Vegetation Cover Change and Non-Timber Forest Product Availability: Implications for Rural Livelihoods in Jubaland, Somalia

Louis Njie Ndumbe[1*]; Verina Ingram[2]; Ettagbor Hans Enukwa[1]

[1]University of Buea, Department of Forestry and Wildlife, Faculty of Agriculture and Veterinary Medicine, P.O. Box 63, Buea, Cameroon
[2]Forest and Nature Conservation Policy Group, Wageningen UR, P.O. Box 47, 6700 AA, Wageningen, The Netherlands.

Corresponding Author: Louis Njie Ndumbe[1*]

Publication Date: 2026/06/11

Abstract: Non-timber forest products (NTFPs) contribute significantly to rural livelihoods in dryland ecosystems, yet vegetation cover changes threaten their long-term availability. This study examines the dynamics of land use and land cover change in Jubaland State, Somalia, and assesses implications for NTFP availability and household livelihoods. Using Landsat satellite imagery (2010-2022) analyzed through supervised classification with the Maximum Likelihood Classifier, combined with household surveys (n=132), focus group discussions (n=3), and key informant interviews (n=5), we quantified vegetation changes and their socioeconomic impacts. Results show that scrub/shrub vegetation increased by 672,028 ha (annual rate +0.68%), while forest cover declined dramatically from 2,208,660 ha (19.77%) to 1,503,850 ha (13.46%), a loss of 704,810 ha at an annual deforestation rate of -3.49%. Cultivated areas expanded by 11,667 ha (+1.70% annually), and built-up areas increased by 3,579 ha (+3.27% annually). Community perceptions identified tree cutting (100% of respondents) and charcoal production as primary deforestation drivers. NTFP species including *Acacia senegal*, *Adansonia digitata*, *Ziziphus spina-christi*, and *Commiphora myrrha* were reported as declining in availability. Over 65% of households depend on NTFPs for subsistence, with 30% deriving cash income from NTFP sales. Inter-state and international trade were dominated by males (85%), while women dominate local processing (90%) and retailing in local markets (99%). However, women face governance constraints including informal taxation and limited market access. We recommend integrating NTFP species into agroforestry systems, strengthening customary governance through 'xeer' revitalization, and establishing state-level dryland forest research centers to support sustainable resource management.

Keywords: *Deforestation, Land Cover Change, Non-Timber Forest Products, Livelihoods, Jubaland, Somalia, Dryland Ecosystems.*

How to Cite: Louis Njie Ndumbe; Verina Ingram; Ettagbor Hans Enukwa. (2026) Vegetation Cover Change and Non-Timber Forest Product Availability: Implications for Rural Livelihoods in Jubaland, Somalia. *International Journal of Innovative Science and Research Technology*,11(5), 4035-4042. https://doi.org/10.38124/ijisrt/26may1915

I. INTRODUCTION

Dryland forests and woodlands constitute some of the most vulnerable yet critically important ecosystems on the African continent, providing essential ecosystem services and supporting the livelihoods of millions of people across arid and semi-arid regions [1]. The Horn of Africa, and Somalia in particular, exemplifies the complex challenges facing dryland resource management, where recurrent droughts, political instability, and rapid population growth converge to create unprecedented pressure on natural vegetation. Non-timber forest products (NTFPs), defined as all goods and services derived from forests other than timber, play a particularly vital role in these systems, serving as safety nets during periods of food insecurity, sources of cash income for marginalized households, and providers of essential materials for shelter, medicine, and energy [2], [3]. In Somalia, NTFPs including aromatic resins (frankincense and myrrh), gum arabic, wild fruits, honey, and fodder contribute substantially to both subsistence and commercial economies, yet their contribution remains systematically undervalued in national accounts and development planning.

Over the past three decades, Somalia's forest ecosystems have experienced accelerating degradation and deforestation due to a confluence of factors: escalating demand for wood-based energy for household consumption, illegal charcoal exports that bypass international sanctions,

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26may1915

weak governance structures following prolonged state collapse, insufficient legal protection for natural resources, and the compounding effects of climate change manifested in more frequent and severe droughts [4], [5]. The annual rate of deforestation in Somalia is currently estimated at 1.03 percent, almost twice the average rate of loss for Africa (0.62%) and more than three times that of neighboring Kenya (0.3%) [6]. Between 2000 and 2017 alone, Somalia lost approximately 686,000 hectares of forest, accounting for at least 6 percent of all trees lost in Africa during that period [6]. These losses have profound implications not only for biodiversity conservation and climate regulation but also for the adaptive capacity and resilience of rural communities who depend directly on forest resources for their daily survival.

