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*Full Length Research Paper*

# Mapping of limestone deposits and determination of quality of locally available limestone in Rwanda

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**Soil erosion, soil nutrient depletion and soil acidity associated to Aluminium (Al) toxicities are the main soil related constraints to agricultural development in many countries of sub-Sahara Africa. The lime plays an important role in improving soil acidity and hence favours plant nutrition. The aim of this study was to map out the available limestone deposits and to determine their selected quality. The selected quality of limestone (CaO, MgO and fineness factor) was analyzed using ethylene diamine tetraacetate (EDTA) method. The global positioning system (GPS) coordinates of limestone deposits were taken. The collected data were processed using Arc GIS 9. The fineness factor was determined by mechanically sieving the lime through a stag of 4 sieves of various aperture dimensions (2, 1, 0.5 and 0.2 mm). The map showed that the limestone deposits are scattered in Northern and Western provinces with more concentration in Northern region. Mpenge limestone had an average of 40% ±4.2 of CaO and 3% ±0.9 of MgO. However, its fineness factor of 63% ±2.01 found to be in good range. Gishyita deposit was heterogeneous in $CaCO_3$, its CaO was 50% ± 20.02 indicating high variability within mines where CaO reached < 30%. Mashyuza deposit in Rusizi region had 50% ±3.4 of CaO and moderate MgO of 3% ±0.6. However, its fineness factor was 55.6% ±1.6 .The difference in lime quality observed in this study was possibly due to the origin of limestone rocks. However, the fineness factors were below the acceptable level because of non-additional grinding and lack of technological skills in producing lime. Therefore, this study recommends the use of grounded limestone after fine grinding.**

**Key words:** Limestone deposit sites, CaO, MgO, fineness factor.

## INTRODUCTION

Agriculture is the most important sector of the Rwandan economy, supporting 82% of the population (NISR, 2009). However, agricultural productivity remains critically low. The low productivity of the agricultural sector is largely attributed to low and decreasing soil fertility due to many factors such as soil erosion, continuous cropping, soil acidity and inadequate sustainable soil fertility management. For instance, the acidity affects the fertility of soils through nutrient deficiencies (P, Ca and Mg) and the presence of phytotoxic nutrients such as soluble Al and Mn (Awad et al., 1976). Application of lime in acid soils reduces Al toxicity, improves pH, Ca, Mg and

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**Table 1.** Particle size and efficiency factors of limes.

| Particle size(mesh sieving size) | Opening size (mm) | Efficiency factor |
|---|---|---|
| >8 | >2.36 | 0 |
| 8 - 60 | 2.36 - 0.25 | 0.5 |
| <60 | <0.25 | 1.0 |

Source: Havlin et al. (2005).

increases both P uptake in high P fixing soil and plant rooting system (Black, 1993). The potentials for soils sustainable management are among the options to explore in restoring soil fertility. In agriculture, lime has great importance in improving soil acidity and hence favours plant nutrition. It is observed in Rwanda that even small locally produced limes and liming materials can be used to increase crop production on acidic soils (Yamoah et al., 1992).

The lime is known as a material originated from rocks which can have multiple purposes (construction, cements, water purification, disinfectant, agricultural amendments, etc). Locally available carbonates are relatively common in many countries of sub-Saharan Africa and are well suited for small-scale mining and processing (Van Straaten, 2002). In Rwanda, there is relatively good sources of limestone (travertine) mainly in the Western (Karongi and Rusizi districts) and the Northern (Musanze district) provinces and other small deposits in Gakenke and Rulindo districts. The government of Rwanda through the crop intensification program has singled out the lime use given its impact on crop productivity. Currently, the government is providing some lime to smallholder farmers through the districts administration and local non-governmental organizations (NGOs). However, there is limited information in terms of illustrating the exact location of limestone deposits in Rwanda which implies the insufficient use of lime in many parts of Rwanda. Therefore, this study aimed to map out the lime deposits and to determine the selected quality of locally available limestone in Rwanda.

