Faculty of Forestry and Wood Sciences

Analysis of the Effects of Climate Change on Forest Ecosystem Services: Effects on Socio-Economic Benefits in the North-Central Region of Namibia

Dissertation Thesis Defense

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SUPERVISOR: doc. Ing. Miroslav Hájek, Ph.D.

Czech University of Life Sciences, Prague

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1. Background
2. Methods
3. Results
4. Discussion
5. Conclusions & Recommendations

1. Background

- Millions of local rural communities depend on forest resources for their livelihoods (Ryan et al., 2016; Vrabcová et al., 2019).
- Local communities benefit from forests in various forms (timber and non-timber forest products {NTFPs}) (De Cauwer et al., 2016).
- Local rural communities in southern Africa mostly use forest resources for marketing (commercial) and subsistence uses, i.e. firewood, construction materials, medicine, and food (Langat et al., 2016).
- Although forest ecosystems play an important role in sustaining human communities' livelihoods, the effects of climate change on forest ecosystems and their services around the world are unequivocal (Baciu et al., 2021).

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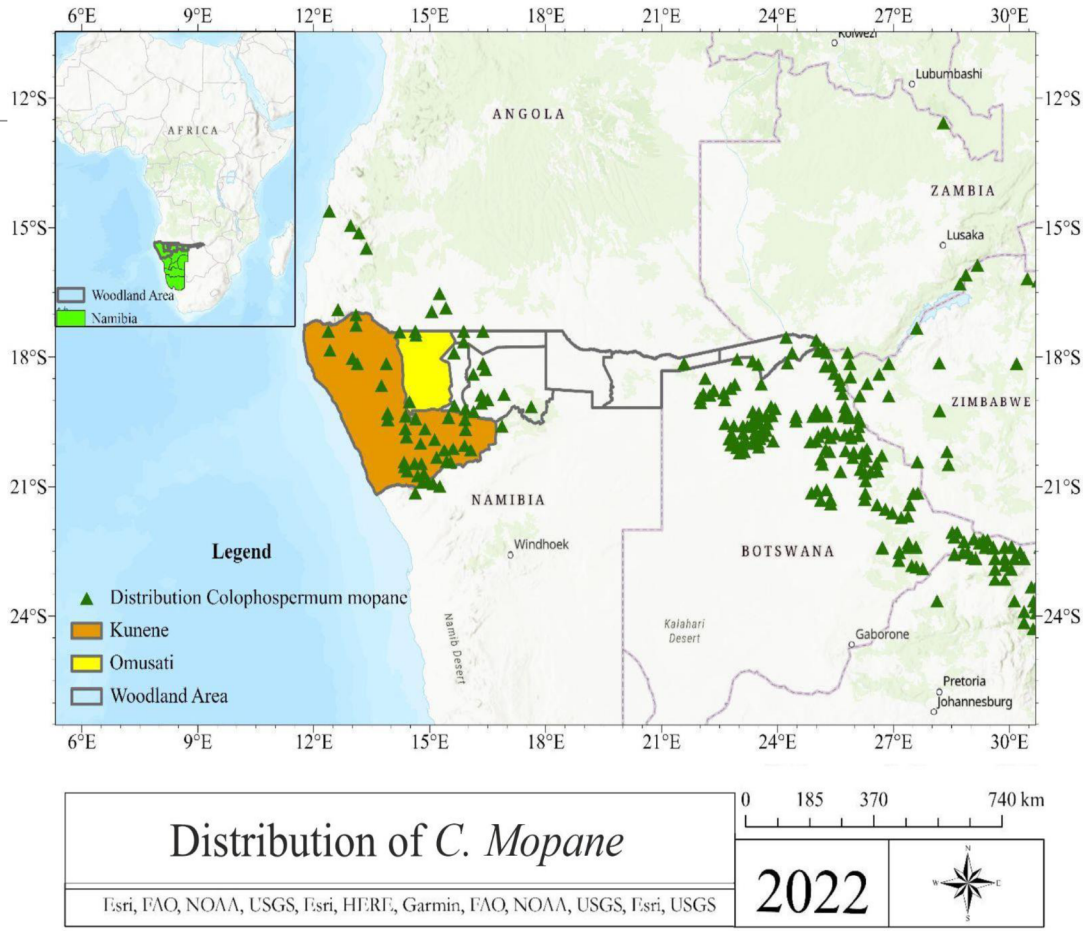
1. Background continues…

- *C. mopane* (Krug, 2017; Potgieter, 2020) is characterized by good wood quality, the ability to endure harsh climatic conditions, and the pressure from rural communities.
- Existing literature about *C. mopane* focuses on other aspects such as its uses, distribution, and adaptation (Mapaure, 1994; Holly, 2012; Makhado, 2014).
- Policy instruments for climate change are directed by the Paris Agreement (United Nations, 2015).
- All policy instruments (Namibia), including cross-sectoral climate change policies are governed by the constitution (Ruppel and Ruppel-Schlichting, 2022).



