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GEOSPATIAL ASSESSMENT AND MODELING FOR THE CONSERVATION OF HERBAL MEDICINE SPECIES IN DELTA STATE, NIGERIA

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ABSTRACT
Herbal Medicine plants are critically under serious threat due to anthropogenic activities in the fragile forest ecosystems in Nigeria. The study therefore examines the herbal medicine plants spatial distribution, change pattern and projects future changes to identify conservation priority areas. Landsat TM 1987 and SPOT 5 2006 satellite images were used in the study. GPS was used to collect training sites sample coordinates and used for signature development in an Object–Based Image Analysis and Segmentation Classification process for Land Change modeling. Land Cover Change Modeler and GEOMOD Modeler with IDRISI were utilized in spatial analysis. The results showed that *Rhizophoraceae* (*Rhizophora mangle, R. racemosa) Species* was declining at 353.53 hectares per year between 1987 and 2006, and projected loss at 376.16 hectares from 2006 to 2025. By implication, approximately 7,147 hectares would be under the threat of loss by 2025. Also, *Rauvolfia vomitoria*, receded at 10.29 hectares per year between 1987 and 2006 but would decrease to a rate of 0.085 hectares from 2006 to 2025, suggesting that about 1.6 hectares would be under extinction by 2025.By implication, the herbal medicinal plants have been susceptible to a series of encroachments due to unsustainable use of the forest resources. In this case, sustainability of these species have been threatened due to unmaintained conditions or low resilience of the species to cope with changing conditions. The study advocates monitoring and controlling of activities and developments within the area, and designating the threatened areas as protected areas.

Keywords: Herbal Medicine Species, Global Positioning System, Object-Based Image Analysis, Segmentation Classification**,** Land Change Modeler, GEOMOD Modeler, Satellite Images, Conservation Priority, Fragile Forest Ecosystem, Protected Areas

INTRODUCTION

The World Health Organization (WHO, 2008), reported that herbal medicine use has increased in recent years as scientific evidence about their efficacy and effectiveness are now widely available, treating various infections and chronic conditions. There is heavy reliance on plant medicine in Africa according to the above organization which is attributable to their relative accessibility, low prices, local availability and acceptance by local communities coupled with the low number of dispensaries and doctors for health care needs especially in rural areas. Interestingly, Lucy and Edgar (1999) observed that modern pharmacopoeia still contains at least 25% drugs derived from plants while many others are synthetic analogues built on prototype compounds isolated from plants.Furthermore, Soetan and Aiyelaagbe (2009) noted that the use of medicinal plants as raw materials in the production of new drugs is ever increasing because of their potentials in combating the problem of conventional drug resistance in micro-organisms. Thus, the demand for medicinal plants is increasing in both developing and developed countries as well.

The World Health Organization (WHO) estimated the present world demand for medicinal plants to be approximately US $14 billion per year (Kala, Dhyani and Sajwan, 2006). They further note that the demand for medicinal plant-based raw materials is growing at the rate of 15 to 25% annually, and demand for medicinal plants is likely to increase to more than US $5 trillion in the year 2050. As pressure is increasing on diminishing medicinal plant supplies, constructive resource management and conservation actions must be identified based upon a clear understanding of the surrounding medicinal plant use and ecosystems where they occur (Cunningham, 1993). According to WHO, IUCN and WWF (1993), no concerted effort has been made to ensure the availability of medicinal plants on a continuous basis in the face of the threats posed by increasing demands, a vastly increasing human population and an extensive destruction of plant-rich habitats such as the tropical forests, wetlands, Mediterranean ecosystems and parts of the arid zone.

Herbal Medicine is the study and use of medicinal properties of plants (Cunningham, 1993). According to WHO (2008), Herbal Medicine includes herbs, herbal materials, herbal preparations and finished herbal products that contain parts of plants or other materials as active ingredients. In other words it involves the use of plant extracts or their active principles (WHO, IUCN and WWF, 1993). However such plants must not be dangerous, be effective and that preparations are not adulterated or made harmful by parasites and micro-organisms (WHO 1978). Herbal Medicine or treatment is the most popular and lucrative form of Traditional Medicine (WHO, 2008). While Traditional Medicine is the sum total of knowledge, skills, and practices indigenous to different cultures that are used to maintain health as well as to prevent, diagnose, improve or treat physical or mental illness (WHO, IUCN and WWF, 1993).

Medicinal plants represent a consistent part of the natural biodiversity endowment of many countries in Africa (Okigbo, Eme and Ogbogu, 2008). Ethnobotanical studies carried out throughout Africa confirm that native plants are the main constituent of traditional African medicines (Kokwaro, 2009). But today many medicinal plants face extinction or severe genetic loss, and detailed information on this is lacking, while for most of the endangered medicinal plant species, no conservation action has been taken. Soetan and Aiyelaagbe (2009) reported that research on medicinal plants is one of the leading areas of research globally and a need to pay closer attention to the issue of conservation and also bioactivity safety. Management of traditional medicinal plant resources was reported by Cunningham (1993), as probably the most complex African resource management issue facing conservation agencies, healthcare professionals and resource users.

Nigeria is rich in biodiversity with a variety of plant and animal species; about 7,895 plant species are identified in 338 families, 484 of which are endangered and 2, 215 genera occurring in different vegetation type from the mangroves along the coast in the south to the Sahel in the north (Federal Ministry of Environment, 2001). It reported that while most of the biodiversity sustain the rural economy, it faces threat from population pressure and human activities. Consequently, the herbal medicinal plants have been susceptible to a series of encroachments due to unsustainable use of the forest resources. In this case, sustainability of these species have been threatened due to unmaintained conditions or low resilience of the species to cope with changing conditions. This can affect the availability of medicinal plants and the health of populations who rely on them for health care. This is in contrast to the principle of sustainable development that emphasize meeting the needs of the present without compromising the ability of future generations to meet their own needs. It would be especially significant in areas with very high demands such as within the study area in Delta State as noted by Oyenye and Orubuloye (1983) who observed that the ratio of Traditional Herbal Doctor to the population of people in former Bendel State (now Edo and Delta States), Nigeria is 1:110 while that of Medical Doctor to the population is 1:16,400 making Herbal Medicine more available and a major source of health care in the region. Furthermore, some of the complexity and problems associated with conservation of medicinal species can be overcome by the use of geospatial technology for studies and decision making. However it is a relatively new and unharnessed especially in most African countries like Nigeria.

Several studies have demonstrated the invaluable application of remote sensing and GIS in habitat and biodiversity studies. According to Clark Labs (2009), applications, such as biodiversity and habitat mapping, can be achieved through Object-Oriented segment-based classification, and is highly suited for medium to high resolution satellite imagery and is useful for mapping land cover and monitoring land change. Laliberte *et al.,* (2007a) monitored the change in vegetation over time, specifically shrub encroachment into native grasslands in the American southwest using Object-Oriented Image Analysis (OBIA). Karl (2010) made spatial predictions of cover attributes of rangeland ecosystems, making use of regression kriging and Object-Oriented Image Analysis of Landsat imagery to predict the distribution of cheatgrass species, shrub and bare-ground. Matinfar *et al.,* (2007) showed that the object-oriented approach is more accurate, giving a higher producer’s and user’s accuracy for most of the land cover classes than those achieved by pixel-based classification algorithms. Similarly, Geneletti and Gorte (2003) found that the limitations of image analysis because of spatial resolution can be overcome by integrating imagery of different resolutions using sequential segmentation and classification with OBIA to produce a land cover map of higher accuracy.

WHO, IUCN and WWF (1993), in Section 2 on the Guidelines for the Conservation of Medicinal Plants, stated that any country's program to use and conserve medicinal plants should include a stock-taking to identify the medicinal plants, outline their distributions and assess their abundance. Nigeria signed and ratified the convention on Biological Diversity geared towards such conservation in 1992 and 1994 respectively. This work therefore attempts to meet these needs for some important medicinal species with the use of geo-information technology. The study therefore identifies changes from 1986 to 2006, likely future changes in the ecological landscape by 2025, investigates their causes and rate of imminent extinction in order to identify locations where conservation efforts may need to be initiated and given utmost priority.

EXPERIMENTAL SECTION

Research Locale

The study area lies between latitudes 5° 24' 10" to 5° 52' 30" North of the Equator and longitudes 5° 29' 15" to 5° 54' 00" East of the Greenwich Meridian. It lies in the Niger Delta Region of Nigeria, comprising of three (3) Local Government Areas in Delta State which are; Warri South, Udu and Uvwie (Figure 1). The major economic activities include fishing, farming, oil and gas, construction, telecommunications and other business services. The area is seasonal tropical with the mean annual rainfall of Warri area lying between 2400 – 3500mm with a monthly mean of 240mm, maximum monthly mean temperature is approximately 32˚C with a minimum of approximately 24˚C, mean monthly relative humidity is approximately 84% (Fakpor, Omisore, and Abegunde, 2009). It is comprised of three ecological zones from the southernmost part northwards – the mangrove forest, freshwater swamps and the lowland rainforests (Moffat and Linden, 1995). The soil type and characteristics differ according to each ecological or vegetation zone. Within the mangrove environment, two soil zones are identifiable; Clayey silt occupying the fringes of the creek and a peaty fibrous soil (Wokoma, 1980).