## MATERIALS AND METHODS

This study was conducted in Northern Province: Musanze, Burera, Rulindo and Gakenke districts, and in Western province: Karongi, Nyamasheke and Rusizi districts). The study consisted by laboratory analysis of selected quality (CaO, MgO and fineness factor) of limestones and taking global positioning system (GPS) coordinates of limestone deposits. The collected data were processed using Arc GIS 9. The collected data were supplemented by exploring previous studies on the same matter.

The Ca (%) and Mg (%) were analyzed by ethylene diamine tetraacetate (EDTA) method (Hesse, 1971), the titration was done with EDTA 0.01N. The CaO (%) and MgO (%) were determined by multiplying Ca with conversion factor of 1.3992 and Mg with conversion factor of 1.6578 (Marcus, 2009). Fineness factor (%) was determined by mechanically sieving the lime through a stag of 4 sieves of various aperture dimensions (2, 1, 0.5 and 0.2 mm) resulting to 5 classes of lime. The particles obtained were multiplied by efficiency factor of 0, 0.5 and 1 (very less degradable, less degradable and quick degradable), respectively (Table 1).

$$\text{Fineness factor (\%)} = \sum \left( \frac{\text{Particle * Respective efficiency factor}}{\text{Sample quantity}} * 100 \right) \quad (1)$$

## RESULTS AND DISCUSSION

### Lime deposits in Rwanda

The deposits of limestone in Rwanda are scattered in Northern and Western provinces with more concentration in Northern region (Figure 1).

Several studies (Verhaeghe, 1963; Grigoriev, 1981; Beernaert, 1999; SOFRECO, 2001; Van Straaten, 2002) indicated that Rwanda has relatively good sources of agricultural lime mainly in Musanze, Karongi and Rusizi districts with small deposits in Gakenke, Rulindo and Nyamasheke districts. Almost all deposits of limestone in Rwanda are located in axis zones of N 35°E, ranging from Mashyuza (south part of Western province) to Ruhengeri (Northern province), this axis is the one of recent major fracture related to the genesis of African rift valley (SOFRECO, 2001).

The study carried out by SOFRECO (2001) found out that the main lime deposits ready to produce lime for agricultural purpose estimated at ±18,700,000 $m^3$ while the deposits not for agriculture was estimated at ±57,550 $m^3$, which may be suited for construction purpose. However, current research demonstrates that the required quantity for addressing all acidic soils in Rwanda, estimated at 2,220,480 t. This quantity is quite low compared to the available lime deposits identified by SOFRECO (2001).

#### *Lime deposits in Northern region*

Lime deposits in northern region are composed by several sites such as Cyiri (Kinoni sector) in Burera District, Kiryi (Kigombe, Mpenge) and Rwaza in Musanze distrcit, Masangano in Gakenke district and Gitagata in Rulindo district (Figure 2).

These lime deposits are being exploited for many years by cooperatives, groups, privates and companies. However, some were discontinued from operating due to

