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Application of Geographic Information Systems in Studying the Relationship between Stock Routes Changes with Water and Pasture Availability for Livestock under a Changing Climate Conditions: A Case of Ilemela and Magu Districts in Mwanza Region-Lake Victoria Basin, Tanzania

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Abstract: Beef cattle production is declining in the areas surrounding LVB (Lake Victoria Basin) due to many factors among which is the climate change. This study was focused on generating spatial knowledge that will be useful in designing appropriate strategies for improving beef cattle production on rangelands of the LVB, through assessing changes in stock routes in relation to water and pasture availability for livestock under a changing climate. The study used participatory mapping and focused group discussions to assess spatial changes of stock routes in relation to water availability and pasture under critical climate changes. Also, GIS (Geographic Information Systems) technologies were deployed in formalization of spatial layers for integration with other pertinent datasets to the facilitate analysis. The study revealed remarkable stock routes changes (i.e. some have been lost, some have been converted into roads, while others have been lost and others narrowed influencing conflicts between pastorists and farmers. The stock routes changes are made by the increased human population which has led to an increase of cultivated areas and subsequently the decline of water sources and grazing land for pastorists. It is recommended that there should be effective land use planning practice, real-time stock route modification concomitant with adverse climate changes and cattle farming practice. Intervention by other mitigation measures particuticularly rainwater harvesting which is a strategy for alleviation of climate change effects for improving beef cattle production in LVB areas is proposed.

Key words: Stock routes changes, participatory mapping, GIS (Geographic Information Systems) technology, beef cattle production, climate change, LVB (Lake Victoria Basin).

1. Introduction

Livestock production contributes about 40 percent of the global value of agriculture output and supports the livelihood of almost a billion people [1]. Approximately 50 percent of the world's livestock are supported by drylands (areas with rainfall lower than the evaporative demand) [2]. Therefore, there are more livestock in the semi arid to arid rangeland which forms nearly 30% of the world's land surface [3]. For the LVB (Lake Victoria Basin), more than 60% of its area is covered by rangeland which contributes 10-20% of the GDP (Gross Domestic Product) of East African economies [4]. One of the contributors of the rangeland to the GDP is the livestock sector, where over 36% of the cattle are in Tanzania and are concentrated in the area surrounding LVB (*ibid*). The beef cattle production system practiced in the LVB is extensive, involving cattle grazing on natural pastures (*ibid*). This system is characterized by overgrazing,

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low livestock production and soil degradation (*ibid*).

In this regard, expansion and intensification of crop production systems, deforestation and urbanization within the region pose challenges of equity of resource management. Under the effects of global climate change, these challenges of resource management are expected to increase [4]. Some challenges increases drought, reduces rainfall and primary productivity of rangelands and hence food insecurity.

The risk of degradation in combination with the increasing demand of livestock production reveal the needs for viable land use strategies that would increase the yield of rangelands while coevally ensuring the long-term ecological as well as economic sustainability, in particular under climate change (*ibid*).

This study was set to apply GIS (Geographic Information Systems) technologies and participatory mapping approach to generate spatial knowledge in designing appropriate strategies for improving beef cattle production underchanging climate conditions. It assesses changes in stock routes in relation to water and pasture availability for livestock for the case of Ilemela and Magu districts in Mwanza Region Lake Victoria Basin, Tanzania.

2. Description of the Study Area

Ilemela and Magu districts are located between latitude 2°10′ and 2°50′ South and longitude 33° and 34° East in Mwanza Region (Fig. 1). Mwanza Region is located in the Northern part of Tanzania, South of Lake Victoria. Ilemela District is bordered by the North of the Lake Victoria, by the East of Magu District, by the South of Misungwi District and by the West of the Mwanza Gulf of Lake Victoria. Part of the Mwanza town is within Ilemela District, while, Magu District is bordered by the North of Lake Victoria and Ukerewe District by the North East of Mara Region