The degradation of forest ecosystems in Somalia is embedded within a complex political economy characterized by competing claims over rights and resources among formal and informal actors at multiple scales [7]. The Somali Federal Government (SFG) and Federal Member States (FMS) nominally hold authority over natural resource management, but real power often resides with clan militias, Al-Shabaab, and influential business elites who control sub-contracts for development support, export businesses, and illicit trans-border trade of forest products. This context creates what Kishor et al. [8] describe as a situation where stakeholders' power and influence are unevenly distributed, institutions are weak, and organizations are inefficient and corrupt, resulting in resource plunder and institutional erosion. Understanding these political economy dynamics is essential for designing interventions that can effectively address the root causes of deforestation rather than merely treating its symptoms.

Jubaland State, located in southern Somalia along the Kenyan border, represents a particularly instructive case for examining vegetation cover change and NTFP dynamics. The region benefits from relatively higher rainfall (400-700 mm annually) compared to central and northern Somalia and supports the only perennial river system (the Juba River). These ecological characteristics have historically supported rich NTFP resources, including commercially valuable species such as frankincense (*Boswellia sacra*), myrrh (*Commiphora myrrha*), and gum arabic (*Acacia senegal*). However, Jubaland also experiences intense pressure from charcoal production, much of it destined for illegal export to Gulf Cooperation Council countries, agricultural expansion, and urbanization associated with population displacement and internal migration.

Globally, land use and land cover change (LULCC) analysis using remote sensing and geographic information systems (GIS) has become an indispensable tool for understanding the spatial and temporal dynamics of vegetation change [9], [10], [11]. These methods have been applied extensively in tropical forest regions, where studies have documented deforestation rates ranging from 0.26% to 1.57% annually depending on location and protection status [12], [13], [14]. Douandji et al. [15] recently demonstrated the effectiveness of the CA-Markov modeling approach in predicting future land cover changes in Cameroon's Mount Nlonako forest, achieving overall classification accuracy above 89% and Kappa coefficients exceeding 0.85. However, comparable systematic assessments remain lacking for Somalia, where data scarcity, security constraints, and prolonged conflict have severely limited environmental monitoring and research capacity.

The integration of geospatial analysis with socioeconomic methods offers particular advantages for understanding the human dimensions of vegetation change [16], [17]. Mixed-methods approaches also capture local perceptions of vegetation change and the gender dimensions of NTFP value chains, as women and men often participate differently in harvesting, processing, and marketing activities, with corresponding differences in vulnerability to resource depletion [18], [19], [20], [21], [22], [23].

This study addresses four interconnected research objectives: (1) to identify potential NTFP tree-producing species suitable for agroforestry use and conservation in Somalia; (2) to investigate the impact of governance and political economy on the commercial viability of NTFP value chains; (3) to analyze the dynamics of land use and land cover change in order to determine the causes of deforestation and degradation; and (4) to investigate institutional capacity gaps that influence land use changes and identify capacity building needs.

II. MATERIALS AND METHODS

- *Study Area*

The study was conducted in Kismayo district, Jubaland State, southern Somalia (approximately 0°22'S, 42°33'E). Jubaland is characterized by flat terrain rising from 6 m above sea level along the coast, with the Juba River as the only perennial river in the three study states. Soils include sandy, clay, lime, and alluvial types. Rainfall ranges from 400–700 mm annually, with two rainy seasons: *Gu* (March–May) and *Dayr* (October–December). Mean annual temperatures range from 20°C to 30°C. Vegetation comprises low deciduous bushland dominated by *Acacia* and *Commiphora* species, with riparian forest along the Juba River and mangrove communities at tidal estuaries [24].

- *Land Cover Classification and Change Detection*

Landsat satellite imagery from 2010 (Landsat 7 ETM) and 2022 (Landsat 8 OLI-TIRS) was acquired from the USGS Glovis data archive. Images were selected from November-December to minimize cloud cover and harmonize seasonal vegetation conditions. Pre-processing included radiometric and geometric corrections, mosaicking, and sub-setting to the study area using ERDAS IMAGINE 2018 software (version 16.5). Images were projected to UTM Zone 38N, WGS 1984.

Supervised classification was performed using the Maximum Likelihood Classifier (MLC), following established methods [25], [26]. Six land cover classes were identified based on visual interpretation and the FAO Land Cover Classification System [27]: (1) Trees (dense forest), (2) Scrub/Shrub, (3) Grass, (4) Crops, (5) Built Area, (6)

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26may1915

Bare ground, (7) Flooded vegetation, and (8) Water surface. Training signatures (180 pixels per class) were developed using false-color composites (bands 4-3-2). Accuracy assessment was performed using confusion matrices, with overall accuracy >85% and Kappa coefficient >0.80 considered acceptable [28], [29].

The annual rate of change was calculated using the Bernier [30] formula:

$$T = [(\ln S2 - \ln S1) / ((t2 - t1) \times \ln e)] \times 100$$

Where S1 and S2 are areas at dates t1 and t2 respectively, ln is the natural logarithm, and e = 2.71828.

