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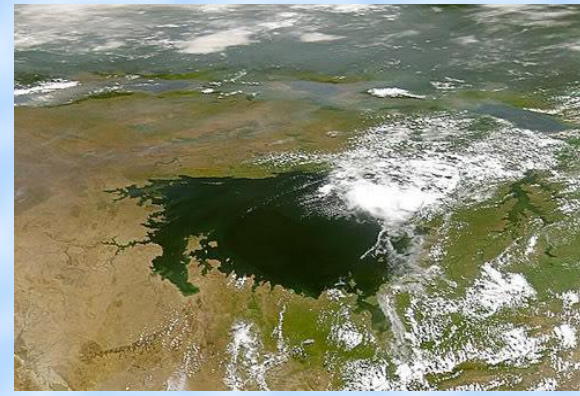
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INVESTIGATION OF THE LAKE VICTORIA REGION (AFRICA: TANZANIA, KENYA AND UGANDA)

RESEARCH AREA:



The study area encompasses region of Victoria Lake and 3 adjoining countries: Tanzania, Kenya and Uganda. Lake Victoria is the second largest fresh water body on the Earth. It has unique environment and gives Origin of the Nile waters.

Fig 1. Image of Lake Victoria. Image from: Encyclopedia. Nation Master.com



Fig 2. Lake Victoria and surrounding countries. Graphic: Eric Daigh/Circle of Blue.

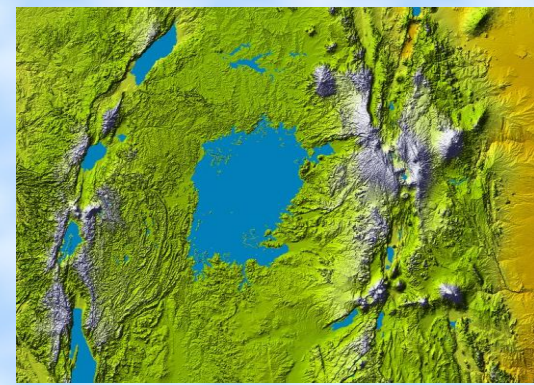


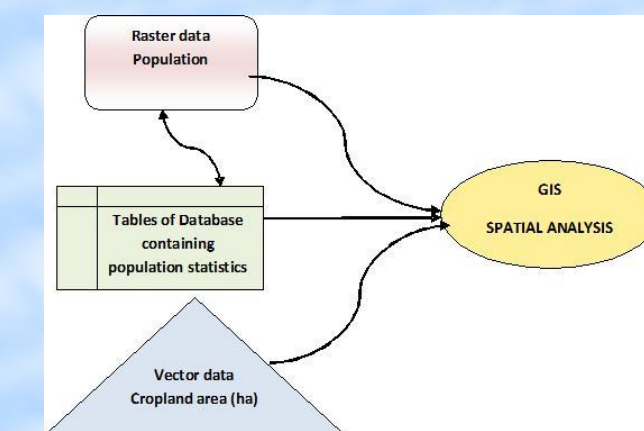
Fig 3. Relief 3-D image of Lake Victoria Image: Wikipedia.

RESEARCH PROBLEM:

Besides unique environment, Victoria lake plays an important role in the economy of the surrounding countries supporting 25 million people through lake fish catchment reaching up to 90-270\$ per capita per annum. Kenya, Tanzania and Uganda control 6%, 49% and 45% of the lake surface, respectively. Thus, the lake catchment provides for the livelihood of ca 1/3 of the population of all three countries which have an agricultural economy mostly supported by fishing and agriculture (tea and coffee plantations). The quality of the environment is therefore a fundamental factor in maintaining and increasing living standards of the growing population. The main actual problem of this region is sustainable development, well-balanced between overusing of the natural resources and human economic well-being and progress. Essential factors in this problem are rate of population growth and dimensions of natural resources management.