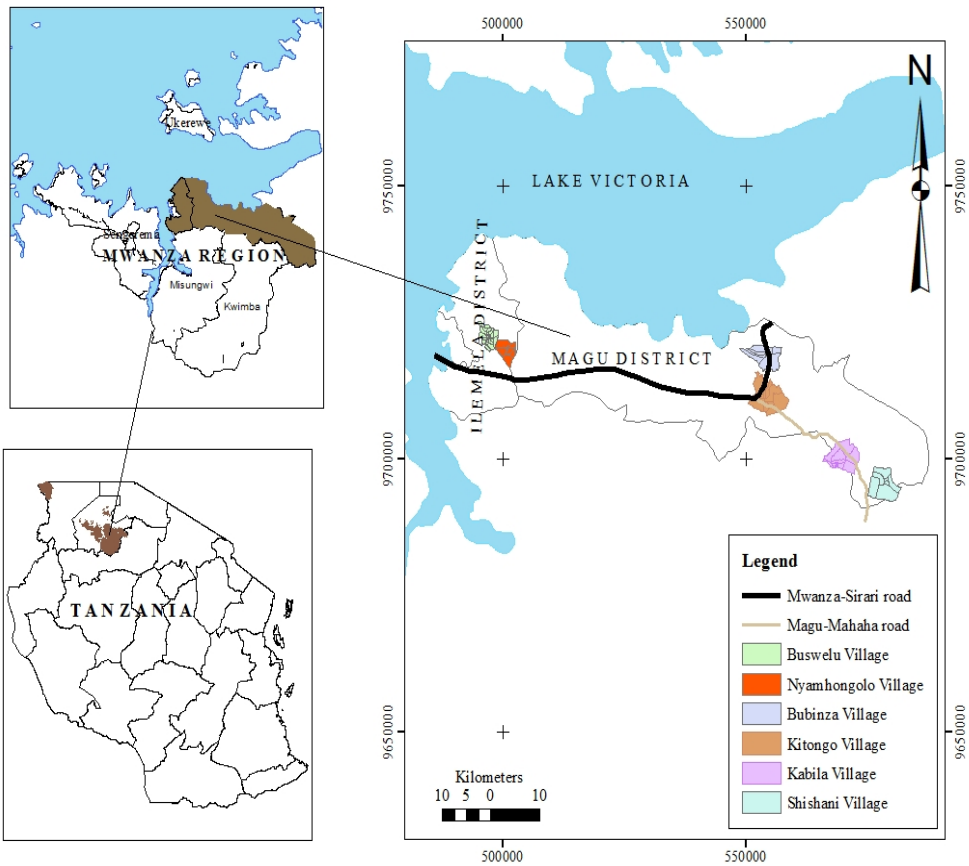

Fig. 1 Ilemela and Magu Districts.

and the South East border Shinyanga Region. Kwimba and Misungwi districts are to the south, while the western border is shared with Ilemela of Mwanza City.

The districts have tropical temperature ranging between 25 °C and 30 °C. The rainfall pattern is bimodal, October to December and March to May, ranging from 700 mm to 1,000 mm (2011). Temperatures and rainfall are strongly influenced for their proximity to Lake Victoria and Equator [5].

Ilemela District is a highly populated (human and livestock) area with the consequent pressures on land and competition between human and livestock requirements. According to the 2012 Tanzania National Population and Housing Census, the population of people in Ilemela District was 343,001, and as per year 2005/2006 according to URT (2008) the population of cattle was 73,621. Magu District has high population densities though there is a slight decrease towards the eastern end in Kivukoni Division [6]. A large proportion of the population is concentrated along the Lakeshore, which makes the pressure along this part very high. According to 2012 National Population and Housing Census, the population of people in Magu District is estimated to be 299,759, and as per year 2005/2006 according to URT (2008) the population of cattle was 320,163.

Livestock keeping is the third leading economic activity of the majority of people in Mwanza Region with estimated cattle of 1,976,971 (URT, 2012). The main crops grown in the study districts are cotton, paddy, maize, sorghum, sweet potatoes, groundnuts, cassava and horticultural crops, such as tomatoes, onions and vegetables. Outside crop farming and livestock keeping fishing is a major economic activity in Magu District, while services, commerce and industries are major economic activities in Ilemela District outside crop farming and livestock keeping.