➢ *Socioeconomic Data Collection*

Primary data were collected from April to June 2022 using mixed methods. Household surveys (n=132) using structured questionnaires captured NTFP collection practices, species used, income sources, and perceptions of vegetation change. Focus group discussions (FGDs) (n=3, average 6 participants each) were conducted with elders and NTFP harvesters following established participatory rural appraisal techniques [31]. Key informant interviews (n=5) targeted government officials, customs authorities, and market traders. Market surveys were conducted in Kismayo to document NTFP prices and value chains. Stakeholder consultations were held with the Ministry of Environment of Jubaland, Ministry of Agriculture and Irrigation, Ministry of Commerce, and Kismayo Port Authority. This mixed-methods approach has been widely used in NTFP value chain research [16], [17].

Quantitative data were analyzed using SPSS version 26 and Microsoft Excel. Qualitative data were analyzed using thematic analysis [32].

III. RESULTS

➢ *Land Cover Classification Accuracy*

Classification accuracy for 2010 and 2022 land cover maps exceeded acceptable thresholds. Overall accuracy was 89.85% for 2010 and 91.48% for 2022, with Kappa coefficients of 0.85 and 0.87 respectively. User's and producer's accuracies for individual classes ranged from 82.6% to 96.6%, with the lowest values for Built-up Area and Dense Forest classes due to spectral mixing with surrounding land covers.

➢ *Land Cover Change in Jubaland (2010–2022)*

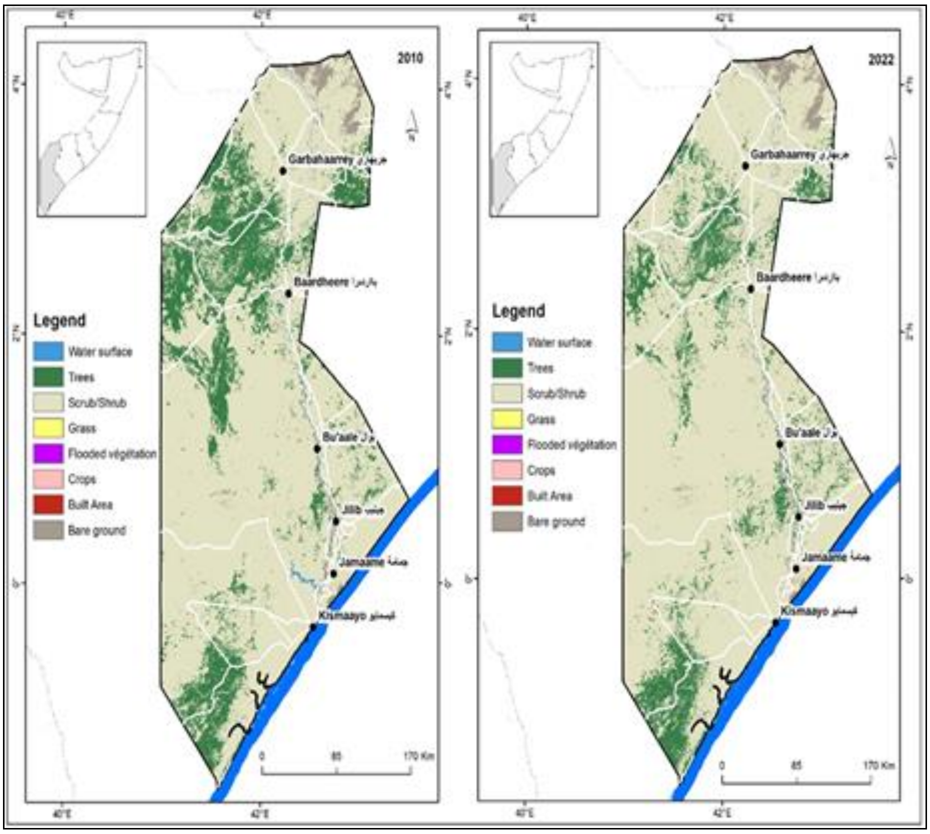

Fig 1 Land Cover in the State of Jubaland Between 2010 and 2022

Figure 1 shows land cover state in Jubaland for 2010 and 2022, whilst Table 2 presents the area statistics for each land cover class in 2010 and 2022. In 2010, Scrub/Shrub dominated the landscape, occupying 8,687,896 ha (77.77%), followed by Trees (forest) at 2,208,660 ha (19.77%). Bare ground covered 166,751 ha (1.49%), Crops 56,565 ha (0.51%), and Water surface 39,796 ha (0.36%). Built-up area, Grass, and Flooded vegetation occupied minor proportions (<0.1% each).