RESEARCH OBJECTIVES:

The current research focuses on the detailed investigation of the environmental, biological, social and economic characteristics of the region, aimed to monitoring and sustainable management of the area of interest. The main objective of this research is to create a database in form of Personal Geodatabase (.mdb) of the ArcGIS 9.3 software, that will be useful for solving the question of the sustainable development of the region. This database is intended to be used by environmental groups working for monitoring purposes.



Creating of GIS project for spatial analysis included integration of raster and vector Data as well as text information available from metadata and descriptions of the Vector layers (e.g. legend for land cover map). ArcGIS 9.3. software was used to organize and manage thematic data. Some operations and technique Procedures were made using modules and components of ArcGIS(e.g. Spatial Analyst). The architecture of the project was supported by the ArcCatalog application. Spatial referencing and re-projections were performed using ArcToolbox application.

MATERIALS USED:

- For the GIS Project of the Victoria Lake region we used following thematic data available:
- Shape files of **administrative boundaries** (ArcGIS compatible format .shp), separately for Uganda, Tanzania and Kenya. Each .shp file has also additional supporting files like as .shx and .prj, which show additional information about projection and metadata.
 - UNEP grids for the same spatial extent of Uganda, Tanzania and Kenya
 - Precipitation climatic** data in text format, containing meteorological data in digital format: precipitation values in different months and years. The initial climatic data were in ASCII format which is text recording of the values of the annual precipitation for the whole Africa continent.
 - Digital Elevation Models (DEMs)** showing relief characteristics and elevation of the research area. Data are taken from USGS website. 2 tiles of the USGS DEM map format (single file set of ASCII-encoded text containing numbers of coordinates and elevations) Initial Geographic reference was *WGS84*, projection - *Lambert Azimuthal Equal Area*, which is common for each DEM USGS tile. The metadata with geo-referencing information for the images is available in .prj files. There are two available data of GTopo30 - E020N40.DEM covering territory of Kenya and Uganda, and E020S10.DEM showing south-eastern part of Tanzania. DEM files contain horizontal grid spacing of 30 arc seconds (approximately 1 kilometre).
 - Land Cover data** in raster format which is stored in .bsq format: IGBP.bsq. This file is a part of the global land cover characteristics database. The pixel values correspond to class numbers defined in the appropriate land cover classification scheme legend. Land Cover data projected in the Lambert Azimuthal Equal Area projection for the Africa land cover characteristics.
 - Population data** were downloaded from the UNEP website. They contain raster data for the whole Africa continent. We have chosen data of population for two years for our research – 1990 and 2000 years. Each dataset had two different files – population density (popd00 and popd90 respectively) and population total.
 - Additional, miscellaneous data set, containing **Landsat ETM+** images in MrSid format - S-36-00_2000.sid.

RESEARCH METHODOLOGY:

Data Pre-Processing

- Administrative data preparation**
 The initial vector data were received from UNEP website. They are shapefiles covering both the whole region of interest and separately for each of the country - Kenya and Uganda. In spatial reference properties the *Africa Albers Equal Area* projection was defined for these files, which is the default main projection for the whole GIS Project.
- Climatic precipitation data conversion:**
 Climatic data are initially available in ASCII text data format, which was converted to raster using ArcToolbox / Conversion Tools / ASCII to Raster. After the conversion it was reprojected into *Africa Albers Equal Area Conic* projection

RESEARCH METHODOLOGY (continue):

Data Pre-processing (continue)

c) DEM raster processing
 For both files E020S10.DEM and E020N40.DEM we set up following spatial geographical reference system, common for all layers of the GIS-project: *Africa Albers Equal Area Conic* projection with standard parallels 20 and -23, central meridian 25 and *Datum WGS-84*. CON function was used for highlighting all pixels with high values and subtract 65536 from them, to receive negative values and to indicate water areas exactly (Fig.5). Both tiles of DEM file were merged into one and DEM area was clipped using ROI (Region Of Interest) raster mask containing one class with "1" values: Spatial Analysis / Raster Calculator (Fig.4.)