3. Research Methodology

The methodology was based on assessment of water points and stock routes spatial changes over the period of 30 years (i. e. 1980-2010). Specifically, it involved, participatory mapping of past water resource points and stoke routes in collaboration with key informants and elders representing the communities as well as the current water source points and stoke routes. Participatory mapping was important in this regard, as it facilitated ownership of the process and discussion and open discussion of the evolution of the village landscapes and their characteristics. Additionally, participation of the remaining portion of the community was through guided questions which were asked through focused group. These discussions were carried out purposefully from six villages bordering rangelands in Ilemela and Magu Districts i.e. Buswelu and Nyamhongolo villages in Ilemela District and Bubinza, Kitongo, Kabila and Shishani villages in Magu District. The study was carried out in two phases

4. Results

4.1 Ilemela District

Comparative response during focused group discussions in Buswelu and Nyamhongolo villages in Ilemela District has been revealed for the past 30 years;

There is remarkable change in land cover due to the increase of human population increase and urbanization. This has led to the decline of both pasture and water sources. Ref. [8] ascertained this, whereby the coverage of anthropogenic activities (settlements and cultivated areas) increased, while riverine vegetation and woodlands declined between 1980 and 2010. This implied that much of the riverine vegetation and wood lands were cleared from increased anthropogenic activities. This has exacerbated climate change within the district as indicated by the declining rainfall.

These changes have brought changes in stock routes to grazing land and water sources. Initially these stock routes which were used by livestock to pasture and drink water have become roads and lost (Figs. 2 and 3).

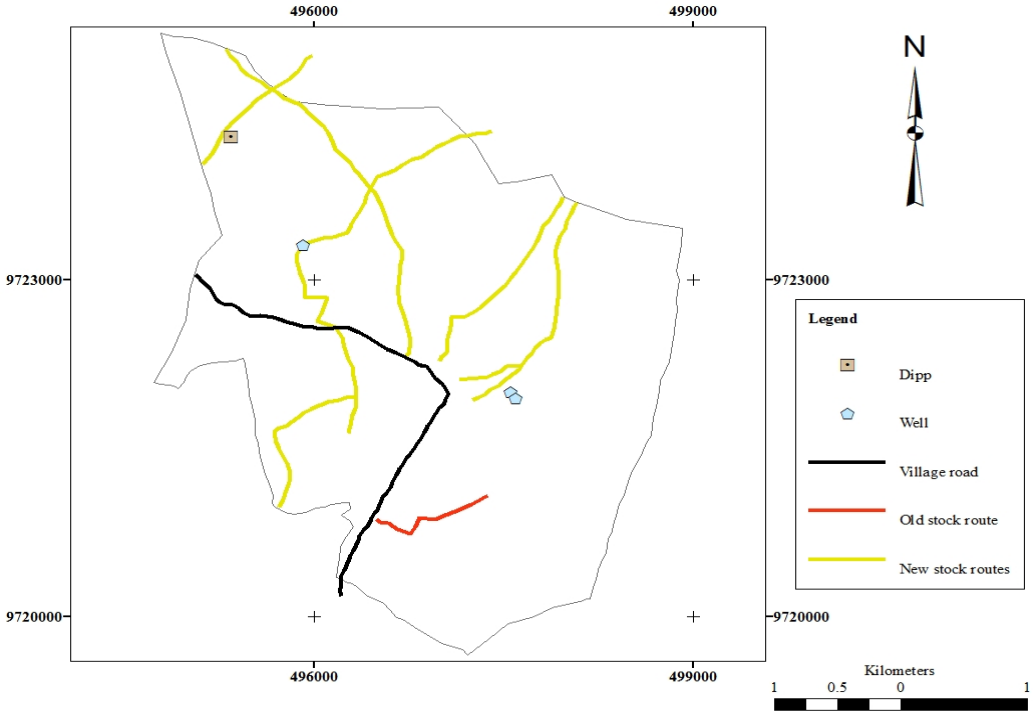

Fig. 2 Map of Buswelu Village showing changes in stock routes in relation to water availability and pasture for livestock, as well as a road used as a stock route.