By 2022, Scrub/Shrub had increased to 9,359,924 ha (83.79%), representing a net gain of 672,028 ha. Conversely, forest cover (Trees) declined dramatically to 1,503,850 ha (13.46%), a loss of 704,810 ha. Crops expanded to 68,232 ha

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26may1915

(0.61%), Bare ground increased to 199,291 ha (1.78%), and Built-up area grew to 11,858 ha (0.11%). Water surface decreased to 26,540 ha (0.24%), and Flooded vegetation declined from 3,165 ha to 1,403 ha.

Table 2 Land Use Statistics in Jubaland State (2010–2022)

Land cover	Area 2010 (ha)	% 2010	Area 2022 (ha)	% 2022	Change (ha)
Water surface	39,795.60	0.36	26,540.40	0.24	-13,255.20
Trees	2,208,660.00	19.77	1,503,850.00	13.46	-704,810.00
Flooded vegetation	3,164.77	0.03	1,403.08	0.01	-1,761.69
Crops	56,564.80	0.51	68,232.10	0.61	+11,667.30
Built Area	8,279.04	0.07	11,857.60	0.11	+3,578.56
Bare ground	166,751.00	1.49	199,291.00	1.78	+32,540.00
Grass	62.83	0.00	76.01	0.00	+13.18
Scrub/Shrub	8,687,895.86	77.77	9,359,923.72	83.79	+672,027.86
Total	**11,171,173.90**	**100**	**11,171,173.90**	**100**	**-**

The annual rate of change (Table 3; Figure 2) revealed that Flooded vegetation experienced the most rapid decline at -7.39% per year, followed by Water surface (-3.68%) and Trees (-3.49%). Built-up area expanded most rapidly (+3.27% annually), followed by Crops (+1.70%), Grass (+1.73%), and Bare ground (+1.62%). Scrub/Shrub increased at +0.68% annually.

Table 3 Annual Rate of Land Cover Change in Jubaland (2010–2022)

Land cover	Change (ha)	Annual rate of change (%)
Water surface	-13,255.20	-3.68
Trees	-704,810.00	-3.49
Flooded vegetation	-1,761.69	-7.39
Crops	+11,667.30	+1.70
Built Area	+3,578.56	+3.27
Bare ground	+32,540.00	+1.62
Grass	+13.18	+1.73
Scrub/Shrub	+672,027.86	+0.68

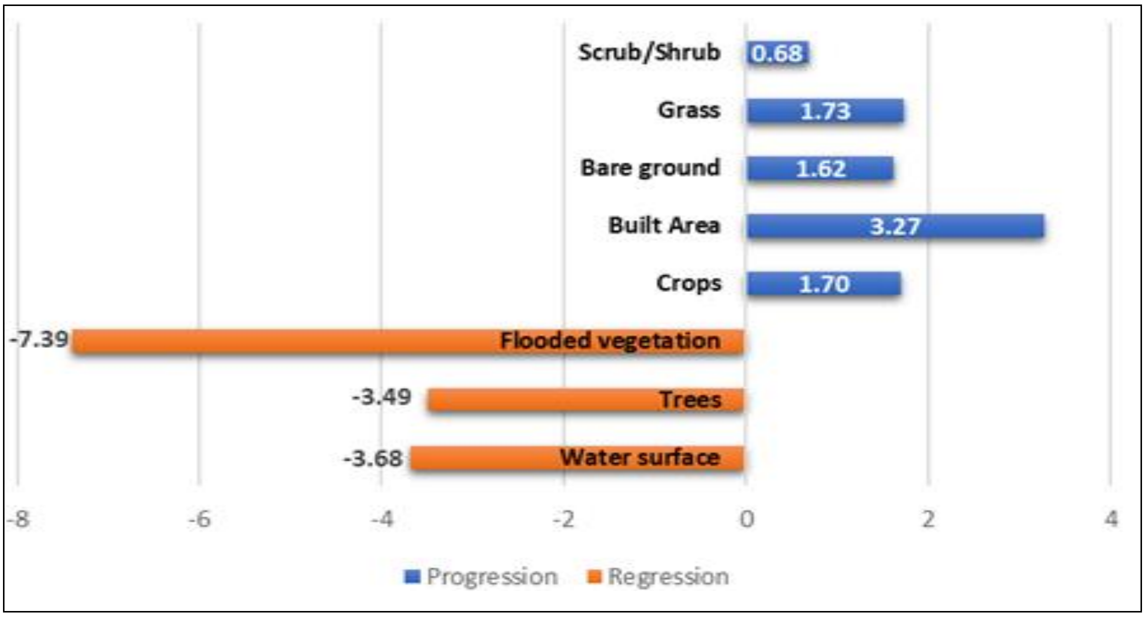

Fig 2 Annual Rate of Change of Spatial Tenure Categories in Jubaland (2010–2022)

- (Note: Figure 2 shows highest negative rates for flooded vegetation (-7.39%), water (-3.68%), and trees (-3.49%), with positive rates for built area (+3.27%), grass (+1.73%), crops (+1.70%), and bare ground (+1.62%))*