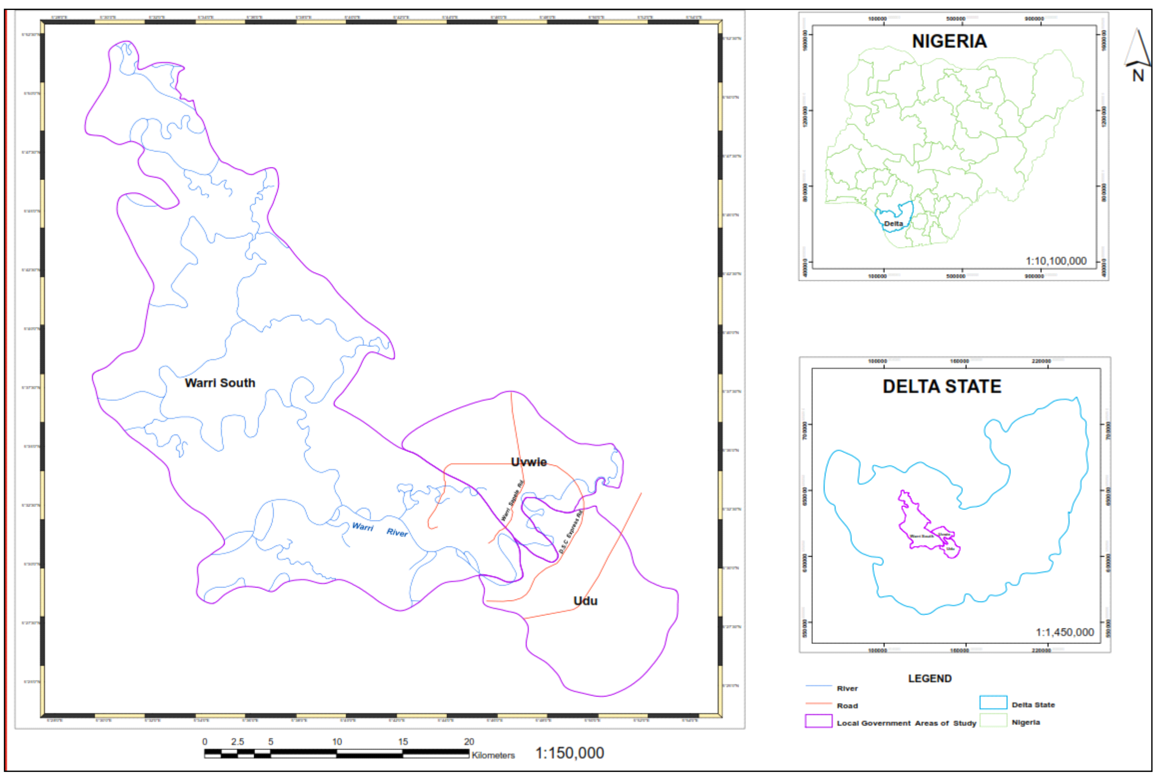


Figure 1: Map of the Study Area

Data Preparation and Methods

Landsat TM of 1987 (30m resolution) and SPOT 5 (4.5m resolution) of 2006 satellite images were processed, with the Landsat resampled to the same resolution as the SPOT. Three different species have been preliminarily identified as some very important medicinal species used by the people within the study area. They are *Rhizophora mangle* L., *Rhizophora recemosa* G. R. W. Meyerand *Rauvolfia vomiteria* Afzel. Training sites sample coordinates of the species using hand-held Global Positioning Systems (GPS) were collected within their homogenous clusters in a relatively undisturbed forest in the study area. This was used for signature development in an Object – Based Image Analysis (OBIA) and Segmentation Classification process with IDRISI Selva Software performed on the high resolution SPOT 5 of 2006 and Landsat of 1987, to show the three identified species; their spatial distribution and along with other land cover/land uses. The other land cover/land uses were assessed and grouped into the following classes: Mangrove Swamp Forest Species, Freshwater Swamp Forest Species, Lowland Rainforest Species, Water body, Agriculture – Farmland and Built up – Industry.

Modeling Medicinal Species and Ecological Land Change

Land Cover Modeling (LCM) with IDRISI Selva software was performed on the SPOT 5 image of 2006, and Landsat of 1987 to assess changes in the quantity and distribution of the different medicinal species identified and other land cover/land uses in the ecological landscape. Furthermore, Land Change and a prediction into the next 19years in 2025 for each medicinal species to the rest of the other classes were carried out using GEOMOD Modeler in IDRISI. The RECLASS module was used to aggregate multiple categories into two states before GEOMOD was applied to model the change between the two generalized states. The Land Cover Modelling (LCM) results generated were used to identify the various land uses and human activities that are responsible or pose threat to the survival of medicinal plants. Sources of threats were verified through ground-truthing. This was used together with the land change information previously identified for the final stage of analysis – identifying areas for conservation actions and their priority in line with the principle of sustainable development that promotes development objectives through the sustainable utilization of species and ecosystems while maintaining essential ecological processes and life supporting systems, including the preservation of genetic diversity.

The spatial distribution of herbal medicinal species, their rate of change in the ecological landscape, the various threats to medicinal species/habitats, were integrated within the GIS database. The Class' variables in terms of their contribution to net loss or gain of Medicinal Species in quantity and spatial allocation of pixel, their probability of change or transition potential from 1987, 2006 and to the projected future state in 2025 formed the criteria for evaluating conservation requirements in IDRISI Selva software. Areas that were onceoccupied by the medicinal species as at 1987 but became lost in 2006 and will still remain lost in 2025 was given the highest priority – "Very High"; those that persisted till 2006 but will be lost in 2025 was the next, rated "High"; those areas that were not occupied by the species as at 1987 but was gained in 2006 and will eventually be lost in 2025 was rated "Medium"; if it was gained in 2006 and will persist till 2025 was ranked as "Low". Areas of the medicinal species that will remain unchanged and persist from 1987 till 2025 were rated as, "Low" as well and the non-medicinal species areas that had persisted from 1987 till 2025 were rated "Undetermined" as they are not the focus of this work.

RESULTS AND DISCUSSION

Spatial Distribution of Herbal Medicinal Species and Land Change between 1987 and 2006

The results of the Object – Based Image analysis and segmentation classification for the study revealed changes for the selected medicinal flora and some of the drivers of change. In 1987 water occupied the largest land area of 32,407.31 hectares (36.94%) followed by *Rhizophoraceae Species* 19,257.30 hectares (21.95%) and other swamp forest species 18,063.31 hectares (20.59%) while *Rauvolfia vomitoria Species* occupied the least of 208.63 hectares (0.12%), followed by built up–industry of 3,903.94 hectares (4.45%) and agriculture–farmland of 4,229.24 hectares (4.82%) as shown in (Table 1). However, in 2006, *Rauvolfia vomitoria* Spp. experienced the greatest change with a reduction of 88.09% occupying a new area of 13.21 hectares. *Rhizophoraceae Species* (occupying 12,540.30 hectares in 2006)experienced the next largest reduction (21%) while water reduced by 11.63%. The rest changes within the ecological landscape was positive with agriculture-farmland having the largest increase of 38.08% (occupying 25 653.38 hectares in 2006), next is built up-industry occupying 5,577.20 hectares in 2006 (17.65%), while other swamp forest species increased to23,868.74 hectares (13.84% change). Figure 2 presents the spatial distribution and pattern of change between 1987 and 2006 of all classes.

Table 1: Herbal Medicinal Species and Land Change between 1987 and 2006

Category	Area Extent 1987		Area Extent 2006		Change (2006 - 1987)		Legend (Classes)
	Hectares (ha)	Per centt %	Hectares (ha)	Per cent %	Hectares (ha)	Per cent%	
1	32407.31	36.94	25653.38	29.24	-6753.93	-11.63	Water
2	19257.30	21.95	12540.30	14.29	-6717.00	-21.12	*Rhizophoraceae Spp.*
3	208.63	0.24	13.21	0.02	-195.42	-88.09	*Rauvolfia vomitoria* Spp.
4	18063.31	20.59	23868.74	27.21	5805.43	13.84	Other Swamp Forest Spp.
5	9669.72	11.02	10654.91	12.14	985.19	4.85	Other Lowland Forest Spp.
6	4229.24	4.82	9431.71	10.75	5202.47	38.08	Agriculture-Farmland
7	3903.94	4.45	5577.20	6.36	1673.26	17.65	Built up–Industry
Total	**87739.45**	**100**	**87739.45**	**100**	**0000.00**	**00.00**	

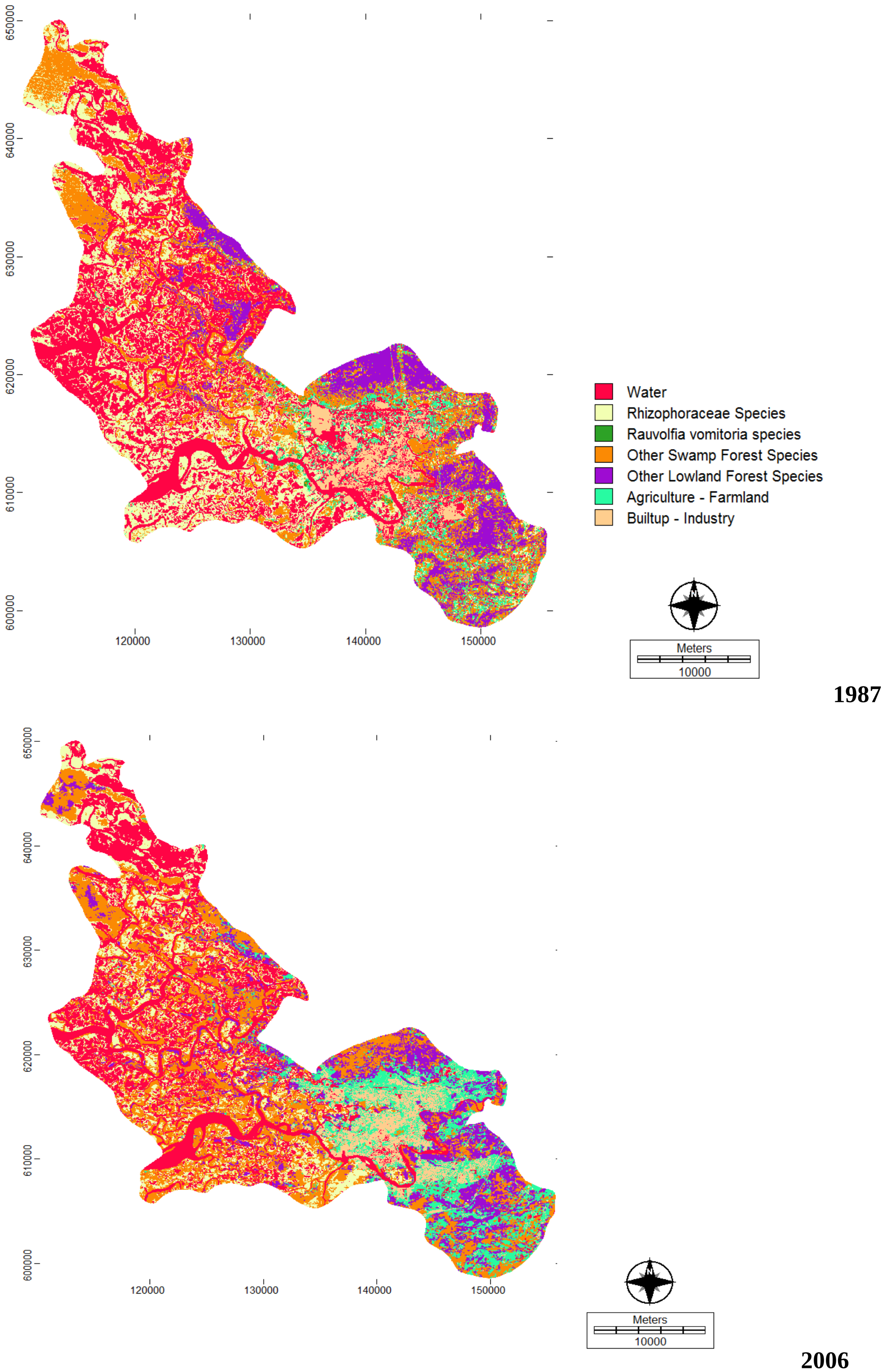


Figure 2: Object-Oriented Image Segmentation and Classification of the Study Area (1987 & 2006), showing some important Medicinal Species and other Land Changes.