1. Background continues

Research objectives

Main objective: to investigate the socio-economic benefits of *C. mopane* in a changing climate in rural communities and the implementation of policy instruments for climate change adaptation actions in northern Namibia.

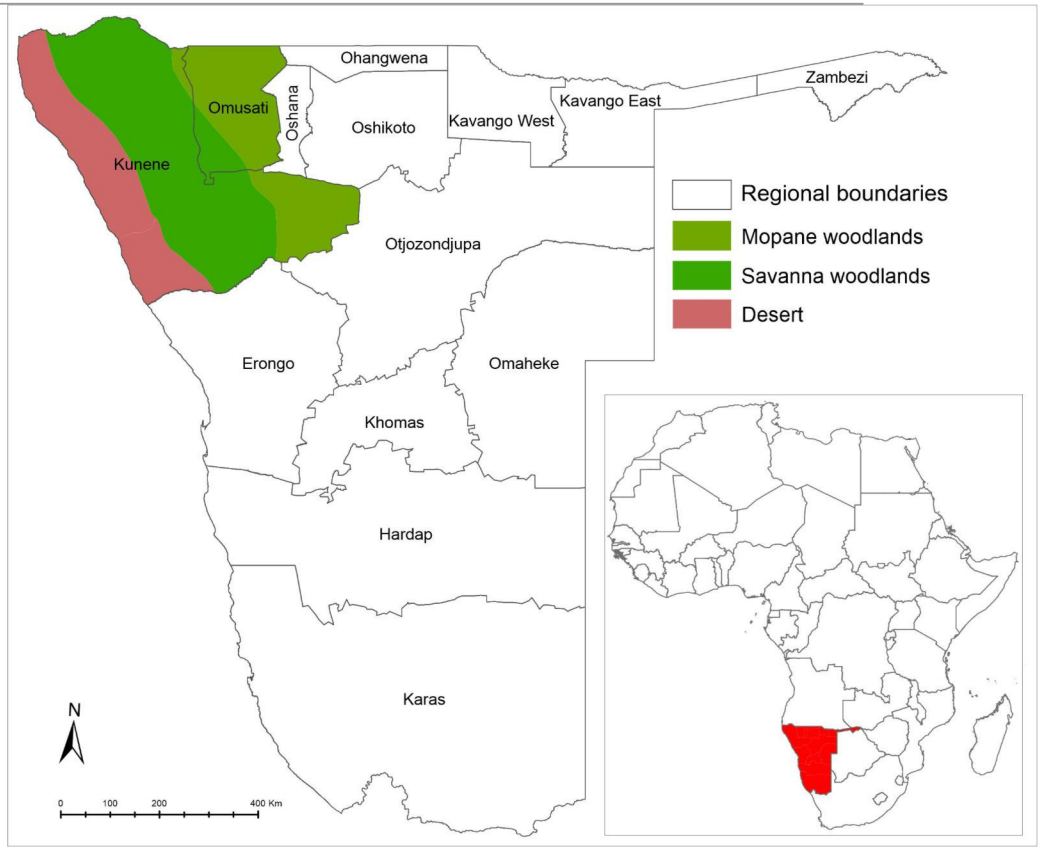
Specific objectives

- To analyse the socio-economic benefits of *C. mopane* in a changing climate by focusing on the products harvested for use at the local community level in northern Namibia;
- To assess trends in temperature and precipitation in *C. mopane* woodlands in northern Namibia;
- To investigate the implementation of policy instruments for climate change adaptation actions in mopane woodlands in northern Namibia.

2. Research methods

Study area

- The study focused on two regions in northern Namibia - Omusati and Kunene regions.
- These two regions together cover 17% of the total area and constitute 13% of the population of Namibia.
- The regions form part of the Baikiaea-mopane woodlands of southern Africa (Olson et al., 2001) and represent areas with the highest distribution of *C. mopane* in Namibia.
- The Omusati region has the highest species distribution among the two regions (Vrabcová et al., 2019).
- The northern part of Namibia is predominantly rural and is one of the hotspots for climate change-related impacts (Kapuka & Hlásny, 2020; Spear & Chappel, 2018).