➢ *NTFP Species and Perceived Availability*

Household surveys identified 16 NTFP species collected, with 14 species documented in Jubaland (Table 4). The most frequently collected species included *Acacia senegal* (gum arabic), *Adansonia digitata* (baobab), *Ziziphus spina-christi*, *Acacia nilotica*, and *Balanites aegyptiaca*. *Commiphora myrrha* (myrrh) and *Boswellia sacra* (frankincense) were reported as commercially important. *Cordeauxia edulis* (Yi'ib/Yicib) was reported as having limited availability in Jubaland.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26may1915

Table 4 NTFP Species Collected and Perceptions of Availability in Jubaland

Scientific Name	Local Name	Perceived Availability	Primary Use
Adansonia digitata	-	High	Food, medicine
Ziziphus spina-christi	-	High	Food, fodder
Acacia nilotica	-	High	Fodder, medicine
Balanites aegyptiaca	-	High	Food, medicine
Cordeauxia edulis	Yicib/Yi'ib	Limited	Food (nuts)
Dobera glabra	Garas	Limited	Famine food, fodder
Berchemla discolor	Dheen	High	Food, medicine, construction
Ziziphus mauritiana	Gob	Limited	Food, fodder
Grewia penicillata	Hoohob	High	Food, construction
Givotia gosai	Goosay	High	Food (famine)
Acacia edgeworthii	Jeerin/Quule	Medium	Food, medicine, fencing
Melia volkensii	Xar	High	Boat construction, fodder
Boswellia sacra	Moxor/Mohor	High	Resin (frankincense)
Commiphora malmal	Dhidin/Malmal	High	Resin (myrrh)
Acacia senegal	Caddaad	Medium	Gum arabic, firewood

Perceptions of declining availability were widespread. Focus group participants reported that *Acacia tortilis* and *Acacia busei*, preferred species for charcoal production, have become increasingly scarce, requiring longer travel distances for collection. One respondent noted: "*Dry logs used to be available nearby, but now we have to go far into remote areas, sometimes we cross the border into Ethiopia and spend days in the forest*."

➢ *NTFP Contribution to Household Livelihoods*

NTFPs contributed to both subsistence and cash income for households in Jubaland. 65% of households reported using NTFPs for subsistence needs, 30% for sale, and 5% for other benefits. Firewood and charcoal production were the dominant forest income-generating activities for over 80% of the population. 40% of respondents identified agro-pastoralism as their main income source, with NTFPs as the second most important source (30% of interviewees).

➢ *Gender Dimensions of NTFP Value Chains*

Gender analysis revealed distinct patterns across value chain nodes (Table 5). While collection was relatively balanced (61% male, 39% female), inter-state and international trade were dominated by males (85%), while women dominate local processing (90%). However, women-dominated local NTFP markets, with 99% of locally traded NTFP retailers being women. In the frankincense value chain, men dominated harvesting, transportation, and export, while women were responsible for sorting, cleaning, and packaging, activities with lower remuneration.

Table 5 Gender Distribution Across NTFP Value Chain Nodes

Gender	Collectors (n=133)	Traders (n=135)	Processors (n=135)
Male	82 (61%)	115 (85%)	14 (10%)
Female	53 (39%)	20 (15%)	121 (90%)

Focus group discussions revealed cultural constraints affecting women's participation in research: "*In Jubaland, women were not allowed to be part of the group discussions, and only a few accepted to be photographed during the interviews*."

➢ *Governance Regimes and Resource Access*

Customary governance systems administered by clan elders (*Nabadoono*) regulate NTFP access on communal land. Multiple entities control NTFP resources on communal land, including tribal leaders, local community, landlords, and joint tribal leader-government arrangements. For frankincense trees (*Boswellia* and *Commiphora* species), tree tenure is often individual or family-based, with inheritance through generations. Boundaries are well-known locally but not formally demarcated, leading to occasional conflicts.

Governance challenges identified include: (1) open-access harvesting for many species leading to sustainability concerns; (2) weak enforcement of existing regulations; (3) informal taxation by militia groups; (4) limited state capacity - the Ministry of Environment in Jubaland had only two staff with Master's degrees in natural resources management out of 17 employees; and (5) lack of formal NTFP trade data and monitoring systems.

➢ *Perceived Drivers of Vegetation Change*

Household surveys identified multiple drivers of vegetation change. In Jubaland, 100% of respondents identified tree cutting as the primary cause of forest depletion, compared to charcoal production (ranked second), drought, overgrazing, and urbanization. Charcoal production specifically targets high-energy species including *Acacia tortilis* and *Acacia busei*, with destructive practices including deliberate tree killing using salt and used engine oil to contaminate root systems. Focus group participants reported that charcoal traders and militia groups capture most of the value: for a bag of charcoal sold at USD 8 in local markets, only USD 2-3 is shared between producer and vendor, with the balance captured by intermediaries.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26may1915

IV. DISCUSSION

➢ *Rates and Patterns of Deforestation in Jubaland*

This study documents an annual deforestation rate of -3.49% for forest cover in Jubaland between 2010 and 2022, representing a loss of 704,810 ha over 12 years. This rate substantially exceeds national estimates of 1.03% annually [5] and is nearly six times the African average of 0.62% [4]. The disparity may reflect localized pressures in Jubaland, including intensive charcoal production for export, expansion of irrigated agriculture along the Juba River, and in-migration.