Projected Future Scenario of the Medicinal Species after 19years (2025)

The result of the projected scenario of the medicinal plants identified for this study is presented in Figure 3 below. Details of the spatial assessment and change modeling of the species for decision support in conservation management is examined subsequently.

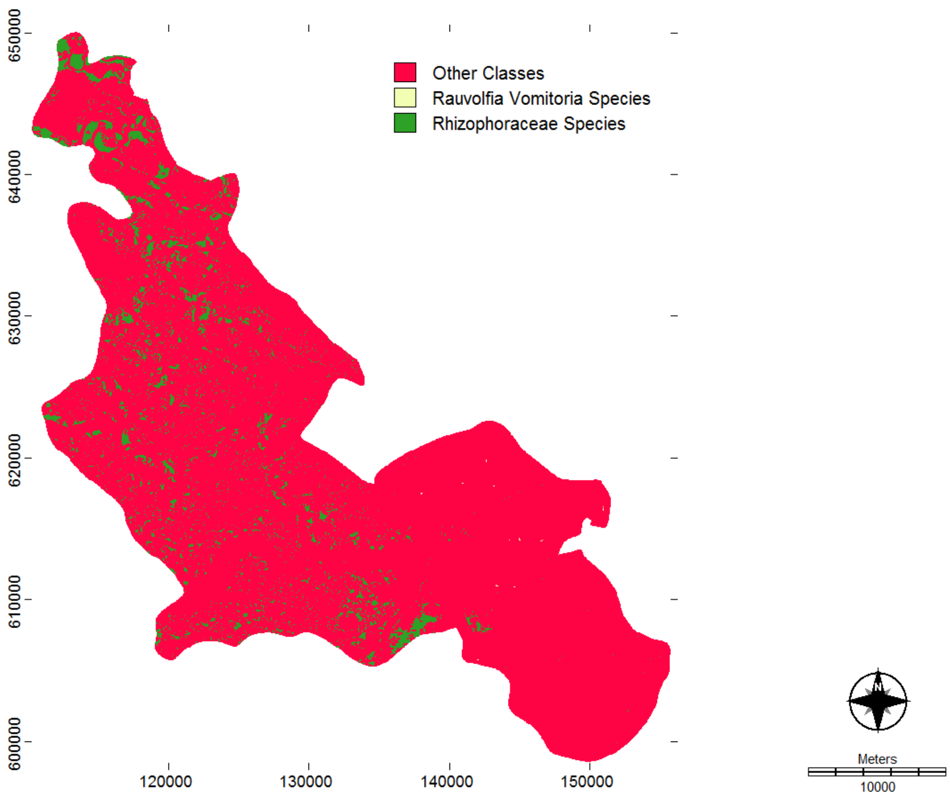
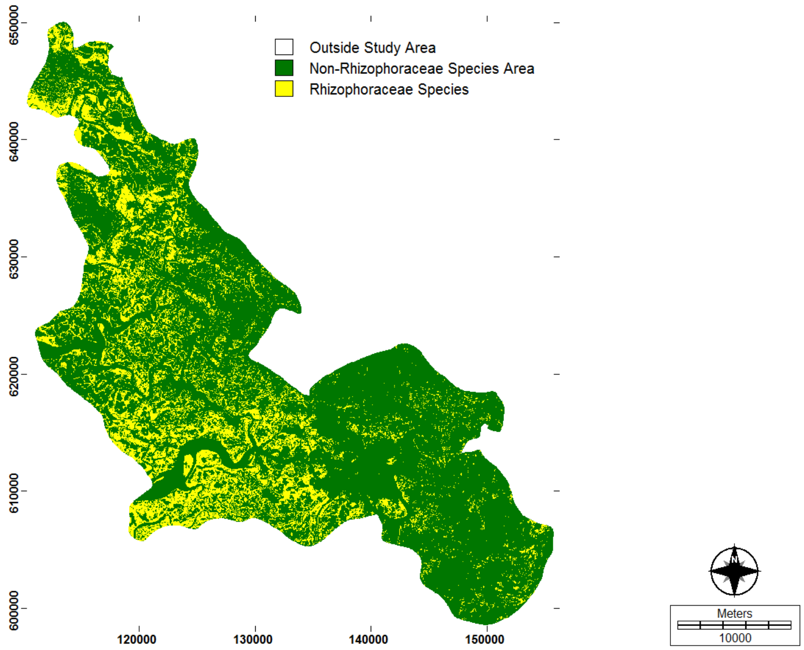


Figure 3: Model of projected Scenario of *Rhizophoraceae (Rhizophora mangle* and *R.racemosa)* and *Rauvolfia Vomitoria* Species at 2025

Analyses and Modeling of Rhizophoraceae Species Change (1987 – 2006 – 2025)

From the Change analyses results of *Rhizophoraceae Species* between 1987, 2006 and the projected date of 2025, there was a loss from 19257.3 to 5393.29 hectares (Figure 4). A model of the medicinal species distribution within the study area and non-species area is presented in Figures 5 and 6. The species changes from 1987 to 2006 in both quantity and location is expressed in areas of gains, losses and persistence as described in Figure 7 and Table 2. The total area that was lost was 15.83% with 8.18% areas of gain. Persistence was observed in 6.12% of the area. The LCM result of change analysis identified the threat to the survival of *Rhizophoraceae* Species presented in Figure 8 below as contributors to its net change experienced. Table 2 showed the area in hectares of *Rhizophoraceae* that were actually lost to this group of classes. Spatial distribution model showing the locations where the loss of this medicinal species (*Rhizophora mangle and Rhizophora racemosa*) took place was presented in Figures 9, 10, 11 and 12.



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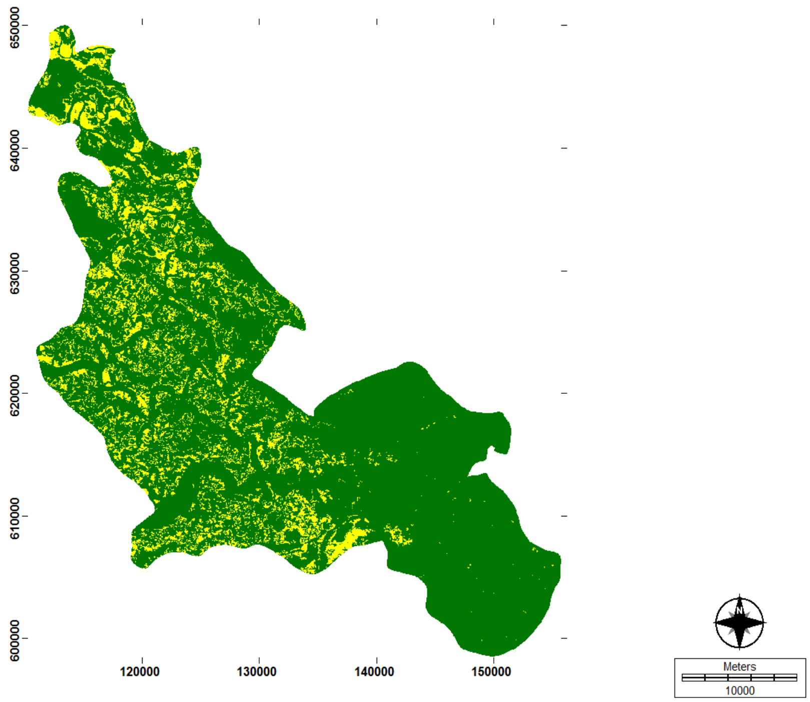

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Figures 4 & 5: Spatial Distribution of *Rhizophoraceae (Rhizophora mangle and Rhizophora racemosa)* Species of the Study Area in 1987 and 2006

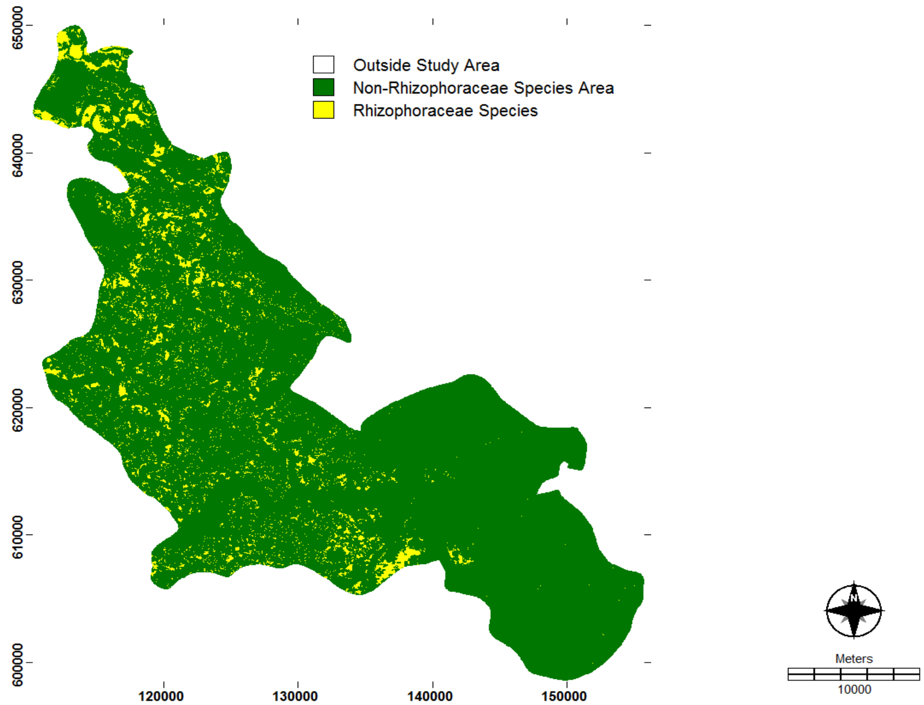


Figure 6: Spatial Distribution of *Rhizophoraceae (Rhizophora mangle and Rhizophora racemosa)* Species in the Study Area at the Projected Future date by 2025.