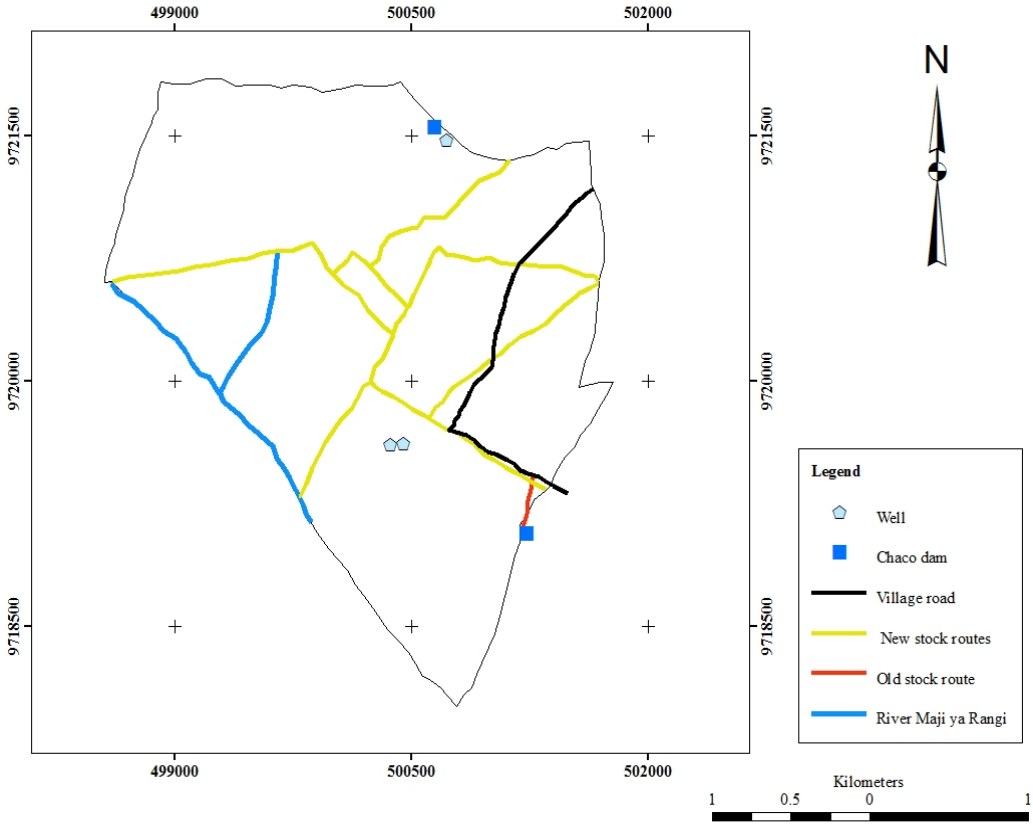

Fig. 3 Map of Nyamhongolo Village showing changes in stock routes in relation to water availability and pasture for livestock, as well as a road used as a stock route.

N. B. Stock routes were used by livestock to water sources and pasture land, but now have become roads and other blocked by houses due to urbanization. Moreover, urbanization has resulted to the decline of pasture land and water sources.

4.2 Magu District

Comparative response during focused group discussions in Bubinza, Kitongo, Kabila and Shishani villages in Magu District has been revealed for the past 30 years;

There are many changes in land cover due to the loss of forests and wetlands vegetation; increase of settlements, institutions, farmlands and woodlots as a result of population increase. This is also ascertained [7] whereby the coverage of anthropogenic activities (settlements and cultivated areas) increased, while riverine vegetation and woodlands declined between 1980 and 2010. This implied that, the increase of anthropogenic activities (settlements and cultivated areas) have resulted in the general decline of woodland, riverine vegetation and hence leading to environmental problems such as drought, famine, drought, land degradation and others.

N. B. Stock routes were used by livestock to drink water and pasture, but now they have become roads, lost or invaded by crop farmers due to population increase and expansion of agricultural activities. Moreover, these land use changes have resulted in the decline of pasture land.

N. B. Stock routes which were used for providing food and water for livestockin the past, now have become narrow due to expansion of agricultural activities and settlements. This has caused land use conflicts, as livestock are invading the crops.