The observed pattern of forest conversion to scrub/shrub, cropland, and bare ground is consistent with deforestation dynamics documented elsewhere in sub-Saharan Africa. In Cameroon's Mount Nlonako forest, Douandji et al. [15] reported a deforestation rate of -1.08% annually, with dense forest declining from 75.42% to 45.89% of total area. Similarly, Feudjio et al. [10] documented forest loss of -0.84% to -1.57% annually in the Santchou wildlife reserve. The higher rate in Jubaland likely reflects weaker governance and the absence of protected area status for most forest resources.

The expansion of scrub/shrub vegetation (+0.68% annually) suggests forest degradation rather than complete removal, with selective logging of high-value timber and charcoal species leading to structural changes in vegetation. This pattern mirrors findings from the Congo Basin, where selective logging and shifting cultivation result in forest degradation without complete conversion [12], [33].

➢ *Implications for NTFP Availability and Livelihoods*

The dramatic decline in forest cover directly threatens NTFP availability for households dependent on these resources. Species reported as declining, including *Acacia senegal*, *Commiphora myrrha*, and *Boswellia sacra*, are slow-growing trees requiring decades to reach maturity. Their loss has disproportionate impacts on poor and female-headed households who rely on NTFPs as safety nets during droughts and economic shocks [2], [3].

The finding that 65% of households use NTFPs for subsistence and 30% for cash income aligns with studies elsewhere in Africa. However, the contribution in Jubaland may be underestimated due to the informal nature of NTFP trade and the absence of official statistics.

The dominance of women in local NTFP trade (99% of retailers) but their exclusion from higher-value nodes reflects patterns documented across sub-Saharan Africa [34], [35]. Gender constraints, including limited access to capital, lower education levels, and cultural restrictions on mobility, prevent women from capturing greater value from NTFP commercialization.

➢ *Governance Challenges and Capacity Gaps*

The governance of NTFP resources in Jubaland operates at multiple levels: customary (*xeer*), state, and informal (militia taxation, clan politics). The weak capacity of state institutions, exemplified by only two trained natural resources staff in the Ministry of Environment, severely constrains policy implementation and enforcement. This finding mirrors the Somali Country Environmental Analysis [5], which identified institutional capacity as the primary constraint to environmental management.

The political economy of NTFP value chains, particularly charcoal and frankincense, is characterized by rent-seeking by intermediaries and militia groups. Similar patterns have been documented in conflict-affected regions elsewhere in Africa [8], [7]. The capture of value by informal actors reduces incentives for sustainable harvesting and reinvestment in resource management.

➢ *Methodological Reflections and Limitations*

This study's integration of geospatial and socioeconomic methods provides a comprehensive assessment of vegetation change and livelihood impacts. The classification accuracy (89.85-91.48%) and Kappa coefficients (0.85-0.87) exceed recommended thresholds [29], [28], indicating reliable land cover mapping. However, several limitations should be acknowledged. First, the 12-year study period (2010-2022) may not capture longer-term vegetation dynamics. Second, the Maximum Likelihood Classifier assumes normally distributed spectral data, which may not hold for heterogeneous dryland vegetation [36]. Third, security constraints prevented field validation of all land cover classes. Fourth, the lack of historical NTFP trade data precluded quantitative assessment of production trends.

V. CONCLUSION

This study has demonstrated that Jubaland State is experiencing rapid and accelerating deforestation, with forest cover declining by 704,810 hectares (29.53% of original forest area) between 2010 and 2022 at an annual rate of -3.49%, substantially higher than national and continental averages. This forest loss has been accompanied by expansion of scrub/shrub vegetation, cultivated areas, and built-up areas, indicating both conversion of forest to alternative land uses and progressive degradation of forest structure.

The consequences for NTFP-dependent livelihoods are severe. Fourteen NTFP species were documented in Jubaland, with 65% of households relying on these products for subsistence and 30% deriving cash income from their sale. Women dominate local NTFP trade but are largely excluded from higher-value nodes of value chains. Key commercial species including frankincense, myrrh, and gum arabic are reported as declining in availability, threatening both household resilience and national export revenues. Without urgent intervention, continued deforestation will further erode livelihood security, particularly for poor and female-headed households.