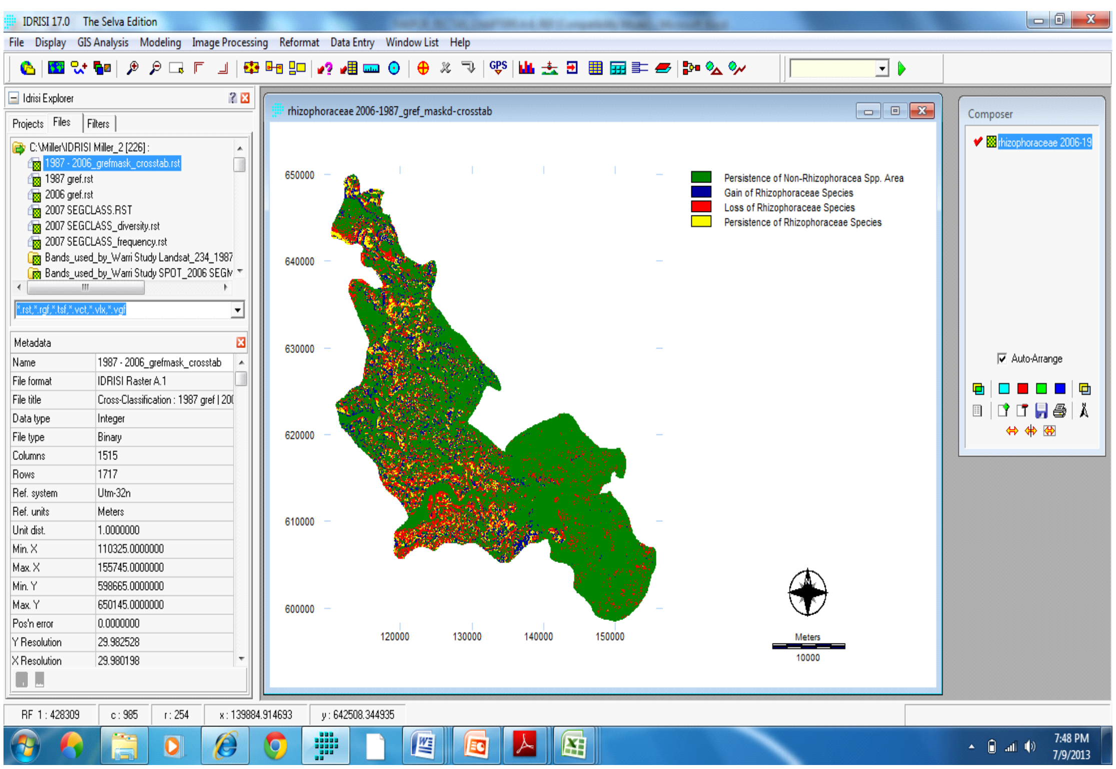


Figure 7: Spatial allocation of Change (Areas of Losses, Persistence and Gains) of *Rhizophoraceae* Species in the Study Area between 1987 and 2006

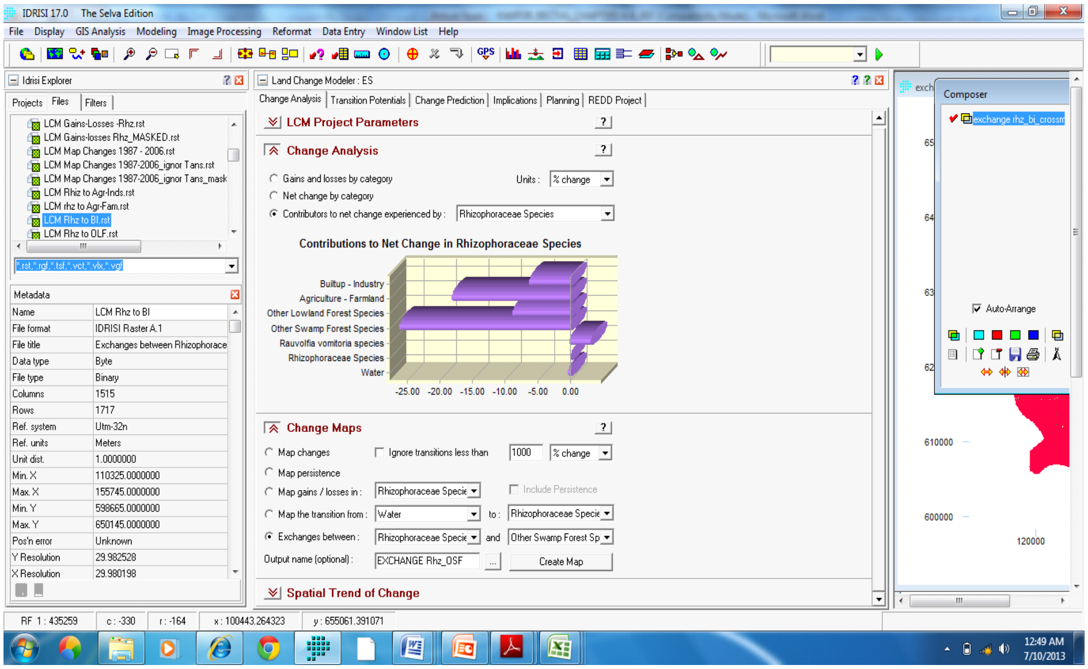


Figure 8: Result of LCM Analysis showing Contributors to Net Change Experienced by *Rhizophoraceae* Species in the Study Area from 1987 to 2006 in percentage, where a negative sign indicates a loss to that class while a positive sign a gain from it

Table 2: Quantity of Change (Losses, Persistence and gains) of *Rhizophoraceae Species*

Category	Hectares	Percent	Legend
1	61307.264	69.87	Persistence of Non-*Rhizophoracea Species* Area
2	7174.877	8.18	Gain of *Rhizophoraceae Species*
3	13891.863	15.83	Loss of *Rhizophoraceae Species*
4	5365.427	6.12	Persistence of *Rhizophoraceae Species*
Total	**87739.431**	**100.00**	

Table 3: Major Contributors to Loss experienced by *Rhizophoraceae* Species

	Agriculture–Farmland	***Built-up-Industry***	***Other Lowland Forest Spp.***	***Other Swamp Forest Spp.***	***TOTAL***
Loss of *Rhizophoraceae* Spp. (Hectares)	839.74	298.25	915.06	6266.29	8319.34

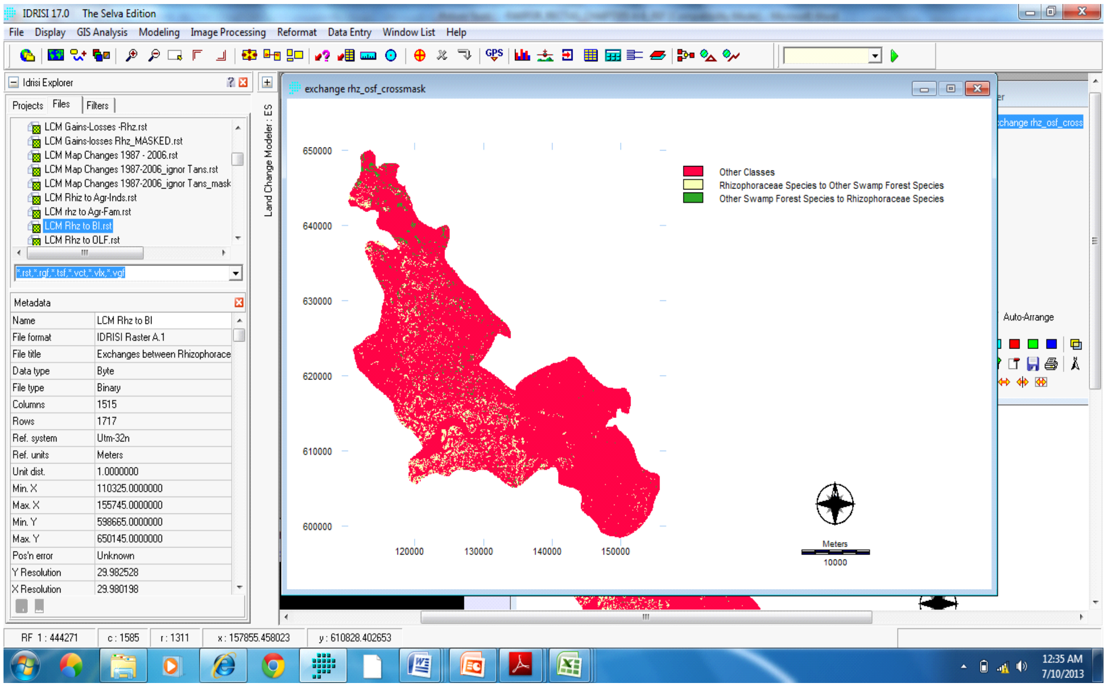


Figure.9: Spatial distribution of the net change experienced by *Rhizophoraceae* Species resulting from Other Swamp Forest Species between 1987 and 2006. The yellow patches indicate Threatened Areas from this class

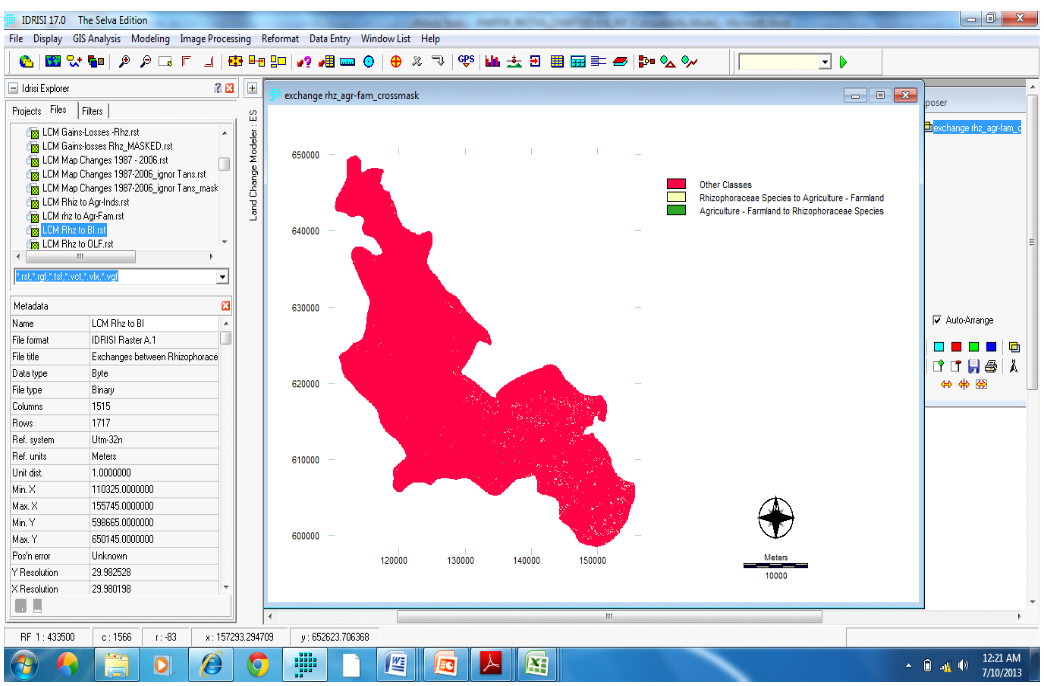


Figure 10: Spatial distribution of net change experienced by *Rhizophoraceae* Species resulting from Agriculture and Farmland between 1987 and 2006. The yellow patches indicate Threatened Areas from this class

