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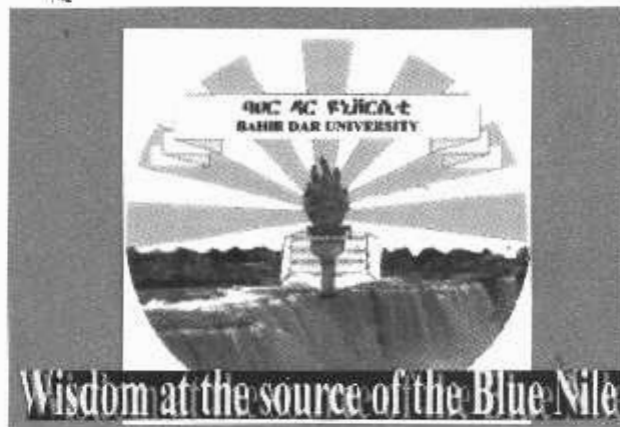
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SPATIO-TEMPORAL ANALYSIS OF MAJOR
SPECIES DYNAMICS IN DESA'A FOREST USING
SUBPIXEL CLASSIFIER AND NDVI MODELLING,
NORTHERN ETHIOPIA



BY

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FACULTY OF SOCIAL SCIENCE

BAHIR DAR UNIVERSITY

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SPATIO-TEMPORAL ANALYSIS OF MAJOR SPECIES
DYNAMICS IN DESA'A FOREST USING SUBPIXEL
CLASSIFIER AND NDVI MODELLING, TIGRAY,
NORTHERN ETHIOPIA

A thesis submitted to the school of graduate studies of Bahir Dar
University in partial fulfilment of the requirement for the degree of
Master of Science in Geo-information

By

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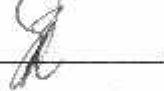
Bahir Dar University

June, 2013



The thesis entitled as "Spatio-temporal analysis of major species dynamics in Desa'a forest using Subpixel classifier and NDVI modelling, northern Ethiopia" by Mr Hadgu Hishe is approved for the degree of Master of Science in Geo-information.

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LIST OF ACRONYMS AND ABBREVIATIONS

M a.m.s.l.	Meter Above Mean Sea Level
AOI	Area of Interest
BLI	Bird Life International
DEM	Digital Elevation Model
EFAP	Ethiopian Forestry Action program
EMA	Ethiopian Mapping Agency
EPRDF	Ethiopian People's Revolution Democratic Front
ERDAS	Earth Resource Data Analysis System
ETM ⁺	Enhanced Thematic Mapper Plus
FAO	Food and Agriculture Organization
FDRE	Federal Democratic Republic of Ethiopia
FNF	Forest Non-Forest
GCPs	Ground Control Points
GIS	Geographic Information System
GLCF	Global Land Cover Facility
GPS	Global Position System
Ha	Hectare
ITC	The International Institute for Aerospace Survey and Earth Sciences
MLH	Maximum Likelihood
MOI	Material of Interest
MSS	Multi Spectral Scanner
NDVI	Normalized Differencing Vegetation Index
NIR	Near Infrared
TBoANR	Tigray Bureau of Agriculture and Natural Resources
TFAP	Tigray Forestry Action Program
TM ⁺	Thematic Mapper Plus

