

The use of remote sensing techniques in assessing the distribution trends of *Commiphora myrrha* in Wajir county, Kenya.

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Abstract

A study was conducted to establish the current trend in distribution of *Commiphora myrrha* in its natural stands in Wajir County. Data was collected through observation, interviews and questionnaires, photographs (remote sensing images) using a Global Positioning System (GPS) to mark the plant's hot spots and locate the tree stand coordinates. A supervised classification of Land Sat images acquired in 2003, 2009 and 2011 was undertaken. The results show that *C. myrrha* covers an average area of 61,620.23Ha. The area under *C. myrrha* had declined between 2009 and 2011 and this could be attributed to human and environmental factors. It is therefore recommended that sustainable management and conservation strategies be adopted to ensure improved tree cover.

1. Introduction

The Genus *Commiphora* comprises of between 150-200 species widespread in the drier parts of tropical Africa and Madagascar. The genus is a very conspicuous and a dominant element in the dry bush lands of Northeast Africa, and a large number of species are endemic in this area (Vollesen, 1989). *C. myrrha* is an indigenous tree or shrub that grows upto 4 m in height; the bark is silvery or whitish to bluish grey, peeling in small to large papery flakes, sometimes reticulate fissured on old trunks; all parts glabrous.



Vollesen (1989) reports that *C. myrrha* grows in Acacia-*Commiphora* woodland and bush land on sandy to loamy soil overlying limestone or granite, rocky lava hills; 250-1,300. Available in the regions: Afar, Sidamo, Bale, Hararge and out of Ethiopia in Somalia; North East Kenya and Arabia.

The chief *Commiphora* gum of highly economic importance is myrrh, produced by *C. myrrha* (Nees) Engl. (1883), (synonym *C. molmol*).

Vollesen (1989) further reports that *C. myrrha* is an important commodity of commerce in Southern and South Eastern Ethiopia (Azene *et al.*, 1993; MacLachlan, *et al* 2002).

Numerous other *Commiphora species* yield resin and it is not clear to what extent these enter commerce (either as adulterants or as inferior types of myrrh). Despite the research evidence from neighbouring countries such as Ethiopia that show there are both economic and ecological benefits associated with *C. myrrha*, little information is available on the distribution (Girmay, 2000; Chikamai and Kagombe, 2002; Mulugeta and Demel, 2003).

This study was undertaken to establish the current trend in distribution of *C. myrrha* in its natural stands in Wajir County.

2. Research methods

This study was undertaken in Wajir County Kenya. Data was collected through the use of observations, group discussions and personal interviews using questionnaires, photographs and use of GPS to mark the tree locations.

The Study Area

Wajir County (Fig. 1) is located in North Eastern Kenya, it borders Manderla to the North and North East, the Republic of Somalia to the East, Garissa to the South and South West, Isiolo and Marsabit to the West, and the Republic of Ethiopia to the North West. The county covers an area of 56,685.8 Km² and lies within the Sahelian climatic region, which is characterized by long dry spell and short rain seasons i.e. it is characterized as Zone VII (100% Arid). Wajir is located between latitudes 3° 20' and 0° 60' North and longitudes 39° and 41° East.