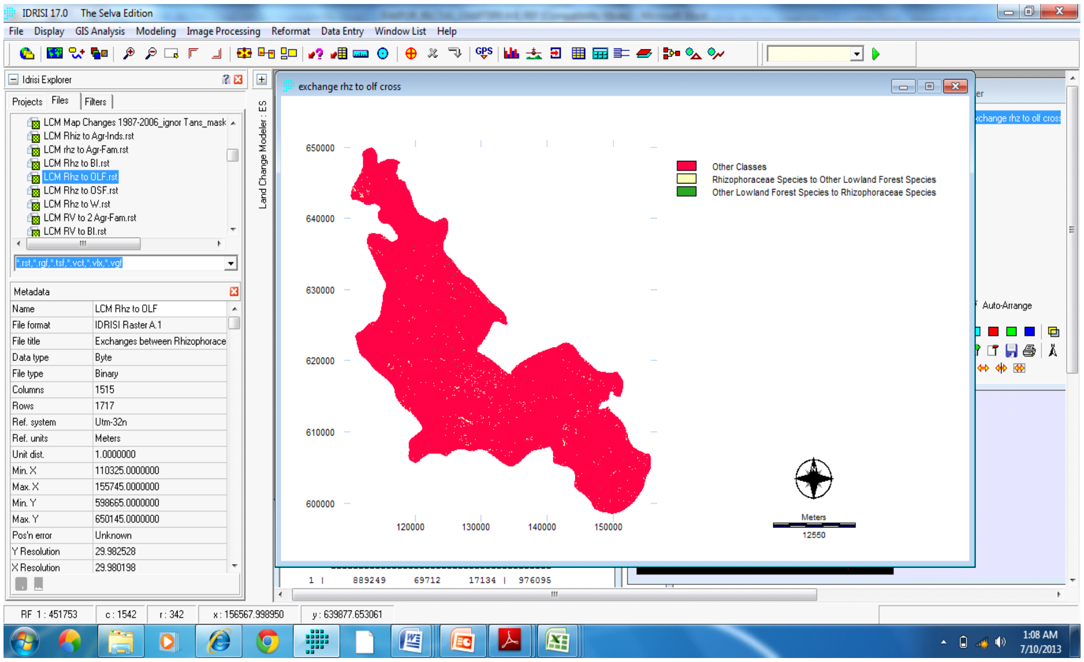


Figure 11: Spatial distribution of net change experienced by *Rhizophoraceae* Species resulting from Other Lowland Forest Species between 1987 and 2006. The yellow patches indicate Threatened Areas from this class

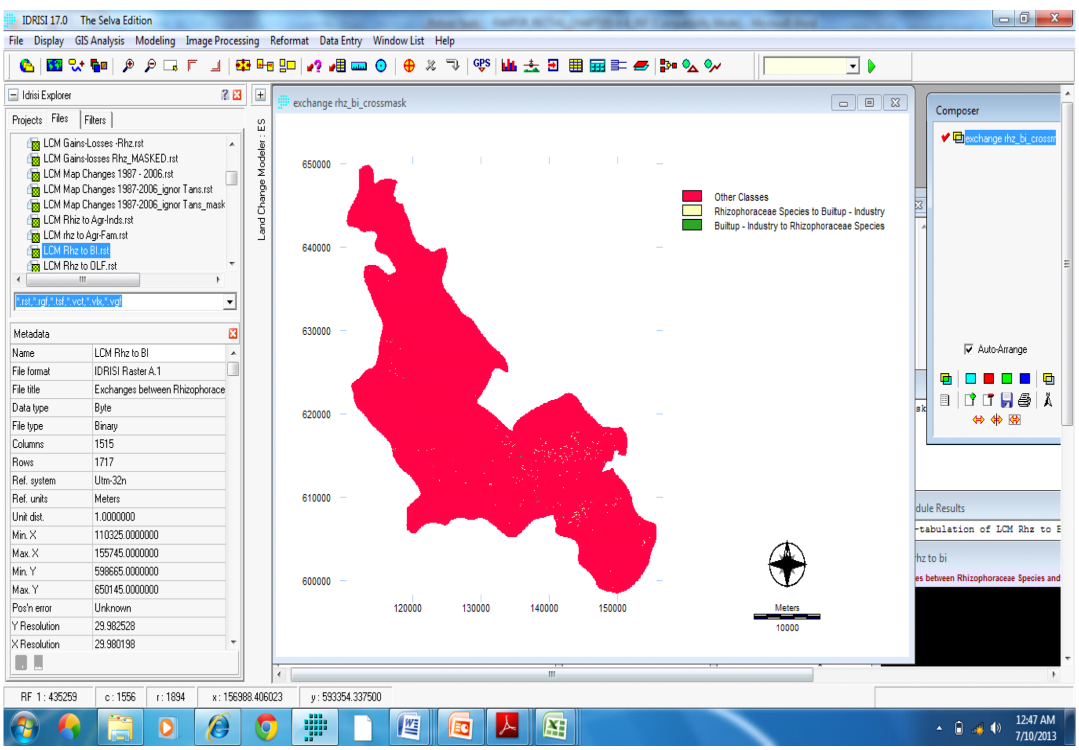


Figure 12: Spatial distribution of net change experienced by *Rhizophoraceae* Species resulting from Built up-Industry between 1987 and 2006. The yellow patches indicate Threatened Areas from this class

Spatial Rate of Change (1987–2025)

From the Change analyses results of *Rhizophoraceae Species* between 1987, 2006 and the projected state in 2025 (5393.29 hectares) and given its probability of transition to all other class, this herbal species will be lost at a rate of 376 hectares per year (2006–2025). Previously it was lost at a lower rate of 353.53 hectares per year (Table 4).

Table 4: Annual Rate of Loss (Imminent Extinction rate) of *Rhizophoraceae Species*

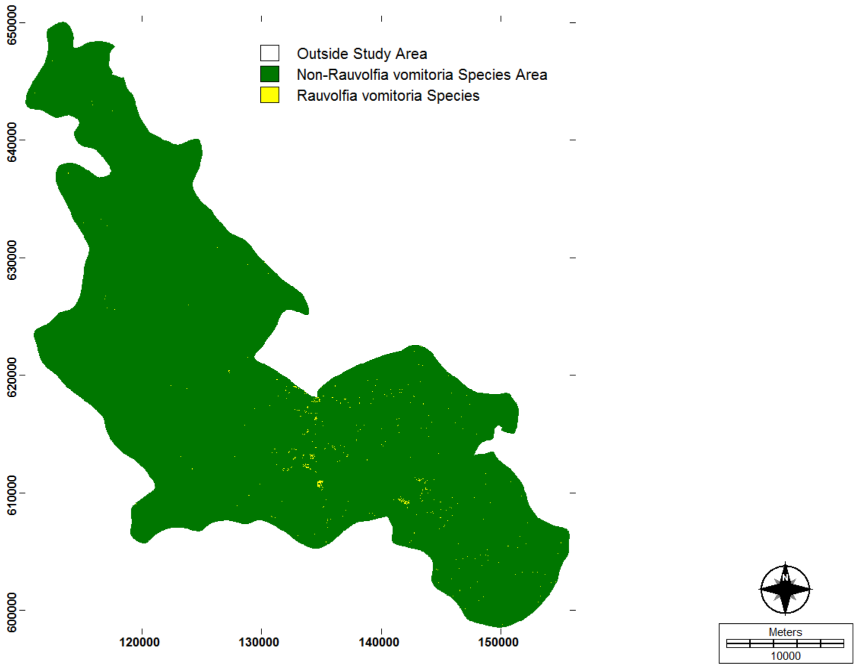
CATEGORY	***Rate of Loss Per Year***		
	(1987-2006) Hectares	*(2006-2025) Hectares*	*(1987-2025) Hectares*
RhizophoraceaeSpecies	-353.53	-376.16	-364.01

Analyses and Modeling of Rauvolfia Vomitoria SpeciesChange (1987–2006–2025)

From the Change analyses results of *Rauvolfia Vomitoria* Species between 1987, 2006 and the projected date of 2025, there was a loss from 208.63 to 11.60 hectares (Figure 13). A model of the medicinal species distribution within the study area and non-species area was presented in Figures 14, 15 and 16. The species changed from 1987 to 2006 in both quantity and location was expressed in areas of gains, losses and persistence as described in Figure 16 and Table 5. The total area that was lost was 0.2373% with 0.0147% areas of gain. Persistence was observed in 0.0004% of the area. Result of the LCM change analysis identified threats to the survival of *Rauvolfia Vomitoria* Species as shown in Figure 17 as contributors to its net change experienced. Table 6 showed the area in hectares of *Rauvolfia Vomitoria* species that were actually lost to this group of classes. Spatial distribution model showing the locations where the net loss of this medicinal species took place was presented in Figures 18, 19, 20 and 21.