RECOMMENDATIONS

To address the challenges identified in this study, the following priority actions are recommended. First, federal and state governments should develop and implement a national forest policy with specific provisions for NTFP

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26may1915

management and agroforestry, while strengthening customary governance systems (*xeer*) through legal recognition and community dialogue. Second, sustainable management practices should be scaled up, including farmer-managed natural regeneration, enclosure systems, and agroforestry demonstration plots that integrate priority NTFP species into farming systems. Third, targeted interventions should support women-led NTFP enterprises through micro-credit programs, training in value addition and market access, and the formation of producer cooperatives. Fourth, institutional capacity must be rebuilt through training of ministry staff in GIS, environmental valuation, and policy analysis, and through the establishment of a dryland forest research center. Fifth, research priorities should include long-term monitoring of NTFP populations, carbon stock quantification for carbon finance, and participatory action research on governance innovations.

ACKNOWLEDGMENT

This study was conducted with financial support from the UK Foreign Commonwealth Development Office (FCDO) as part of the 'Sustainable Dryland Resources Management for Enhanced Livelihoods, Food Security and Climate Change Adaptation in Somalia' project. The research was implemented in collaboration with the Somali Institute for Environmental Peace (SIEP), and the Directorate of Environment and Climate Change (DoECC). We thank the Ministry of Environment of Jubaland, Kismayo Port Authority, and all community members who participated in surveys and discussions.

REFERENCES

[1]. B. A. Hassan, E. K. Glover, O. Luukkanen, M. Kanninen, and R. Jamnadass, "Boswellia and Commiphora species as a resource base for rural livelihood security in the Horn of Africa: A systematic review," *Forests*, vol. 10, no. 7, p. 551, 2019.

[2]. P. Vedeld, A. Angelsen, J. Bojo, E. Sjaastad, and G. Kobugabe Berg, "Forest environmental incomes and the rural poor," *Forest Policy and Economics*, vol. 9, no. 7, pp. 869-879, 2007.

[3]. F. Paumgarten, "The significance of the safety-net role of NTFPs in rural livelihoods, South Africa," M.S. thesis, Environmental Sciences, Grahamstown, South Africa, 2007.

[4]. CEA (Country Environmental Analysis), *Somalia Country Environmental Analysis: Diagnostic study on trends and threats for environmental and natural resources challenges*. World Bank, 2020.

[5]. World Bank, *Somalia Country Environmental Analysis: Diagnostic study on trends and threats for environmental and natural resources challenges*, 2020.

[6]. [6] World Bank, "Somalia needs its trees to restore landscapes and livelihoods," *Africa Can End Poverty Blog*, July 27, 2022.

[7]. C. Webersik, S. J. Hansen, and A. Egal, *Somalia: A political economy analysis*. Norwegian Institute of International Affairs, 2018.

[8]. N. Kishor, S. Castillo, and N. P. Nguyen, *The political economy of decision-making in forestry: Using evidence and analysis for reform*. Program on Forests (PROFOR), Washington DC, 2015.

[9]. M. R. Fokeng, W. G. Forje, M. V. Meli, and B. N. Bodzemo, "Multi-temporal forest cover change detection in the Metchie-Ngoum Protection Forest Reserve, West Region of Cameroon," *Egyptian Journal of Remote Sensing and Space Science*, vol. 23, pp. 113-124, 2020.

[10]. F. L. Feudjio, I. F. Tiomo, B. Y. Kamga, et al., "Predicting land use/land cover changes in the Santchou wildlife reserve (West-Cameroon) using a CA-Markov model," *Trees, Forests and People*, vol. 14, p. 100438, 2023.

[11]. L. F. Temgoua, A. L. Meyabeme Elono, Y. Mfonkwet Njiaghat, A. Ngouh, and C. Nzuta Kengne, "Land use and land cover dynamics in the Melap Forest Reserve, West Cameroon: Implications for sustainable management," *Geology, Ecology, and Landscapes*, vol. 6, pp. 305-315, 2021.

[12]. [12] C. Ernst, P. Mayaux, A. Verheggen, et al., "National forest cover change in Congo Basin: Deforestation, reforestation, degradation and regeneration for the years 1990, 2000 and 2005," *Global Change Biology*, vol. 19, pp. 1173-1187, 2013.

[13]. S. M. C. Momo, L. F. Temgoua, E. Fedoung, and D. R. Zangmene, "Vegetation and functional spectrum of the Koupa Matapit gallery forest (West-Cameroon)," *International Journal of Tropical Ecology and Geography*, vol. 42, pp. 147-158, 2018.

[14]. M. D. Liliane, N. J. Romain, M. S. M. Caroline, T. Abigaele, and T. T. A. Loic, "Quantifying forest loss in the Mbalmayo Forest Reserve (Center Region, Cameroon)," *Journal of Geoscience and Environment Protection*, vol. 10, pp. 271-288, 2022.