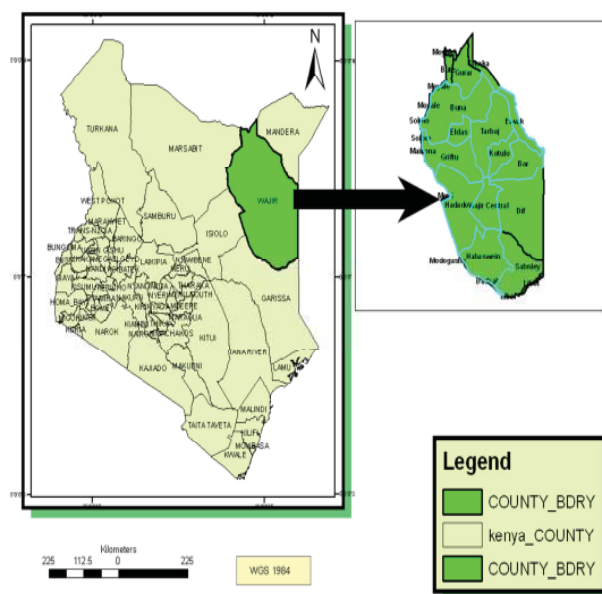


Figure 1. Location of study area

The population of Wajir County stood at 661,941 based on the 2009 census. Its climate is characterized by frequent droughts and unreliable rainfall, unfavorable for pasture for livestock keeping and agricultural activities. Wajir has a mean annual temperature of 28 °C with rainfall amounts ranging between 250mm and 700mm per annum in different parts of the county (GoK, 2009). The research targeted 7 districts namely: Gurar, Bute, Buna, Eldas, Giriftu, Central, Talbaj, Habaswein districts and the Hadado sub district where the *C. myrrha* was found in large quantities.

Geographic Information Systems techniques

Geographic Information Systems (GIS) techniques were used to mark and map the plants' cover over a range of period. This was undertaken through supervised classification of Land Sat images acquired in 2003, 2009 and 2011 acquired from the Global Land Cover Facility were used to create distribution maps for the plant's showing their status and extend. The maps showing infrastructure, administrative boundaries and land cover were acquired from International Livestock Research Institute, Kenya. Lastly the Wajir county boundary shape for 2011 was acquired from the survey of Kenya. The years were selected depending on the availability of information to provide on the change in vegetation trends.

Processing and analysis of the data

A personal computer (PC) (Pentium IV RAM 3GB, 2.2 GHZ, 250 GB Hard disk), idrissi was used to mosaic and classify the images, Arc view 3.2 was used to capture and georeference the spatial and non spatial data, Arc-view GIS 3.2 was used for image visualisation, analysis and editing and Arc map 9.3 processing software were

used in the processing and analysis of the data. Microsoft word, excel and power point were used in report writing

3. Results and discussions

Preparation of Landsat images

Color composites

During the time of image preparation the research sites were visited and GPS coordinates of way points were picked for *C. myrrha* growing areas. This was achieved by travelling to various *C. myrrha* growing sites. These way points were later downloaded and changed into shape files which could be opened in any GIS software together with the images. The GPS points were used to aid in development of training sites for classification and groundtruthing. Image data were acquired in composites which were in Tagged Image File Format (TIFF). Preparation of these images for analysis involved geometric registration, clipping to area of interest, conversion to Idrisi format, image compositing and histogram equalization. The composites were false colour with bands 4, 3, 2 corresponding to the Red, Green and Blue channels respectively for green vegetation mapping, vegetated against non-vegetated mapping and plant species discrimination.

Mosaicking

Mosaicking is the process of joining different georeferenced Landsat images which contains different parts of the area of interest in order to form a single image covering the whole area of interest. The input maps must all contain map projection information and must fit side by side. The six georeferenced images sheets were mosaicked using Arcmap 9.3 software (Fig.2)