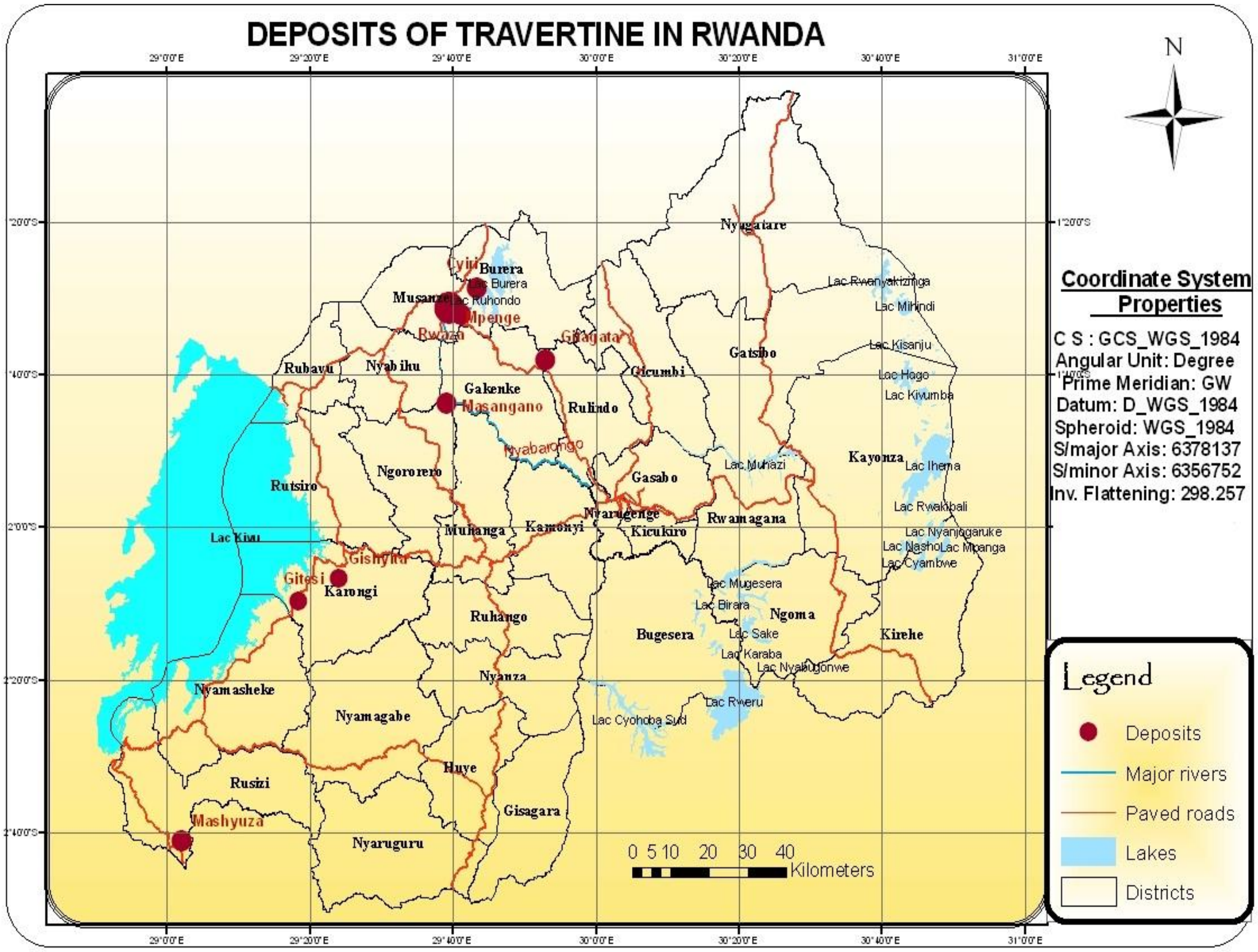


**Figure 1.** Map illustrating limestone deposits in Rwanda.

1994 Genocide. Majority of product is in the form of burned lime for construction and not for agricultural purpose. Among all sites, Mpenge site has the appropriate lime for agricultural practice, because of hardness, the rest (Cyiri, Kigombe, Rwaza, Gitagata and Masangano) are suitable for construction and other purposes. The studies of Beernaert (1999) found that the grounded Mpenge limestone is suitable for agriculture and could replace burned lime (Nduwumuremyi et al., 2013). All lime producers in this region are relying on traditional techniques and they do not possess machines for finely grinding limestone, consequently, the produced products are less effective and therefore, are very expensive as they are needed in bulk quantity (Coventry et al., 1989) to meet the requirement in the acidic soils.