[15]. F. M. D. Douandji, B. Y. Kamga, L. N. Ndumbe, A. D. T. Nkondjoua, M. L. Ngho, and V. F. Nguetsop, "Land use/land cover dynamics and future changes using a CA-Markov model in the Mount Nonako forest and peripheries (Littoral, Cameroon)," *Journal of Geoscience and Environment Protection*, vol. 13, 2025.

[16]. V. J. Ingram, *Win-wins in forest product value chains?: How governance impacts the sustainability of livelihoods based on non-timber forest products from Cameroon*. Dissertation, Faculty of Social and Behavioural Sciences, University of Amsterdam, Amsterdam.

[17]. R. P. Neumann and E. Hirsch, *Commercialisation of non-timber forest products: Review and analysis of research*. Bogor: CIFOR, 2000.

[18]. M. R. Pérez, O. Ndoye, A. Eyebe, and D. L. Ngono, "A gender analysis of forest product markets in Cameroon," *Africa Today*, vol. 49, no. 3, pp. 96-126, 2002.

[19]. F. Paumgarten and C. Shackleton, "The role of non-timber forest products in household coping strategies in South Africa: the influence of household wealth and gender," *Population & Environment*, vol. 33, no. 1, pp. 108-131, 2011.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26may1915

[20]. H. Purnomo, R. Achdiawan, M. Melati, R. H. Irawati, Sulthon, B. Shantiko, and A. Wardell, "Value-chain dynamics: strengthening the institution of small-scale furniture producers to improve their value addition," *Forests, Trees and Livelihoods*, vol. 23, no. 1-2, pp. 87-101, 2014.

[21]. T. Sunderland, R. Achdiawan, A. Angelsen, R. Babigumira, A. Ickowitz, F. Paumgarten, V. Reyes-Garcia, and G. Shively, "Challenging Perceptions about Men, Women, and Forest Product Use: A Global Comparative Study," *World Development*, 2014.

[22]. L. N. Ndumbe, "Unshackling women traders: Cross-border trade of Eru from Cameroon to Nigeria," *Africa Trade Policy Notes*, 2013.

[23]. L. N. Ndumbe, V. Ingram, and M. Tchamba, "Gender and Livelihood Sustainability of njansang (*Ricinodendron heudelotii*) Value Chain from the South West Region of Cameroon," *Journal of Tertiary and Industrial Sciences*, vol. 1, no. 1, 2020.

[24]. R. G. Wieland and M. J. A. Werger, "Land types and vegetation in the Luuq district of south-western Somalia," *Journal of Tropical Ecology*, vol. 1, no. 1, pp. 65-87, 1985. doi:10.1017/S0266467400000092

[25]. F. Al-Ahmadi and A. Hames, "Comparison of four classification methods to extract land use and land cover from raw satellite images for some remote arid areas, Kingdom of Saudi Arabia," *Journal of King Abdulaziz University-Earth Sciences*, vol. 20, pp. 167-191, 2009.

[26]. M. S. Mondal, N. Sharma, P. K. Garg, and M. Kappas, "Statistical independence test and validation of CA Markov land use land cover (LULC) prediction results," *Egyptian Journal of Remote Sensing and Space Science*, vol. 19, pp. 259-272, 2016.

[27]. A. Di Gregorio and L. J. M. Jansen, *Land Cover Classification System (LCCS): Classification concepts and user manual*. Rome: FAO, 2000.

[28]. J. Gao and D. Skillcorn, "Capability of SPOT XS data in producing the land cover maps of a semi-arid environment," *Geocarto International*, vol. 13, pp. 55-61, 1998.

[29]. J. R. Anderson, E. E. Hardy, J. T. Roach, and R. E. Witmer, *A land use and land cover classification system for use with remote sensor data*. US Geological Survey Professional Paper 964, 1971.

[30]. P. Bernier, *Introduction à la télédétection*. Presses de l'Université du Québec, 1992.

[31]. R. Chambers, "The origins and practice of participatory rural appraisal," *World Development*, vol. 22, no. 7, pp. 953-969, 1994.

[32]. V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 77-101, 2006.

[33]. C. Megevand, *Deforestation trends in the Congo Basin: Reconciling economic growth and forest protection*. World Bank Publications, 2013.

[34]. A. Awono, V. Ingram, J. Schure, and P. Levang, *Guide for small and medium enterprises in the sustainable non-timber forest product trade in Central Africa*. CIFOR, 2013.

[35]. V. J. Ingram, *Win-wins in forest product value chains? How governance impacts the sustainability of livelihoods based on non-timber forest products from Cameroon*. Dissertation, Faculty of Social and Behavioural Sciences, University of Amsterdam, Amsterdam.

[36]. A. Y. M. Abdullah, A. Masrur, M. S. G. Adnan, et al., "Spatio-temporal patterns of land use/land cover change in the heterogeneous coastal region of Bangladesh between 1990 and 2017," *Remote Sensing*, vol. 11, p. 790, 2019.