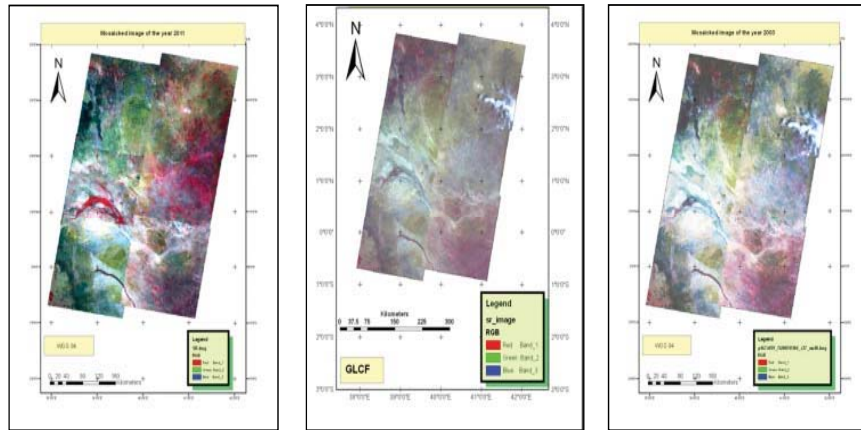


Figure2. Mosaicked and composite Images

The county boundary map (Fig. 3) was used to georeference the 2011 Landsat image using Arcmap software. This was done by opening two arcmap windows one displaying the land sat image and the other displaying the topographic map. Using zoom tool and identifying similar points on the image with respect to that of topographic map, coordinate point of this point were read on the topographic map and using add control tool on georeferencing extension in arcmap control point was added to the point on the image. This procedure was repeated for five control points and a root mean square (rms) was noted for the image.

The georeferenced images were clipped to the area of interest using Arc map (Fig. 4).The raster image was loaded to Arc map software and the boundary Shape file of the research area was overlaid on it and area to be clipped selected using select tool. The selected area was then exported as raster and elevation in geotiff format and saved in a specified drive in hardisk. The clipping process involved one image each at a time. The clipped images for each year are as shown below:

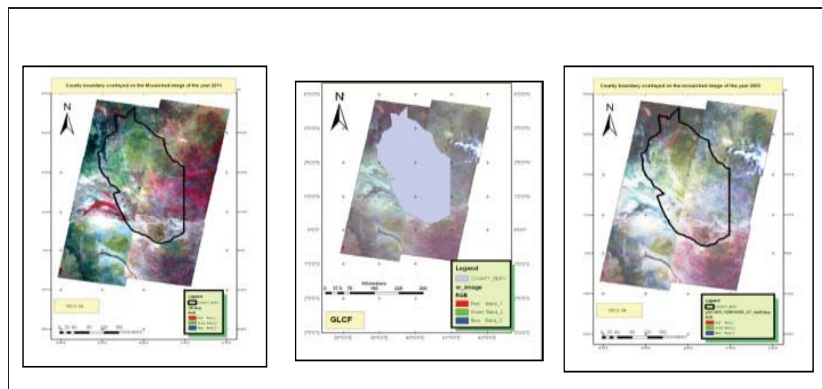


Figure 3: Wajir County boundary overlaid on a composite image

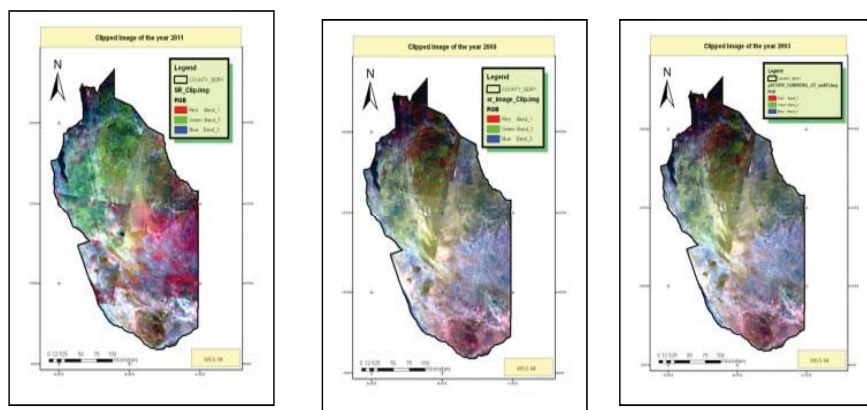


Figure 4. Clipped images

Preparation of composite images

Image composites were prepared by first importing the clipped images to arc catalog working directory by setting the path.

Image classification

Image classification was carried out using idrissi software and supervised classification method to classify the images into different theme classes. Spectral signatures of known categories were developed and used to classify the image. The image was displayed using idrissi display launcher and vector file named training site was created on this vector file each category developed above was digitized as polygon and assigned a unique integer value such as 1, 2, 3, 4 to the last category. During digitization it was ensured that areas under same category had homogenous spectral values.