**Selected quality (CaO, MgO and fineness factor) of Mpenge limestone:** This study showed that in Northern region, Mpenge limestone (travertine) is suited for agricultural practices with an average of 40% ±4.2 of CaO and 3% ±0.9 of MgO. However, its fineness factor of 63% ±2.01 found to be in good range, but to improve the reactivity (solubility) for reasonable period after its application, it is still to be increased by finely crashing limestone by appropriate machine. The good range of fineness factor was reported to be at least >60% (Crawford et al., 2008). Several studies (Rwagashayija, 1990; Rukeratabaro, 1991; Beernaert, 1999; SOFRECO, 2001) reported that the grounded limestone (travertine) from Mpenge site was ±50% of fineness which is very low to the recommended fineness level and can compromise the effectiveness of lime in soils.

### *Lime deposits in Karongi region*

Lime deposits in Karongi region are composed by two main sites, Ruhundo/Gitesi in Karongi district and Gishyita site, the last borders two districts (Karongi and Nyamasheke). The deposit of Gitesi was discarded from exploitation due to the inaccessibility, poor liming effect or quality (low in CaO) and inconsistency in quality within

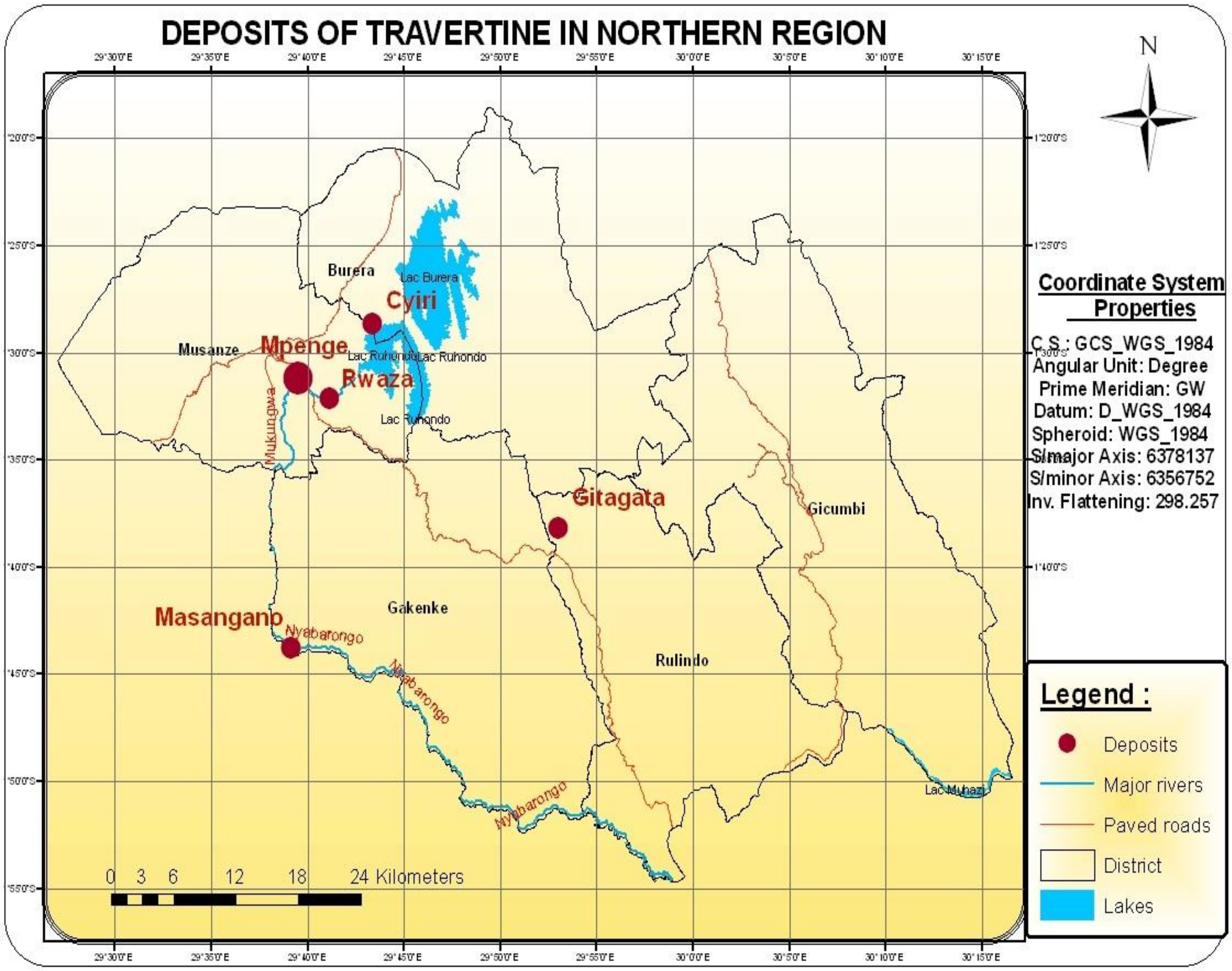


**Figure 2.** Map illustrating limestone deposits in Northern region.

the deposit. In additional, the high slope of the deposit associated with traditional techniques (manually) without appropriate equipments and safety materials render the deposit dangerous for mine workers. The lime deposit of Gishyita was reported to be approximately 1,000,000t of heterogeneous $CaCO_3$ (SOFRECO, 2001) because of its variability in $CaCO_3$. Additionally, this deposit is geographically accessible by good road on axis Rusizi-Karongi (Figure 3).

