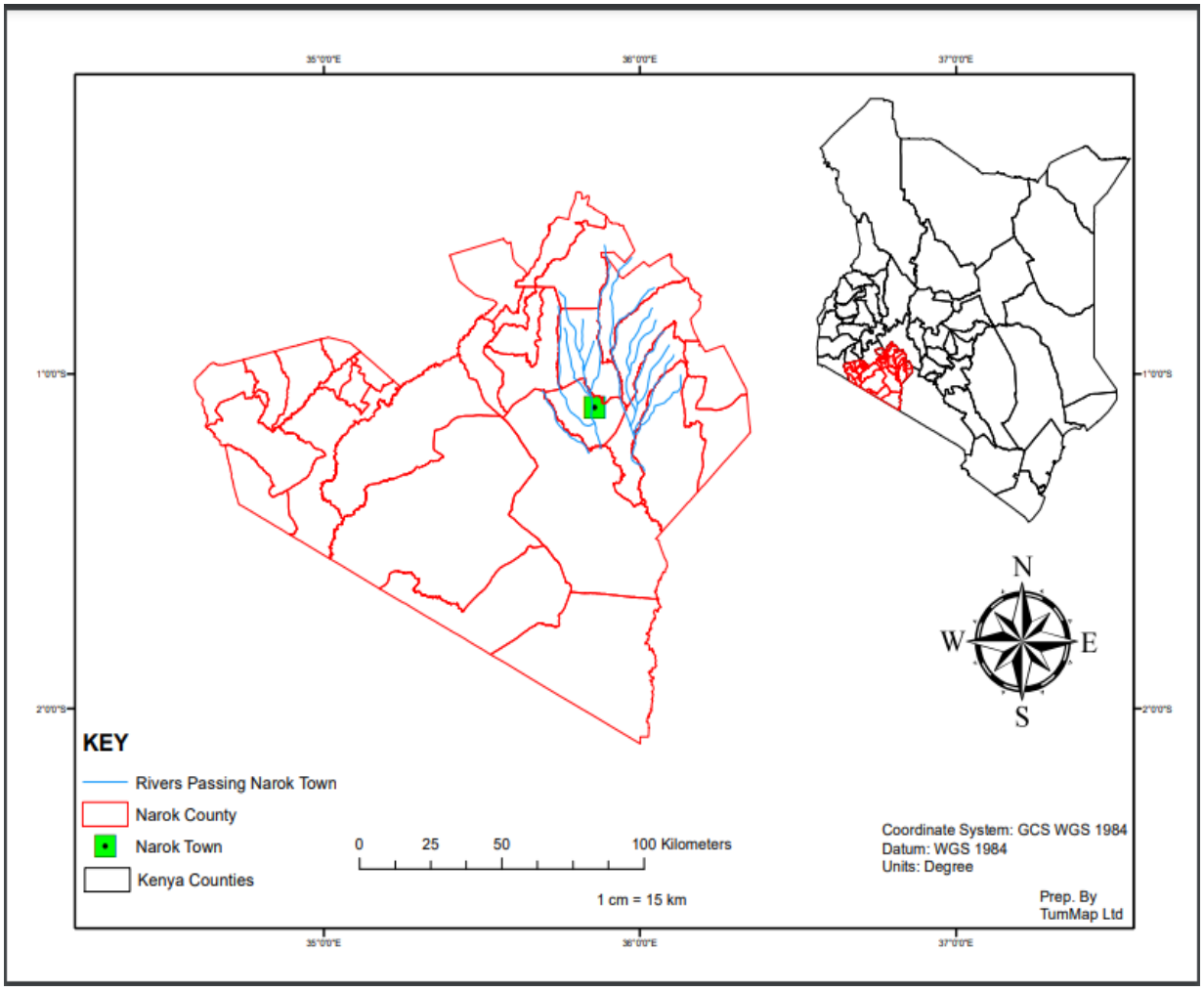

Figure 2.1 Map of study area

Source: Researcher (2021)