Table 5: Quantity of Change (Losses, Persistence and gains) of *Rauvolfia Vomitoria* Species

Category	**Hectares**	**Percent**	**Legend**
1	87517.946	99.7476	Persistence of Non-*Rauvolfia Vomitoria Spp.* Area
2	12.854	0.0147	Gain of *Rauvolfia Vomitoria Species*
3	208.271	0.2373	Loss of *Rauvolfia Vomitoria Species*
4	0.360	0.0004	Persistence of *Rauvolfia Vomitoria Species*
Total	**87739.431**	**100**	



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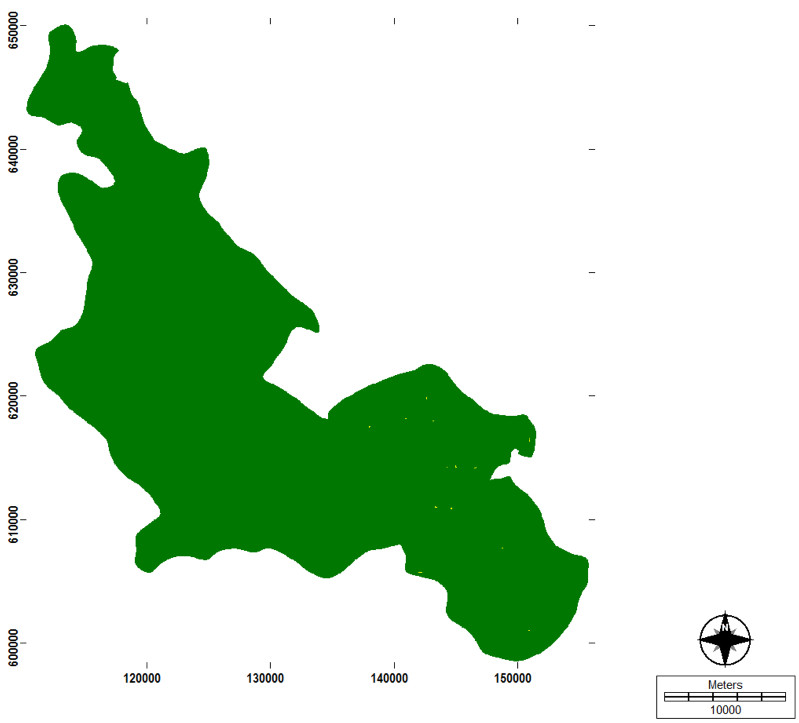

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Figures 13 and 14: Spatial Distribution of *Rauvolfia vomitoria* Species of the Study Area in 1987 and 2006

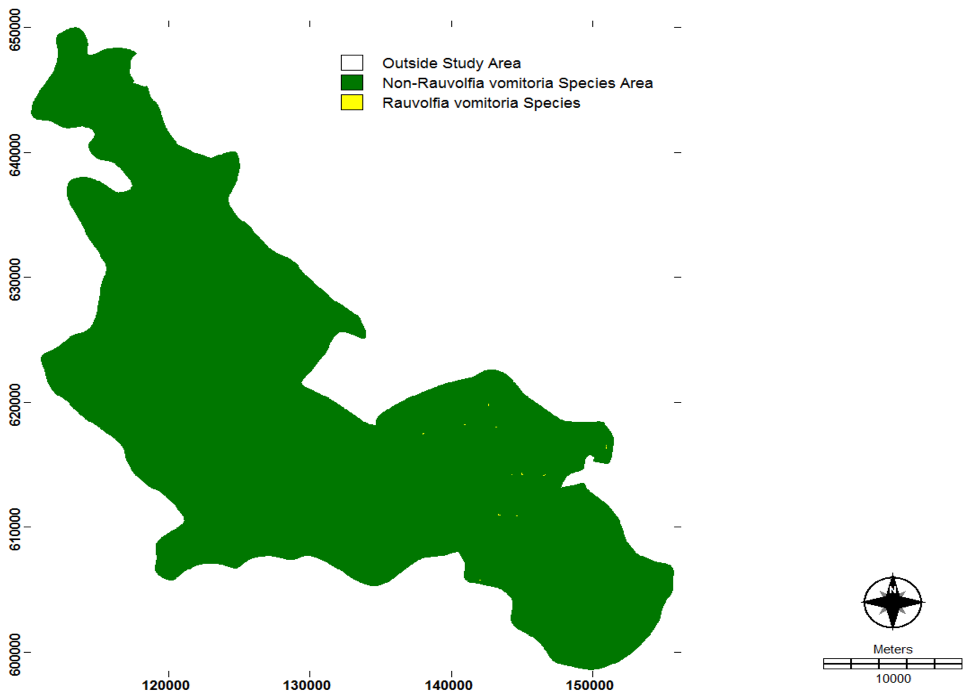

Figure 15: Spatial Distribution of *Rauvolfia Vomitoria* Species in the Study Area at the Projected Future date by 2025

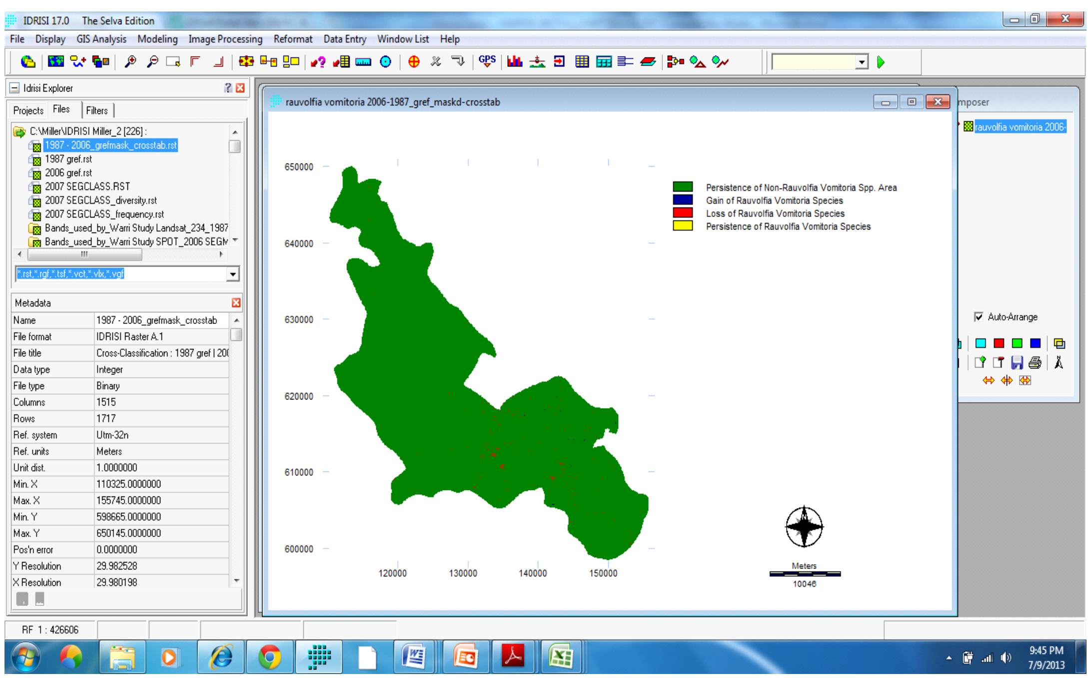

Figure 16: Spatial allocation of Change (Areas of Losses, Persistence and gains) of *Rauvolfia Vomitoria* Species in the Study Area between 1987 and 2006

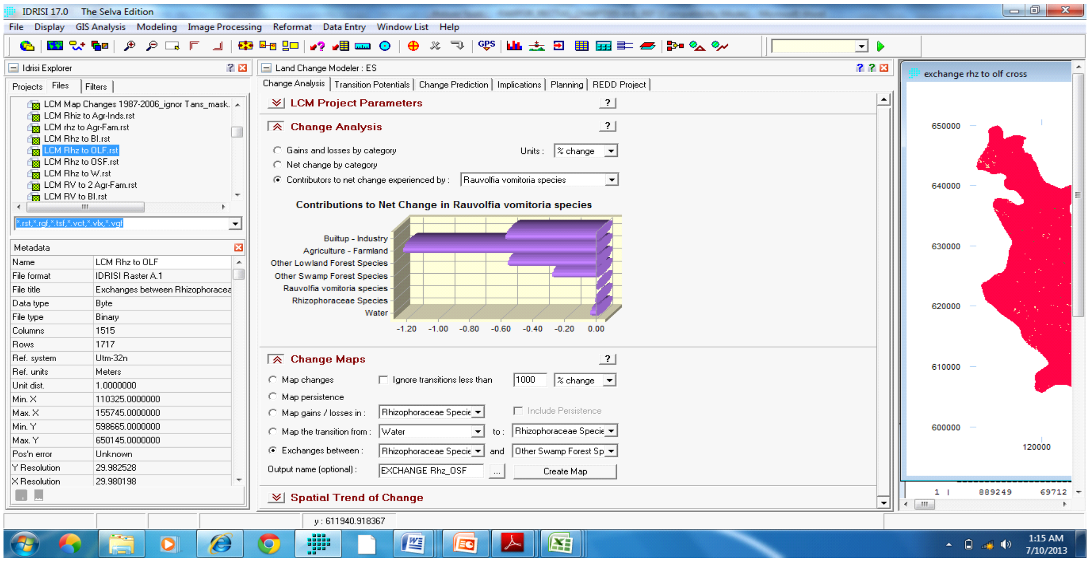

Figure 17: Result of LCM Analysis showing Contributors to Net Change Experienced by *Rauvolfia Vomitoria Species* in the Study Area from 1987 to 2006 in percentage, where a negative sign indicates a loss to that class while a positive sign, a gain from it

Table 6: Major Contributors to Loss experienced by *R. Vomitoria* Species

	Agriculture–Farmland	***Built up-Industry***	***Other Lowland Forest Spp.***	***Other Swamp Forest Spp.***	***TOTAL***
Loss of *R. Vomitoria Spp* (Ha)	53.75	22.56	57.08	54.92	188.31

<u>Spatial Rate of Change (1987–2025)</u>

The spatial rate of change of *Rauvolfia Vomitoria* Species is presented here. From the results, given the probability of transition of this species to all other classes from 1987 to the projected state in 2025 (11.60 hectares) it will be lost at a rate of 0.085 hectares per year (2006–2025). Earlier between 1987 and 2006 it was lost at a higher rate of 10.29 hectares per year (Table 7).

Table 7: Annual Rate of Loss (Imminent Extinction) of *Rauvolfia Vomitoria* Species

CATEGORY	Rate of Loss Per Year		
	(1987-2006) Hectares	(2006-2025) Hectares	(1987-2025) Hectares
Rauvolfia Vomitoria Species	-10.29	-0.085	-197.04

<u>Priority Areas/Habitats for Conservation Efforts</u>

Spatial assessment and modeling of land change dynamics involving the three Herbal Medicinal Species under study, revealed Safe Areas and those under Threat of Loss by the year 2025 and the Priority for Conservation Action identified. Figures 18 and 19; Tables 8 and 9 showed the location and area of *Rhizophoraceae Spp. and Rauvolfia Spp.* where conservation efforts need to be focused. Figures 20 and 21; Tables 10 and 11 showed areas requiring different degree of conservation actions for the medicinal species.