d) Land Cover data processing
 Creation of .hdr header file and filling it out with technical data about map: № of bands, rows, columns, resolution, etc. Conversion file from .bsq to GRID raster ESRI format (band sequential raster file). In the new GRID file spatial reference (WGS84) was defined, and then file was projected it to the *Albers Equal Area Conic* projection and clipped using ROI raster file (Fig.3). Linking Land Cover classes legend to the GRID raster file using *Join* function and common columns (classes from 2nd to 17th)

e) Population data processing
 Projection of .tiff data which initially had following geodetic reference system: *Projection GEOGRAPHIC, Spheroid CLARKE1866* into *Africa Albers Equal Area Conic* projection with standard parallels 20 and -23, central meridian 25 and *Datum WGS-84*. New data is in .tiff raster format. After the projection, clipping data using ROI raster file (Fig.6.)

Data Processing, Mapping and Calculations

Population Statistics: Population for the Country and Provincial level was calculated using *Zonal Statistics in Spatial Analyst*. The area statistics was calculated using Dissolve Manager in ArcToolbox: the necessary file (Adm_1) was dissolved so that we received the joined areas. To receive Population data for Provinces data the dissolved area of each country and population raster clipped for this country were used. To receive the area data Add Field / Calculate Geometry / Square Kilometres was used. From the attribute table of each country layer (Tanzania, Kenya and Uganda respectively) I received info about the size of each province as well as country.

Rain Distribution: According to the layers' Overlay made using ArcMap and transparency function, the precipitation level is higher in the areas with middle precipitation (450-500mm). Correlation between rain distribution and topography was examined using Overlay of DEM relief raster layer and Precipitation GRID ESRI layer. The most characteristic is high precipitation values in the valleys and above the lake, while very low levels in the highlands. Middle values are most probable in the plateau areas. Croplands are mostly located in the uplands. After slicing DEM raster into 5 classes we received a statistics distribution of each elevation type in pixels: 56440 total, 11231 of class 1: 0-999 meters (19.8%); 13478 of class 2: 1000-1999 meters (23.8%); 26899 of class 3: 1999-3000 meter (47.6% of total), 4811 of class 4: 3000,1 -4000 meters (8.5%) and 21 of class 5: higher than 4000,1 meters (0.03%).

Issues

- Estimation the total population in 2030.** For the estimations the following working steps were made: a) Calculation the population growth rate: $Growth\ Rate = \frac{(Pop.\ in\ 2000) - (Pop.\ in\ 1990)}{(Pop.\ in\ 1990)}$. b) Estimation the population in 2030 using population growth and the following formula: $Pop.\ in\ 2030 = (Pop.\ in\ 2020) + (Pop.\ in\ 2020) * Growth\ Rate$.
- Computing of how much cropland would be needed to feed the population in 2030.** For this first population in 2030 and then cropland were estimated. Areas of cropland were estimated using statistics of the raster layer *Lancover*. Amount of crop per capita was computed by dividing of the total cropland in each country (Tanzania, Kenya and Uganda) and their total population in each country respectively. Total Cropland needed in 2030 was estimated by multiplying of the crop per capita needed for the total population in 2030.

III. What % of the total forest area has to be converted to cropland to expand cropland in 2030?

For this estimation first total forest area per country was calculated using raster statistics. Amount of cropland needed in 2030, was estimated by distraction from cropland in 2030 cropland now. Then amount of forest areas was distracted. Negative values were received, because there are more need for croplands than forest areas available. To receive the percentage values of areas we calculated as a percentage from the actual areas.

IV. How much forest can be converted to cropland from protected areas in each country ?

The clipped vector layer of protected areas was converted to raster using *Spatial Analyst / Vector to Raster*. New raster was re-classified to one class (value1). Then Land Cover raster layer was multiplied to the Protected areas layer. After calculation the raster of Land Cover only for the territory of protected area zones was received. Areas for each country were calculated. The outside and inside located areas were estimated by subtraction those areas from the total for each country respectively for Tanzania, Kenya and Uganda.