ABSTRACT

Forests are found scattered in inaccessible and sacred areas in the region of Tigray. Among these is the remnant of the dry afro-montane forest of Desa'a. The presence of severe deforestation and forest deterioration are well studied in this area. However, no comprehensive research or document is found regarding the dynamics of the key and ecosystem dictating species in the dry afro-montane of the eastern escarpment. This study was conducted to evaluate the spatio-temporal and health dynamics of *Olea europaea* and *Juniperus procera* in relation to their potential successors (*Cordia purpurea*, *Calpurnia aurea* and *Tarchonanthus camphoratus*) and deforestation explanatory variables between 1972 and 2010. To achieve the objective set, the power of GIS and remote sensing was combined with SPSS. Satellite images of three different years (1972, 1986, and 2010) were obtained and pre-processed for defects such as atmospheric and sun angle problems. Imagine Subpixel classifier, NDVI and SPSS were used to classify species and estimate their respective area change over the specified times, evaluate the health dynamics of the five species and to identify the deforestation deriving forces respectively. NDVI and altitude values were extracted to each species using the extract values to points function in ArcGIS10. To identify the causes of deforestation, different socioeconomic and physical data were obtained and logistic regression was run. Accordingly, *J. procera* and *O. europaea* covered 3078ha and 3186ha in 1972 which were reduced to 1855ha and 2122ha in 2010. In contrary, both the successors covered 6578ha in 1972 and 10845ha in 2010. The most aggressive species from the early colonizers was *C. aurea* which showed continuous increment between 1972 and 2010. *Juniperus procera* and *Olea europaea* were retreating at a rate of 32ha and 28ha per year; whereas, the early colonizers, and *C. aurea*, *T. camphoratus*, and *C. purpurea* were advancing at a rate of 56ha, 43ha and 12ha per year. Productivity performance of the key species was deteriorating over time. The NDVI values of *O. europaea* were 0.18-0.34 in 1972 which was reduced to 0.04-0.23 and 0.03-0.25 in 1986 and 2010 respectively. Likewise, NDVI values of *J. procera* were within 0.15-0.44, 0.19-0.33 and 0.2-0.34 in 1972, 1986, and 2010 respectively. However, as they did in the area expansion, the early colonizer species were flourishing with time. The most benefited from the degradation process in the forest in terms of productivity performance was *C. purpurea* in which NDVI values progressed from 0.16-0.41 in 1972 to 0.35-1.00 in 2010 though reduction was observed in 1986(0.17-0.32). It was followed by *C. aurea*, the fastest colonizer, which was continually increasing in productivity performance. *Tarchonanthus camphoratus*, the most abundant among the selected species, was also performing progressively with NDVI values 0.08-0.36 in 1972 and 0.15-0.29 and 0.29-0.47. Among the physical drivers of deforestation, slope, altitude, distance from deforested edge, road and settlement areas had negative relationship with deforestation rates. However, aspect was insignificant. From the socioeconomic factors; age, off farm activity and education have negative relationship and family size, farm ownership and gender (male), have positive relationship. The accuracy of the results of Subpixel classifications were assessed using 500 points, 100 for each species. 250 points were extracted from the classified map and 250 from ground to see commissions and omissions respectively. This yielded 83% accuracy level with 5.2% and 11.8% commission and omissions respectively. The loss of the key species in terms of area coverage, health status and altitude constriction is threatening if it continued at this rate. Moreover, they are being replaced by the less economic shrub species which would create a shrub dominated ecosystem in the near future. This, after all, could potentially boost the environmental crisis and socioeconomic disorder in the local community where high dependency on the forest (mainly on the key species) is observed. Therefore, interventions such as implementation existing laws and regulations and zero grazing are needed so as to maintain this multi-important forest patch.

Key words: Desa'a, Forest health, Deforestation, GIS, Remote sensing, Subpixel classifier, NDVI, SPSS, Zonal statistics, Logistic regression

CHAPTER ONE: INTRODUCTION

1.1. Background

Forests are among the crucial natural resources of the earth. They are the basis for the modern civilization and had been widely utilized throughout the globe since ancient times. Forests play a critical role in regulating the environment, they are means on which a number of people depend on for a livelihood, basic inputs for different industrial products and above all are the key for ecosystem balance (FAO, 2001; Feyera and Demel, 2002). However, despite their indispensable importance, they are under continual pressure from different perspectives. Deforestation, clearing forests for different purposes, such as agricultural expansion, charcoal making, fuel wood, timber production, fire and construction is the major problem of all most all countries (Willkie and Gerrand, 2010). Forests being among the most important natural resources in regulating natural environment, providing more than half of the wood used for fuel, more than one billion people being directly dependent on them (World Bank, 2004); globally, 8.9 million ha and 7.3 million ha of forest were cleared every year in 1990 to 2000 and 2000 to 2005 respectively (Willkie and Gerrand, 2010). However, the net loss is decreasing and showed a progress. The net loss has been slowed down to 7.3 million ha per annum between 2000 and 2005 (FAO, 2005). The main reason for this reduction are, forest planting, landscape restoration and natural expansion of forests. For instance, the report from global forest resource assessment, the forested area covered 30% in 2000 (FAO, 2001), 30% in 2005 (FAO, 2005) and 31% in 2010 (FAO, 2010). On the other hand primary forests which accounted for 36% of the forested area in 2005 are continually shrinking at a rate of 6 million ha since 1990 (FAO, 2005). Owing to the multidimensional services they provide, forests have been receiving much pressure to the extent that future sustainability falls under threat (Feyera and Demel, 2002). This clearly showed the planet is facing huge natural forest removal crisis over time.

Ethiopia being the source of *Homo sapiens* evolution, its natural resources has been under persistent pressure. Among the severely affected natural resources by human induced challenges is the forest. Forests are believed to cover more than 40% of the Ethiopian total land mass in the