However, despite its accessibility, Gishyita deposit is barely used in agriculture probably due to its high variability in CaO.

**Quality (CaO, MgO and fineness factor) of Gishyita limestone:** Despite the accessibility of the deposit, the lime deposit of Gishyita was found to be heterogeneous in $CaCO_3$. The level of CaO was 50% ±20.02 with high variability within mines where CaO can even be <30% and MgO was 3% ±11.1, but its variability is also a constraint where it can reach 15% of MgO. These are corroborated to the findings of Beernaert (1999) and SOFRECO (2001) who reported Gitesi deposit to be enriched in MgO (3 to 16%) and poor in CaO (<40%).

### *Lime deposits in Rusizi district*

The size of this deposit is approximately one $km^2$ scattered with small deposits which were not evaluated and measured in this study. Only the site of Mashyuza (Figure 4) was analyzed.

Recently, the CIMERWA (Cemetrie du Rwanda), COCOCHAUMA (Coopérative de Production de la Chaux de Mashyuza) and APC Mashyuza Ltd are the three major enterprises for exploitation of Mashyuza limestone deposits. The CIMERWA uses Mashyuza limestones as one of the materials of mixture for production of Portland cement. The clinker is made by 78% of limestones (travertine), 20% of quartzite, clay and pozzolan. However, COCOCHAUMA and APC Mashyuza Ltd are exploiting limestone for production of quicklime reserved for construction. The production of grounded limestone