Fig. 10. Relief and Topography of the Lake Victoria region

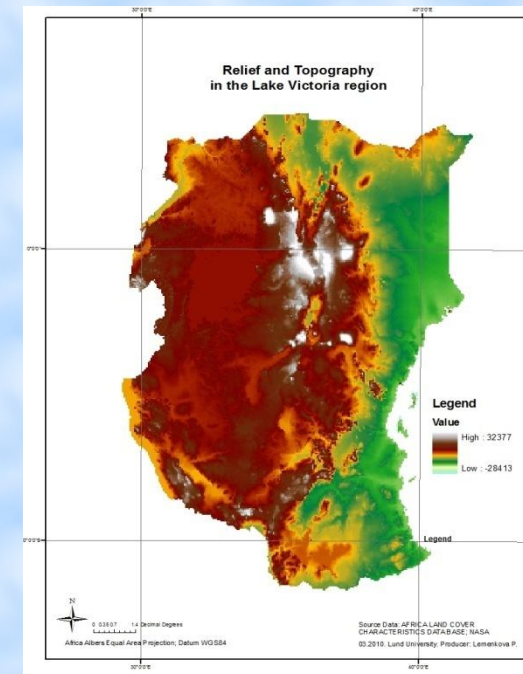


Fig. 11. Rainfall Distribution in the Lake Victoria region

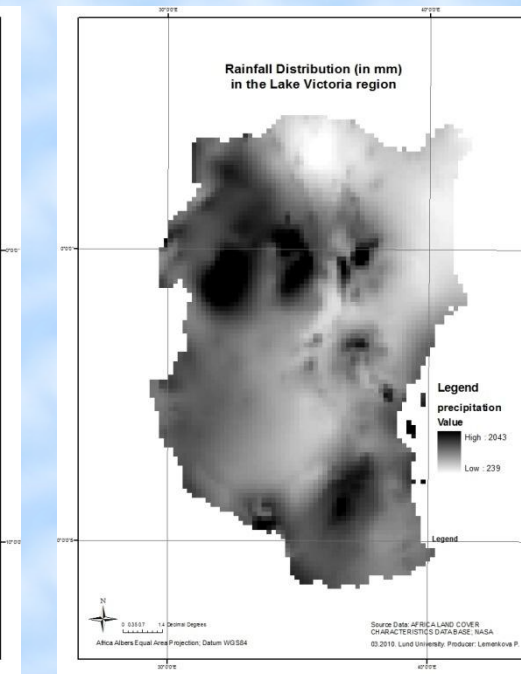


Fig. 12. Land Classes (reclassified to 10 classes)

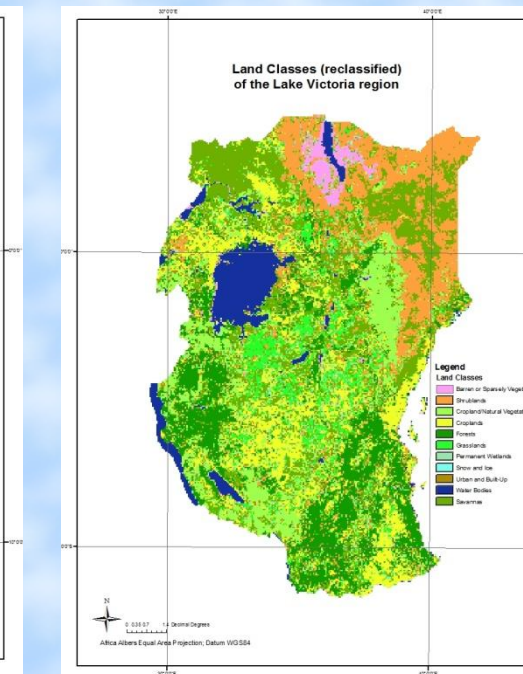


Fig. 13. Land Classes (non-reclassified, 16 classes)