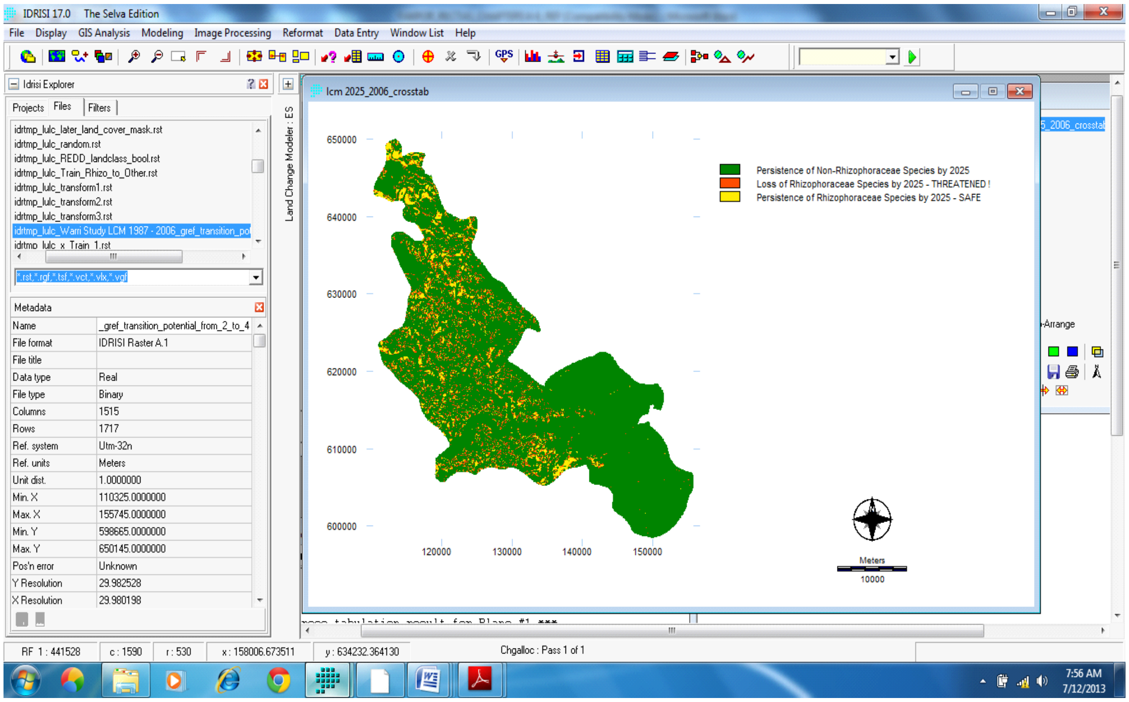

Figure 18: Predicted model of *Rhizophoraceae* Species showing Safe Areas and those under Threat of Loss by the year 2025. No area is expected to be gained by this medicinal plant

Table 8: Safe and Threatened Areas for Conservation Efforts for *Rhizophoraceae Spp.*

Category	Hectares	Legend
1	75199.13	Persistence of Non-*Rhizophoraceae* Species area by 2025
2	7147.01	Loss *of Rhizophoraceae Species* by 2025 - **THREATENED!**
3	5393.29	Persistence of *Rhizophoraceae Species* by 2025 - **SAFE**

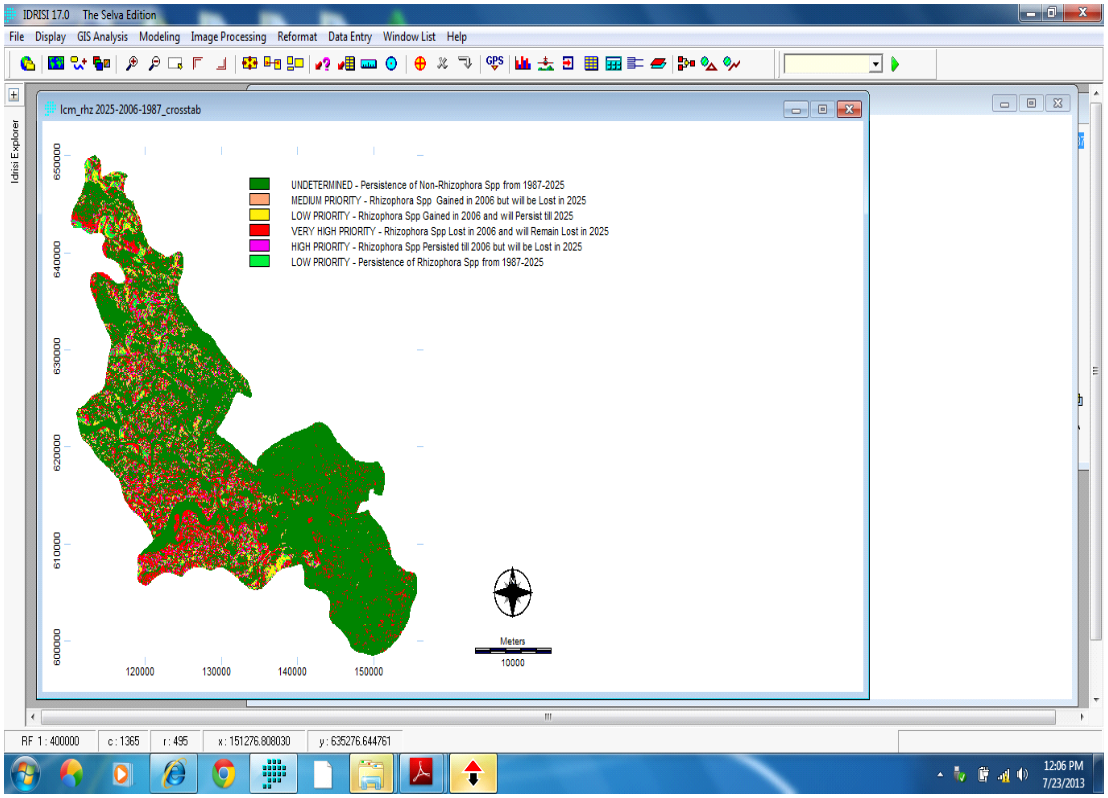

Figure 19: Predicted model of *Rhizophoraceae* Species showing Spatial Distribution of Prioritized Areas for Various Conservation Actions

Table 9: Prioritized Area for Various Conservation Actions of *Rhizophoraceae Spp*.

Category	Hectares	Conservation Action	Legend
1	61307.26	**UNDETERMINED**	Persistence of Non-*Rhizophora Spp*. Area from 1987- 2025
2	4282.45	**MEDIUM PRIORITY**	*Rhizophora Spp*.Gained in 2006 but will Be Lost in 2025
3	2892.42	**LOW PRIORITY (SAFE)**	*Rhizophora Spp*.Gained in 2006 and will Persist till 2025
4	13891.86	**VERY HIGH PRIORITY**	*Rhizophora Spp*. Lost in 2006 and will Remain Lost in 2025
5	2864.56	**HIGH PRIORITY**	*Rhizophora Spp*. Persisted till 2006 but Will be Lost in 2025
6	2500.87	**LOW PRIORITY (SAFE)**	Persistence of *Rhizophora Spp*. from 1987-2025

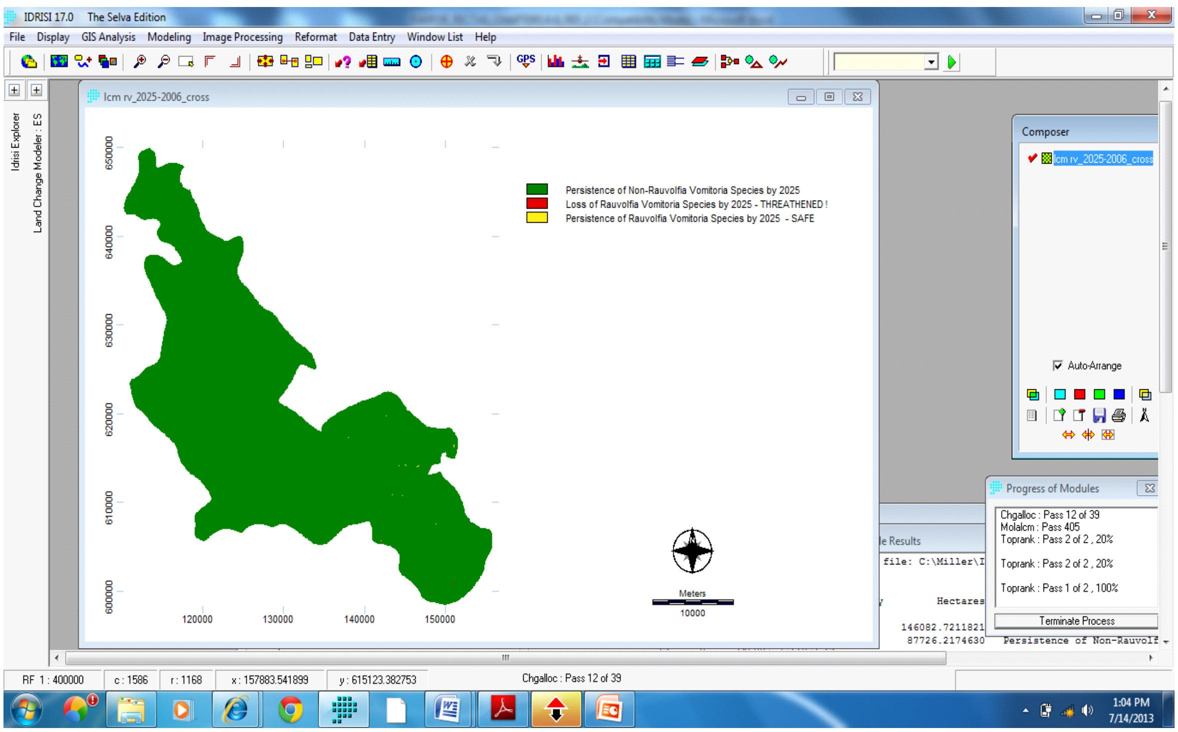

Figure 20: Predicted model of *Rauvolfia Vomitoria* Species showing Safe Areas and those under Threat of Loss by the year 2025. No area will be gained by this medicinal plant