Finally minimum distance to mean classifier and maximum likelihood classifier algorithms were used to partition the image into their respective theme classes as were specified in the training file. The result was a classified image with a legend showing each class. This procedure was repeated for all images and the results obtained for

analysis. After validation of classification the results from minimum distance to mean classifier gave the best results and therefore it was adapted for the research.

Creation of *Commiphora myrrha* distribution map

The georeferenced topographic map of the area of research was displayed in Arc map software. From this topographic map new layers were created and digitized, these were rivers, roads and towns. These feature data sets were created so as to be displayed together with the *C. myrrha* feature class resulting from image classification.

The classified image for 2011 was used to create the distribution map showing *C. myrrha* status in the research area. Since the distribution map was to be displayed together with other themes which were in ESRI, GIS format, the classified image had to be converted to this format. To achieve this the classified image was reformatted by changing from raster to vector, this was done by use of REFORMAT module in Idrisi software which require one to specify the type of conversion raster to vector or vector to raster and also

conversion option i.e raster to polygon, raster to line or raster to point. In this case the reformatting was raster to vector and conversion option was raster to polygon. The resulting vector file was then exported as a shape file, changing it directly from idrisi vector file format to shape file which could be opened any ESRI GIS software, preferably Arc view or ArcGis softwares. The resulting shape file was then displayed in ArcGis software for editing in order to remove other

layers which were not required. The final result was a shape file having only *C. myrrha* polygon layer. To achieve the final result other layers like rivers, roads, research area boundary and towns and GPS points were added to the view. These themes were then assigned their correct symbols with the help of legend editor and finally the resulting map layout was exported as JPEG and pdf formats (Fig. 5).