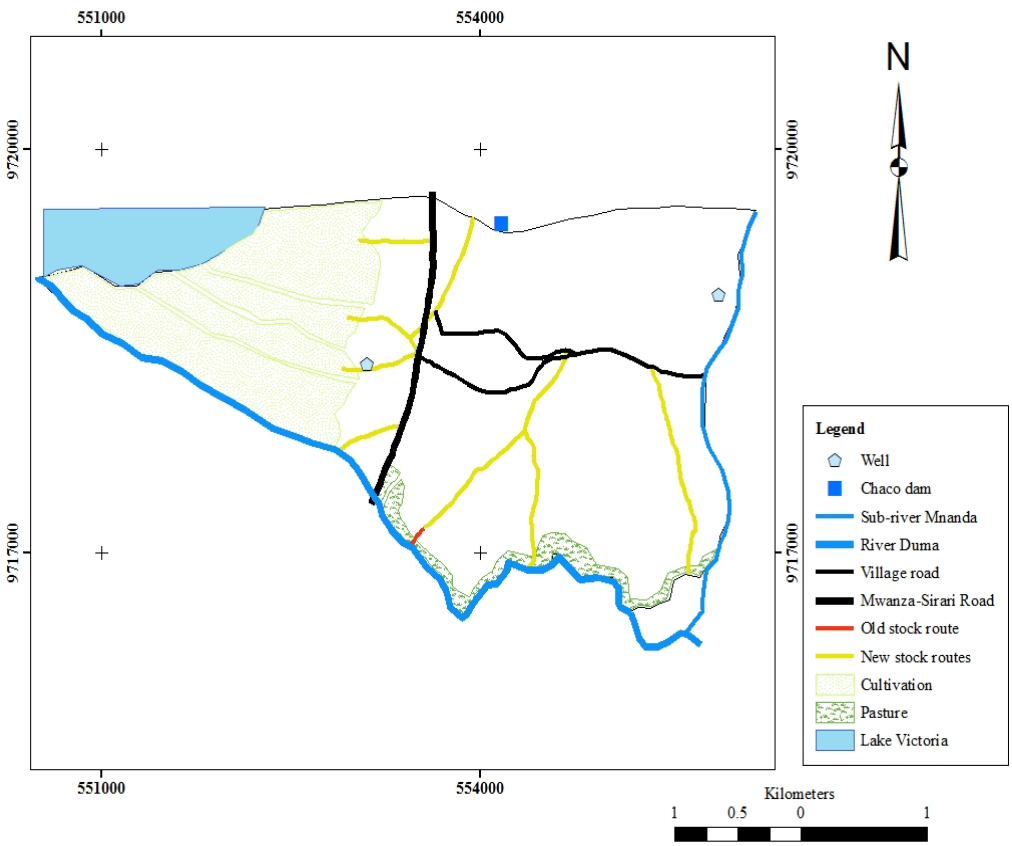

Fig. 4 Map of Bubinza Village showing changes in stock routes in relation to water availability and pasture for livestock, as well as roads used as stock routes.