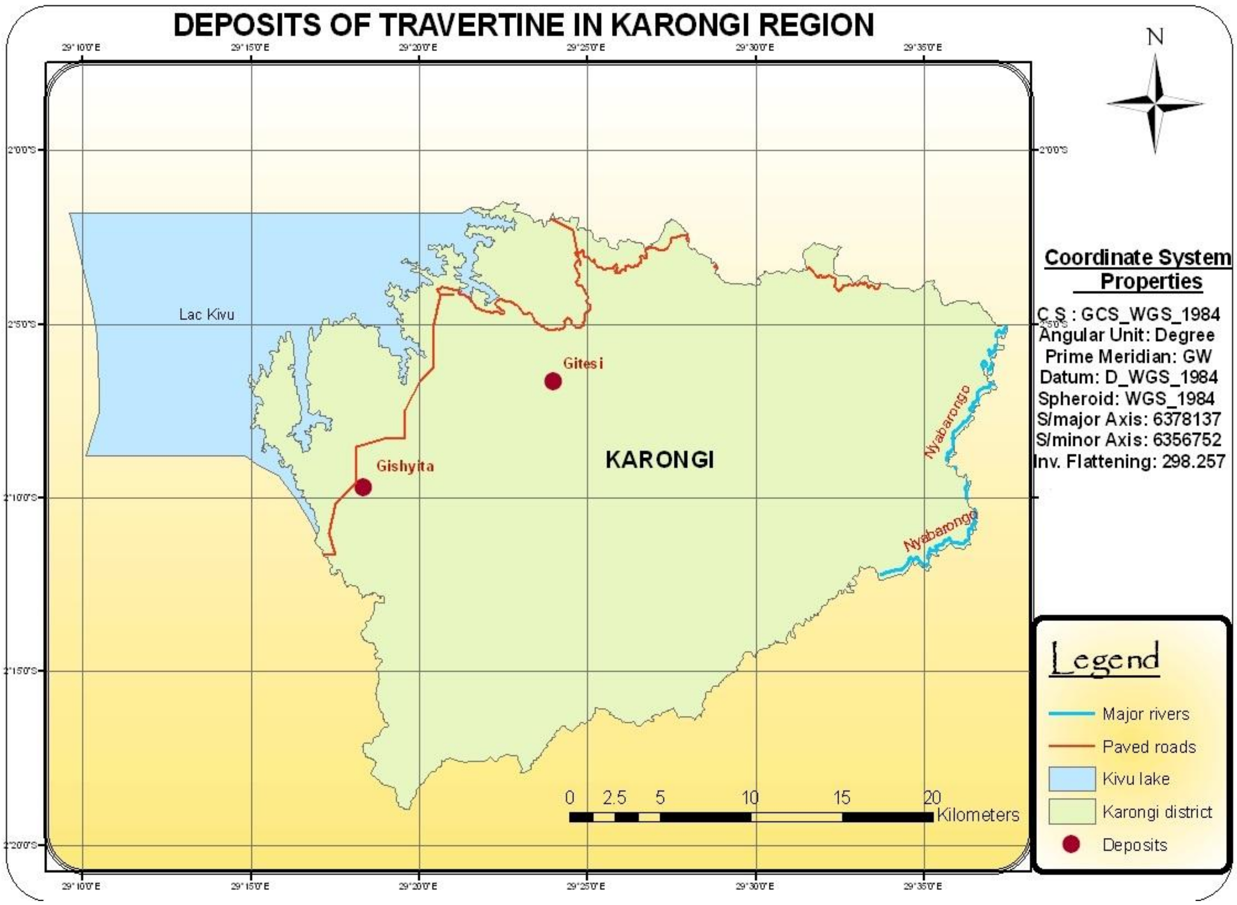


**Figure 3.** Map illustrating limestone deposits in Karongi region.

for agriculture purposes is limited due to the production technology, storage, and small size of market. Although, CIMERWA is well equipped with skilled personnel and modern technology, it is not involved in grounded limestone production for agricultural purpose. Its mission is to produce cement for construction and it seems to be difficult to deviating them for producing lime for agricultural purpose.

**Quality (CaO, MgO and fineness factor) of Mashyuza limestone:** The limestones deposits in Rusizi region found to be enriched in terms of CaO estimated at 50% ±3.4 with moderate MgO of 3% ±0.6. These are in agreement with findings of several authors (Verhaeghe, 1963; Beernaert, 1999; SOFRECO, 2001) who reported that non calcined lime of Mashyuza and calcined lime (pure lime) had the similar level of CaO. Like all other limestone sources in Rwanda, its fineness factor was 55.6% ±1.6 which was below the acceptable level (60%) as reported by Crawford et al. (2008).

## Conclusion

Rwanda has relatively good sources of agricultural lime mainly in Musanze, Karongi and Rusizi districts with small deposits in Gakenke, Rulindo and Nyamasheke districts. Some of these deposits are suited to agriculture practices; others are suitable for houses and roads construction, and sanitary treatment. Mashyuza limestone and burned lime had the same level of CaO. Mpenge and Mashyuza were reported to be suitable for agriculture practices. Despite good qualities, their fineness factors are still below acceptable level. The total size of deposits is not known and the production is hampered by many factors including technological and financial constraints. Therefore, the study advocates to increasing fineness factor through technical and financial support to the cooperatives engaged in lime production in Rwanda. The further analysis of impurities and total reserves and new deposits of limestone in Rwanda are needed to be explored.