Table 10: Safe and Threatened Areas for Conservation Efforts of *Rauvolfia Spp.*

Category	Hectares	Legend
1	87726.23	Persistence of Non-Rauvolfia Vomitoria Spp. by 2025.
2	1.62	Loss of Rauvolfia Vomitoria Spp. by 2025 - **THREATHENED!**
3	11.60	Persistence of Rauvolfia Vomitoria Spp. by 2025 - **SAFE**

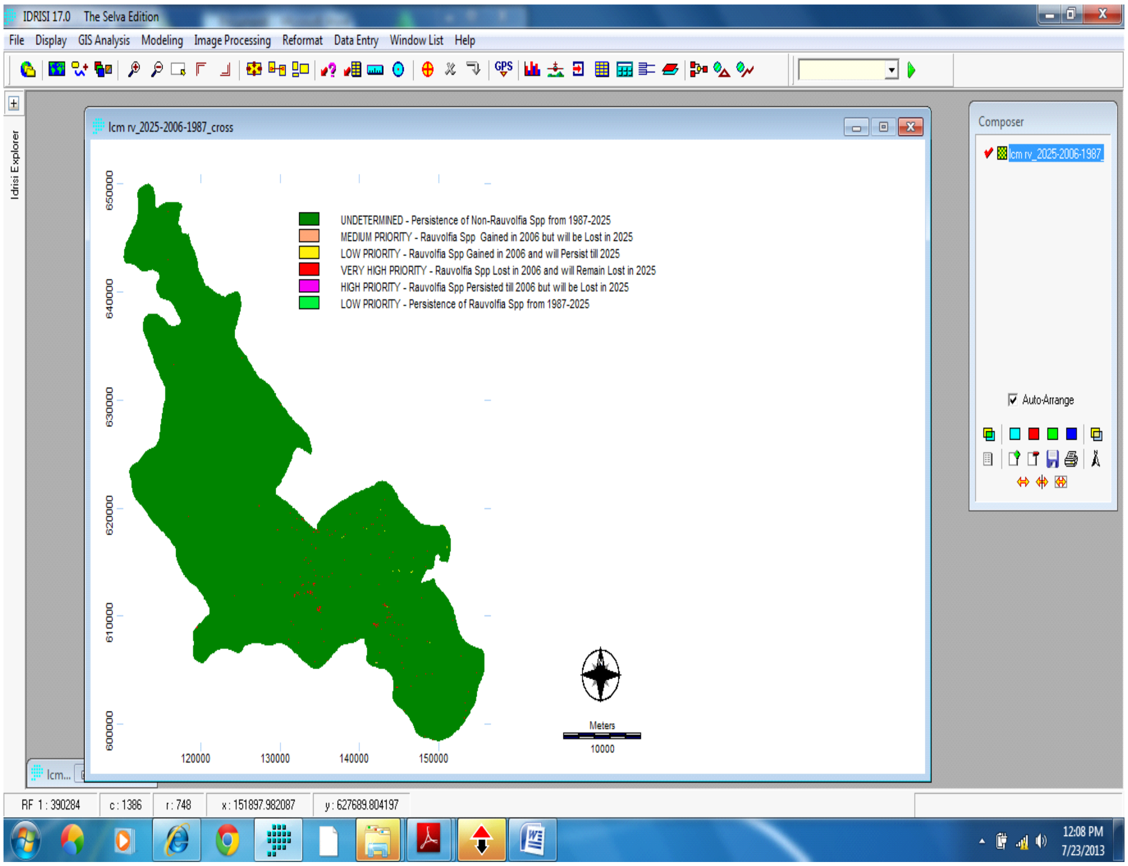

Figure 21: Predicted model of *Rauvolfia Vomitoria* Species showing Spatial Distribution of Prioritized Areas for Various Conservation Actions

Table 11: Prioritized Area for Various Conservation Actions of *Rauvolfia Spp*.

Category	Hectares	Conservation Action	Legend
1	87517.95	**UNDETERMINED**	Persistence of Non-Rauvolfia Spp from 1987- 2025
2	1.44	**MEDIUM PRIORITY**	Rauvolfia Spp Gained in 2006 but will be Lost in 2025
3	11.42	**LOW PRIORITY (SAFE)**	Rauvolfia Spp Gained in 2006 and will Persist till 2025
4	208.27	**VERY HIGH PRIORITY**	Rauvolfia Spp Lost in 2006 and will Remain Lost in 2025
5	0.18	**HIGH PRIORITY**	Rauvolfia Spp Persisted till 2006 But will be Lost in 2025
6	0.18	**LOW PRIORITY (SAFE)**	Persistence of Rauvolfia Spp from 1987-2025

DISCUSSION

Rhizophoracea(R. Mangle and R. Racemosa)

Rhizophoraceae *Species*which occupied about 22% (19,257.30 hectares) of the study area in 1987is being lost at a rate of 353.53 hectares per year between 1987 and 2006, and will increase to 376.16 hectares from 2006 to 2025. Hence, approximately 7,147 hectares is under threat of loss by 2025. This is about 0.47% of over 1,500,000 hectares of the total mangrove area estimated to be found in Nigeria and of which more than 60 per cent is located in the Niger Delta region (James *et al.,* 2007).

The threats to the continuous availability and use of this medicine (*R. mangle and R. racemosa*) were identified to come from; encroachment from other swamp forest species (accounting for about 27% net loss) precipitated by human impact, agriculture and farmland (18%), other lowland forest species (9%) and built up and industry (7%) with some areas now covered by water. This lends credence to Omondi and Peter (2011) who reports that land cover modification generally occurs with the full substitution of one cover type by another as observed in this study. This may be mainly attributable to the ecological threat activities from industry on the water ways. Fakpor *et al.* (2009), observed mangrove death (Moffat and Linden, 1995) and changes in species composition to other ecological type resulting from oil and petrochemical discharges transported along the mangrove swamp waterways. Other threat may be as a result of agriculture-farminginvolving fish farming, harvesting of mangrove woods and built-up activities involving clear-cutting for construction as observed by Salami and Balogun (2006) and sandfilling. This poses serious threat to the continuous availability of the *Rhizophoraceae Spp.* utilized for health care within the study area region. This is against the environmental dimension of the principle of sustainable development that deals with maintenance of a certain stock of natural resources above a certain quality threshold. Conservation actions are rated to be of 'Very High Priority' for about 13,891.86 hectares that was lost in 2006 and will remain lost in 2025, while about 2,864.56 hectares are rated to be of 'High Priority" for those species area that persisted from 1987 to 2006 but will become lost in 2025. "Medium Priority" was rated for 4,282.45 hectares for *Rhizophora spp.* gained in 2006 but will be lost in 2025, "Low Priority" was rated for 2,892.42 hectares for species area gained in 2006 but will persist till 2025 while 2,500.87 hectares is rated as "Safe" for their persistence from 1987 to 2025.

The high rate of loss of this medicinal plants from 1987–2007 and the projected date in 2025 may be driving it to an imminent extinction. Imminent extinction is extinction directly caused by habitat destruction and can be estimated by examining the loss of endemic species to a region. However the estimation of extinction rate as employed in this study based on imminent extinction through Species–Area Reduction (SAR) can be problematic and exaggerated as it is based on the premise that the backward extrapolation of SAR is valid, implying that the loss of species due to habitat reduction is of the same rate as the discovery of species. If the ecological and environmental variables of the past 19 years that dictated the current state of the species remain in the same dynamics, the projected threat to the species may occur and affect its sustainable use.

Rauvolfia Vomitoria

Rauvolfia vomitoria which occupied about 0.24% (208.63 hectares) of the study area in 1987 was observed to be lost at the rate of 10.29 hectares per year between 1987 and 2006 but will decrease to a rate of 0.085 hectares from 2006 to 2025. Approximately 1.6 hectares is therefore under the threat of loss by 2025. *Rauvolfia vomitoria as* observed is found mainly in the lowland rainforest region and few in the swamps as at 1987. However, in 2006 and from current ground-truth, this had declined and encroached mainly by other lowland forest species (accounting for 57.08 hectares of *R. Vomitoria* that was lost to it). This was followed by other swamp forest species (54.92 hectares), agriculture and farmland (53.75 hectares), built-up and industry replacing 22.56 hectares of the species. Pellika, Clark, Hurskainen, Keskinen, Lanne, Masalin, Nyman-Ghezelbash and Servio (2004) observed changes in the forest characteristics due to human induced deforestation processes, ecological changes due to the need for agricultural expansion and land use/land cover changes due to factors related to human influences from increased population. These factors have similarly threatened *Rauvolfia vomitoria species* in the study area.

The rate of loss of the species per area or imminent extinction rate was observed to be very high between 1987 and the projected date in 2025. Conservation actions were rated to be 'Very High Priority' for about 208.27 hectares that was lost in 2006 and will remain lost in 2025, while about 0.18 hectares was rated to be of 'High Priority" for those species area that persisted from 1987 to 2006 but will become lost in 2025, "Medium Priority" for 1.44 hectares of *R. Vomitoria* species that was gained in 2006 but will be lost in 2025. A "Low Priority" rating for conservation was determined for 11.42 hectares for species gained in 2006 and will persist till 2025, while the species area that will persist from 1987 to 2025 which is estimated to be 0.18 hectares is rated as "Safe".

Rivolfia Vomitoria Species unlike the *Rhizophoraceae Species* is not very domineering in the lowland forest ecosystem of the study area where it is found and those that have not reached their maximum maturity height of between 20–40 meters may not be sampled in the midst of other trees that cover its canopy. This can lead to an under estimation of the species' presence and abundance but not on the species cover or area sampled as was carried out in the study.

CONCLUSION

This study has demonstrated that significant changes have occurred in the spatial distribution and abundance of the three selected medicinal species (*Rhizophora mangle, Rhizophora recemosa* and *Rauvolfia vomiteria*) and under threat from built-up, industry, agriculture and other human activities that alter the natural ecological processes that can induce species changes and modify their habitat. Therefore there is an urgent need for their conservation. Specifically, locations or areas for conservation measures have been identified and prioritized with much area under high priority. The sustainable uses of herbal medicine for the health care management of people within and around the study area require insight into their distribution and factors affecting their change. This is in conformity with ecological sustainability that connects human needs and ecosystem services: "meeting human needs without compromising the health of ecosystems."The study advocates monitoring and controlling of activities and developments that have driven the forces of herbal medicinal species loss in the study area. These include agriculture, industry, construction activities and other demographic factors. The conservation of these species alongside their domestication and cultivation in addition to in-situ methods such as the designation of threatened areas as a protected area are recommended.

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