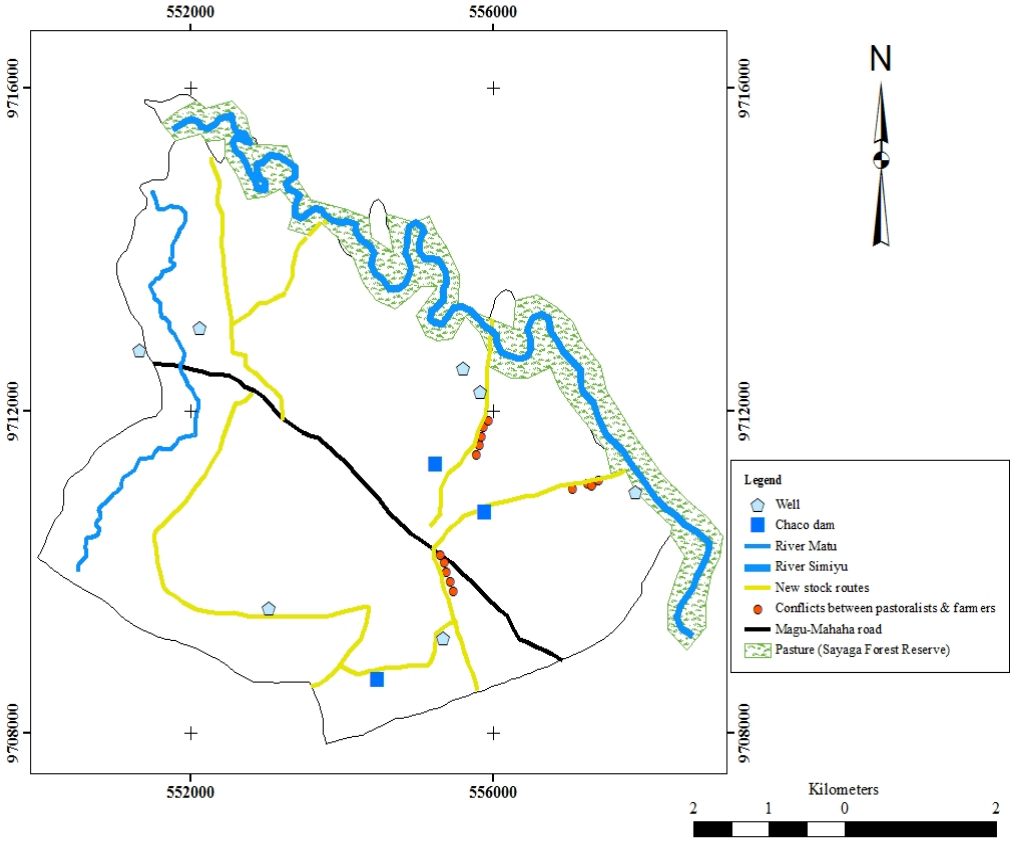

Fig. 5 Map of Kitongo Village showing changes in stock routes in relation to water availability and pasture for livestock, as well as a road used as a stock route.

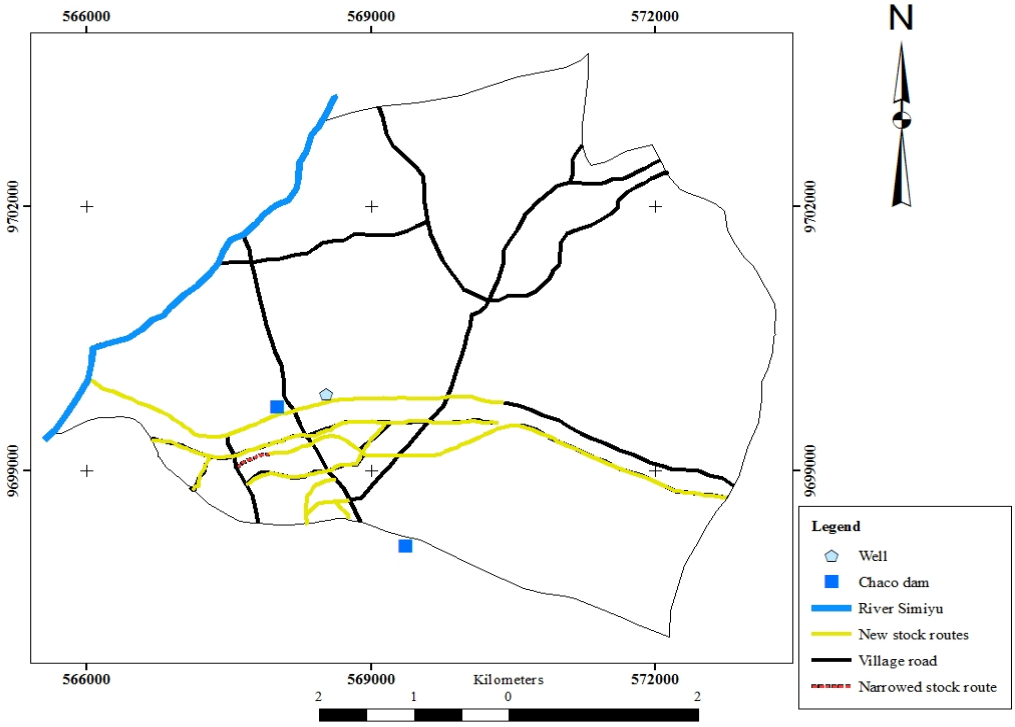

Fig. 6 Map of Kabila Village showing changes in stock routes in relation to water availability and pasture for livestock, as well as a road used as a stock route.