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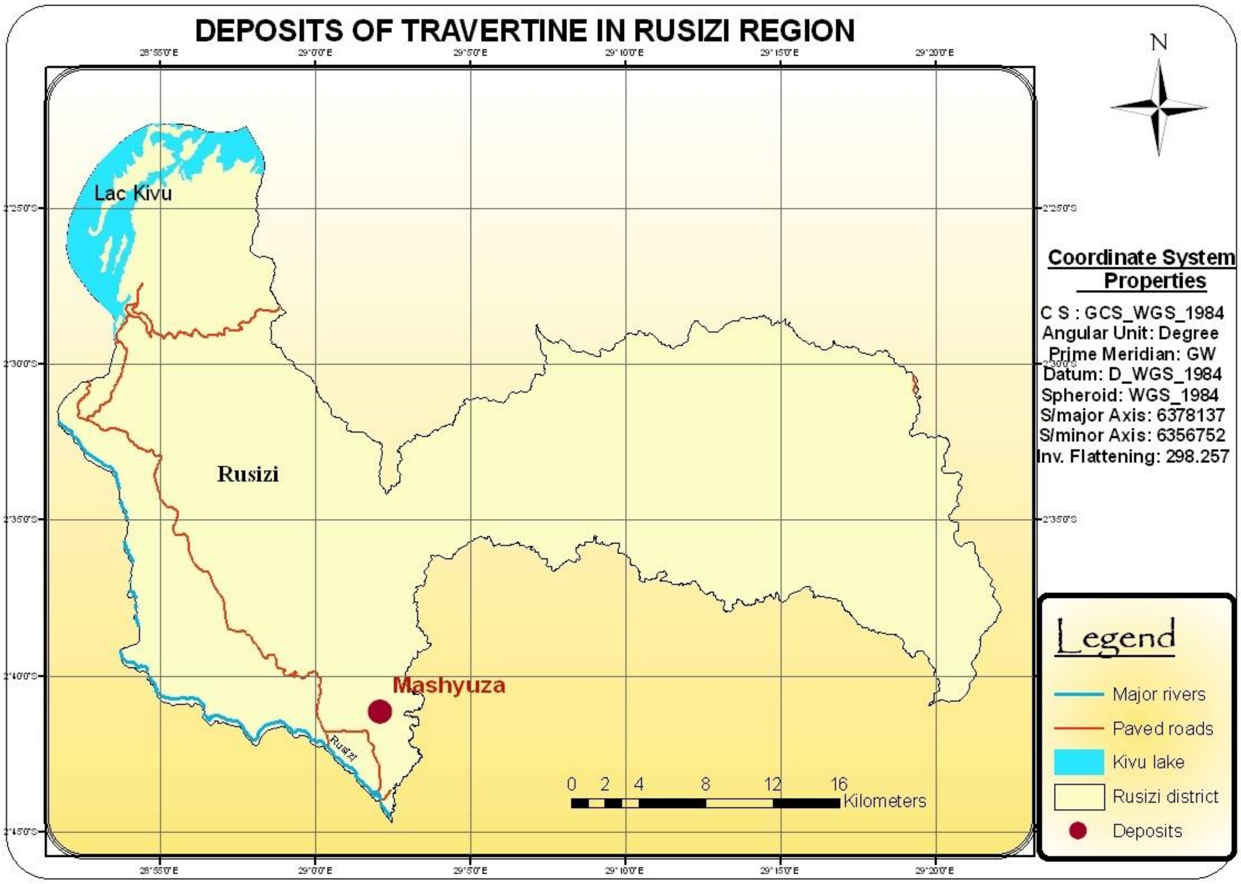


**Figure 4.** Map illustrating limestone deposit in Rusizi district.

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