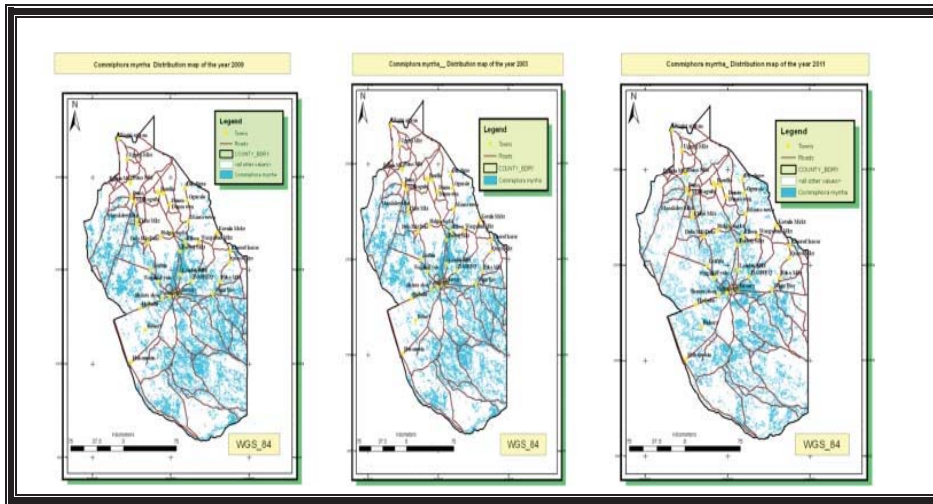


Figure 5. Visual comparison of the images

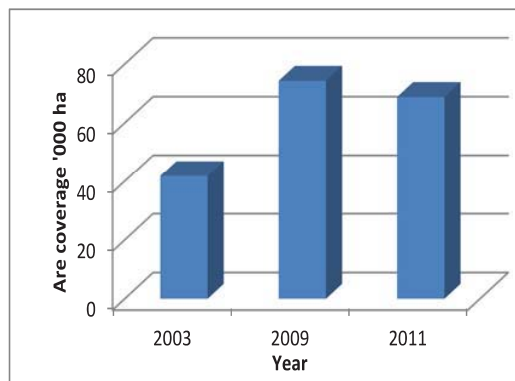


Figure 6. Trend in *C. myrrha* distribution

Change detection and quantification

Images for 2003, 2009 and 2011 were registered and independently classified by supervised approach (Fig. 6). Visual approach was then employed to determine image areas with change in classification between the base image 2003 and 2009 image and also a change between 2009 and 2011 images. The thematic class representing *C. myrrha* was visually compared with classification for different epochs. It was clear that cover change for *C. myrrha* had occurred between the three epochs. Malmal increased from 2003 to 2009 but reduced significantly from 2009 to 2011 most probably due to human encroachment and environmental factors.

The quantification analysis of the different epochs was computed as follows:

- For comparison of areas the maximum likelihood classification were used.
- From the classification the areas for *C. myrrha* were computed.
- Thematic class were compared between epochs and the results reflected change.

The increase in *C. myrrha* area between 2011 and 2003 was 26,988.8 Ha whereas there was an

increase of 32,517.8 Ha between 2009 and 2003. Finally between 2011 and 2009 the *C. myrrha* vegetation cover declined by 5,529 Ha. The overall change in vegetation cover could be attributed to both environmental and human related activities such as use of fire, un-sustainable harvesting methods and over stocking. Frequent incidences of drought and un-reliable rainfall have contributed to the declining vegetation cover in Wajir County.

4. Conclusion and recommendation

The distribution trend of *C. myrrha* was assessed for three years 2003, 2009 and 2011. The average area under *C. myrrha* was estimated at 61,620.23 Ha. There was a significant decline in tree cover between 2009 and 2011 and this can be attributed to human (overstocking, un-sustainable harvesting methods, use of fire, etc) and climate change factors such as frequent drought and unreliable rainfall. There is urgent need to undertake resource assessment at a closer interval to ensure timely mitigation measures are put in place. Sustainable management and conservation approaches need to be adopted as well as stakeholder capacity building programmes.

References

- Azene B.T., Birnie A. and Tengnas, B., 1993. Useful trees and shrubs for Ethiopia: Identification, propagation, and management for agricultural and pastoral communities. Regional Soil Conservation Unit, Swedish International Development Authority (Nairobi, Kenya). 474 p.
- Chikamai, B.N. and J. Kagombe, 2002. Country report for Kenya. In: *Review and synthesis on the state of knowledge of Boswellia spp. and commercialisation of Frankincense in the drylands of Eastern Africa*. KEFRI, Nairobi.
- Girmay F., 2000. The status of gum Arabic and resins in Ethiopia. Pp 29-31 in Chikamai B.N. (ed.) Proceedings of the Meeting of the Network for Natural Gums and Resins in Africa (NGARA). NGARA, Nairobi, Kenya.
- GoK, 2009. Wajir East District Development plan 2008 -2012. Towards a globally competitive

- and prosperous Kenya. Office of the Prime Minister. Ministry of State for Planning, National Development and Vision 2030. 102 pp.
- Maclachlan M., Getaneh E., Tafere F. 2002. Manual of highland Ethiopian trees and shrubs. Revised and expanded. English and Amharic version. Prepared for development agents of «dega» areas in Regon 3. SIM Forestry study project. Injibara, Awi zone, Region 3, Ethiopia. 465 pp.
- Mulugeta L. and Demel T., 2003. Frankincense and myrrh resources of Ethiopia. II. Medicinal and industrial uses. *Ethiopia Journal of Science, SINET* 26 (2) 161-172.
- Vollesen, K., 1989. Burseraceae. In: Hedberg I. and Edwards S. (eds.) *Flora of Ethiopia*, Volume 3. The National Herbarium, Addis Ababa University, Addis Ababa, Ethiopia and Department of Systematic Botany, Uppsala University, Uppsala, Sweden. Pp 442-478