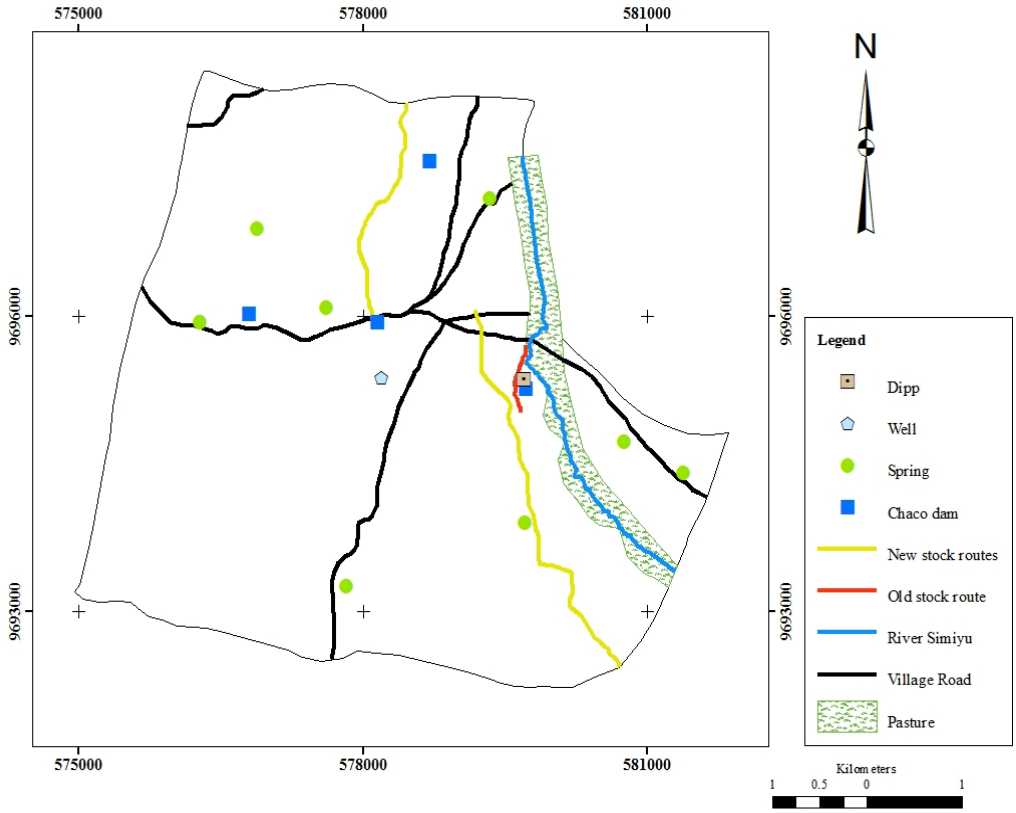

Fig. 7 Map of Shishani Village showing changes in stock routes in relation to water availability and pasture for livestock, as well as a road used as a stock route.

5. Discussions

The assessment of spatial changes in stock routes in relation to water availability and pasture revealed that approximately 5% of stock routes have been lost, 3% narrowed and 92% are now used as village roads. These changes have been brought by the increase of human population which has more settlements and cultivated area. Additionally, anthropogenic activities have resulted in decline of grazing land, water sources and land use conflicts between pastoralists and farmers.

The government of Tanzania [8] stated that pastoralists have been disowned of their grazing lands, due to climate changes. And as human population increases, they are all now scrambling for the productive land which is the origin of conflicts.

Stoke routes have changed course over the last thirty years due to climatic changes towards water sources such as dams, this is a testimony that there has been persistent dryness in the study area over those years, which is threatening livelihood of people and consequently beef production. Unreliable rainfall over the study area due to climate variability, has led to the decline of water sources. Thus, rainwater harvesting as an intervention for improved beef cattle production should be introduced and emphasized. Currently, rainwater harvesting practices are mostly from iron roofs collected in buckets and plastic simtanks for domestic use. Also, there are old and local Chaco dams in Magu District that are used for harvesting runoff water for domestic, livestock and agriculture use during both the rain and dry season. These existing Chaco dams should be repaired and new ones constructed to ensure effective availability of water for improved beef cattle production.

6. Conclusion and Recommendations

The study emphasizes on land use planning and

rainwater harvesting for improvement of beef cattle production in the face of changing climate. Also, stock routes should be continuously modified to mitigate conflicts between pastoralists and farmers. Moreover, livestock keeping within the study area is still predominated with traditional methods which keep the productions low. Due to this, education on effective pastoral farming is highly needed for the improvement of beef cattle production in the face of changing climate.

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