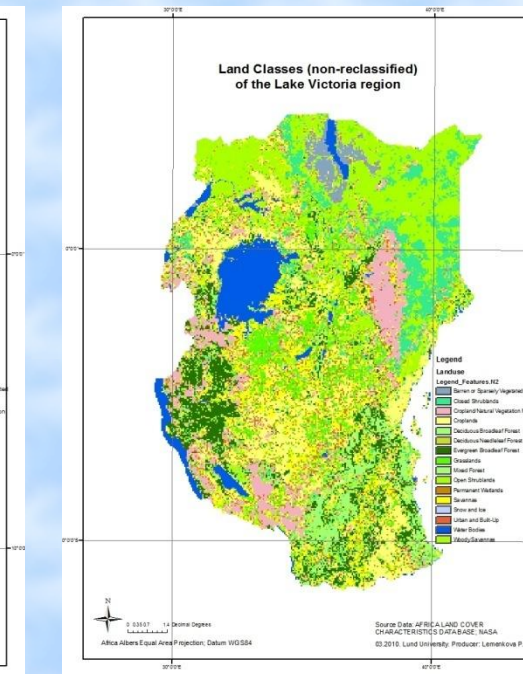


Fig. 14. Correlation of Cropland and Precipitation in Victoria Lake

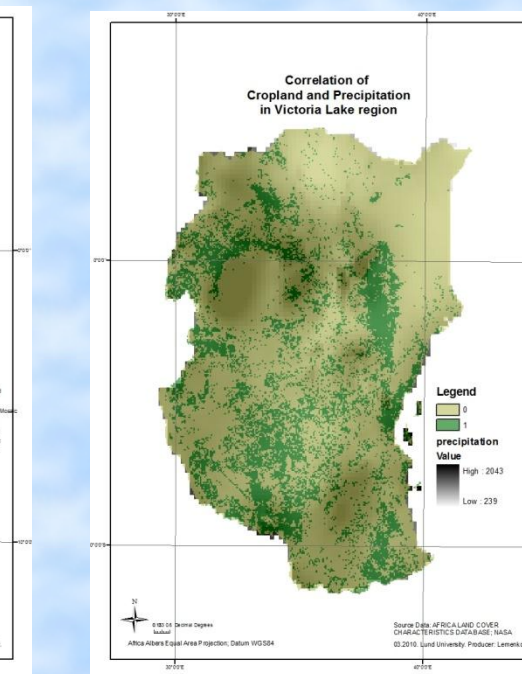


Fig. 15. Correlation of Cropland and Precipitation in Victoria Lake

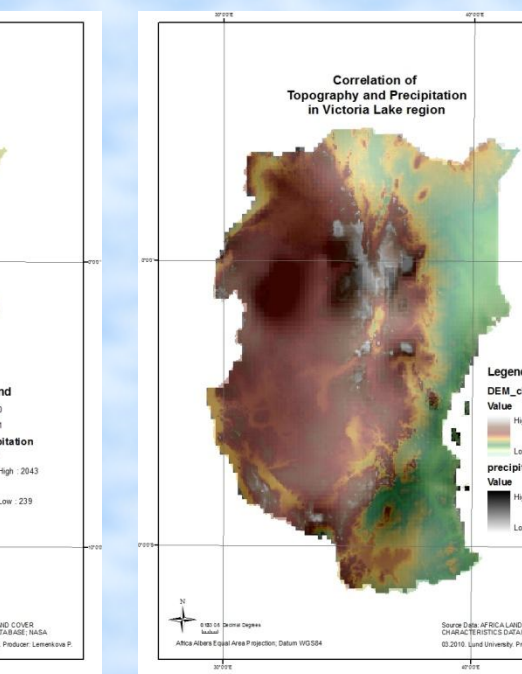


Fig. 16. Topography of Victoria Lake, sliced in 5 classes

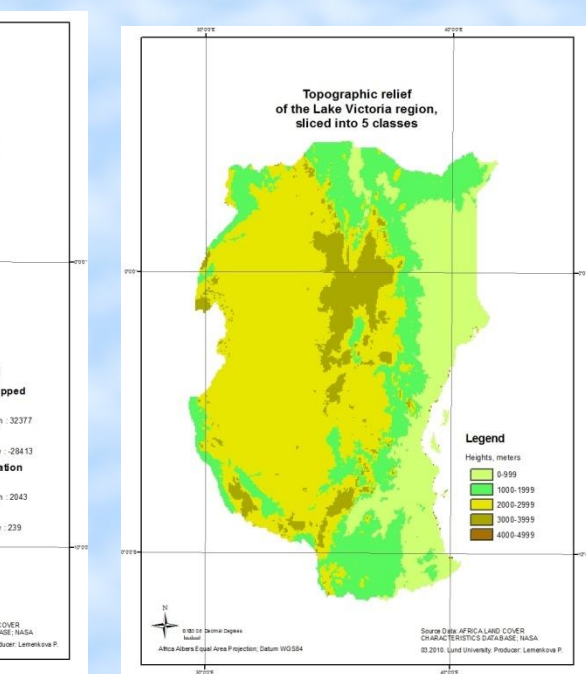


Fig. 3 Landuse clipped and projected layer

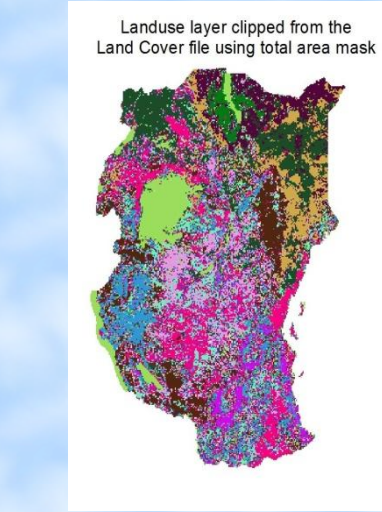


Fig. 4. Clipped and projected DEM raster

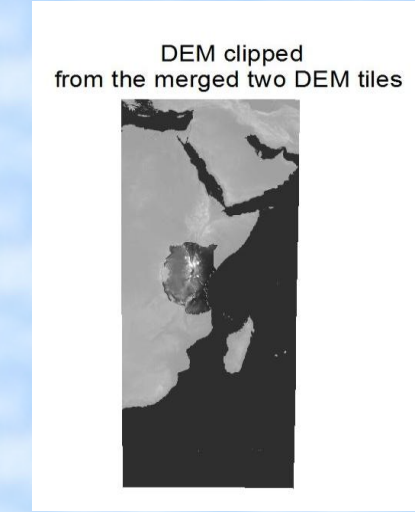


Fig. 5 Highlighted water areas in joined two DEM files

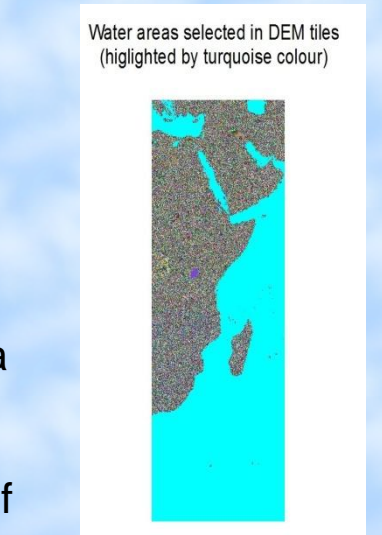


Fig. 6. Population - 2000 clipped and projected layer

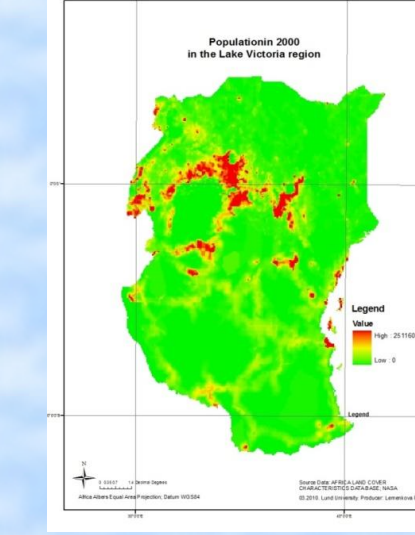


Fig. 7. Zonal Population Statistics in Provinces of Kenya

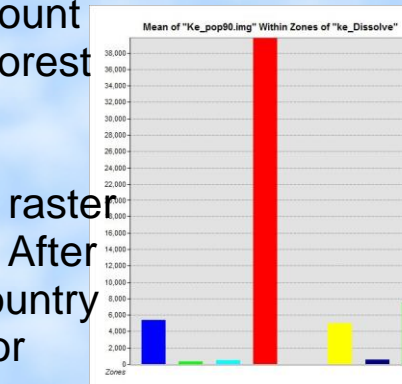


Fig. 8. Zonal Population Statistics in Provinces of Uganda

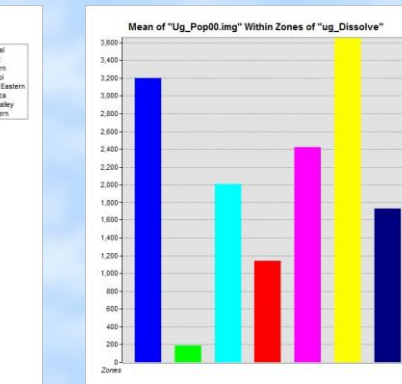
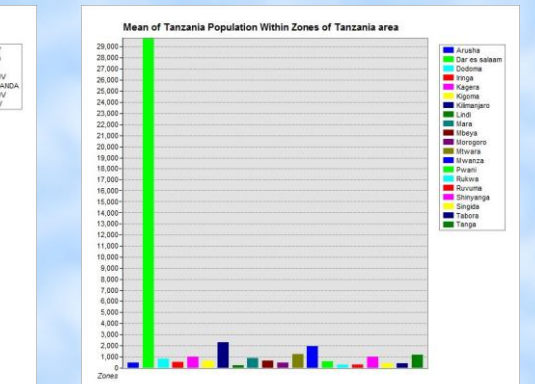


Fig. 9. Zonal Population Statistics in Provinces of Tanzania



RESULTS:

- Total Population of countries in 2030: *Kenya – 67,032,221; Tanzania – 86,375,938; Uganda - 44,202,232*
- To feed population in 2030 the following areas of cropland would be needed in 2030: *Kenya – 248,778 km²; Tanzania – 991,469 km²; Uganda - 153,992 km².*
- From the total forest area the following percentage has to be converted to cropland in 2030: *Kenya – 370%; Tanzania – 148%; Uganda - 618%.*
- From the area of protected zones the following amount of forests can be converted to cropland inside and outside protected areas:
 Inside protected areas: *Kenya – 9km²; Tanzania – 1025 km²; Uganda - 15km²;* Outside protected areas: *Kenya – 795km²; Tanzania – 6484km²; Uganda - 242km²*

CONCLUSIONS:

- Population keeps growing and the demand for the natural resources for the feeding will remain high. Thus pressure on natural landscapes and sustainable capacity will increase
- Therefore, the politics of sustainable development is an absolute prerequisite for successful environmental monitoring in the Victoria Lake region.
- Recommendations: economic development towards less ecology-pressing styles of life and economic model including
 - development of the resource-saving technologies;
 - artificial planting of new forests areas and protecting of existing ones;
 - development of environmental policy and conservation services in the government structure