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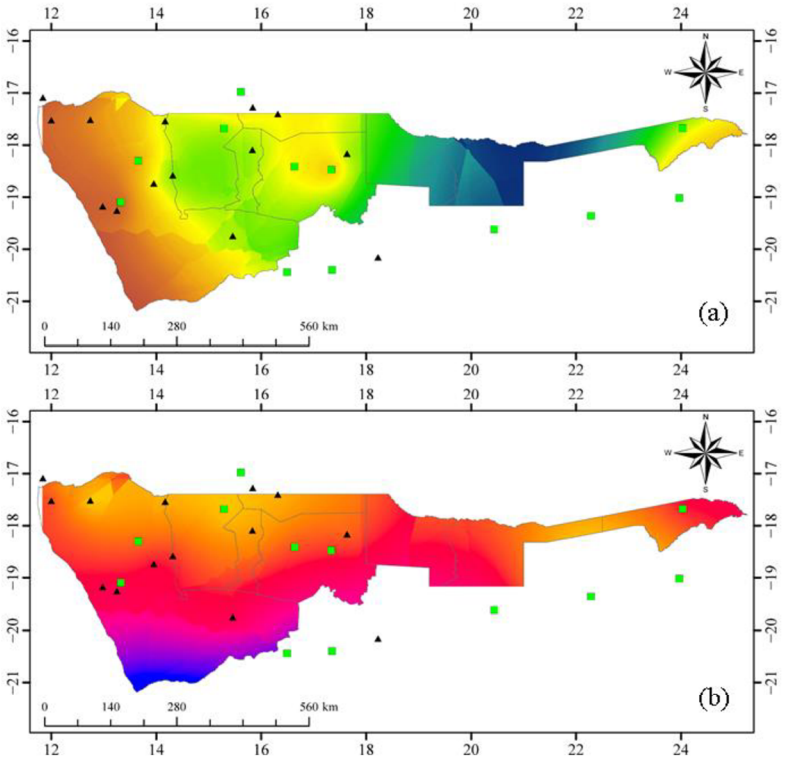
2. Research methods

Approaches, data collection, and analysis

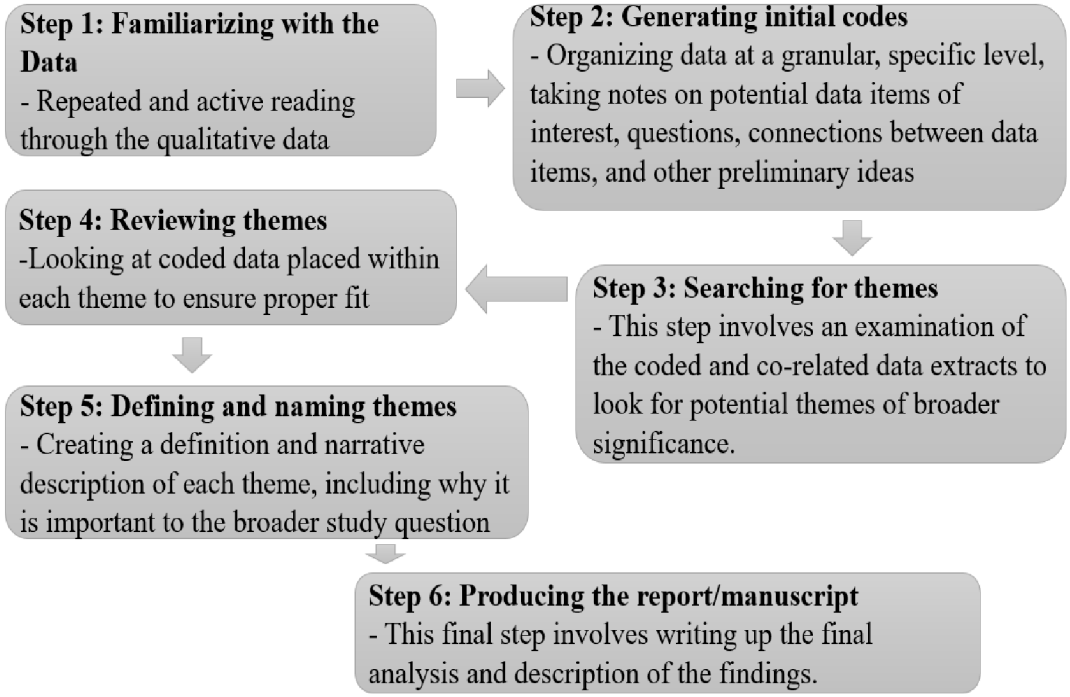
- **Hybrid approach:** quantitative and qualitative
- **Population**: local communities, forestry officials, climate change experts
- **Sample:** Random (local communities), purposive (forestry officials and climate change experts)
- **Sample size:** Harvesting permits from 239 villages across the study area (Omusati and Kunene regions); 128 local communities, forestry, climate change, and other relevant environmental experts (manuscript 1), and 36 experts (manuscript 2)
- **Instruments:** Semi-structured questionnaires (manuscripts 1 & 2)
- **Secondary data:** SASSCAL weather stations, MEFT, Windhoek Meteorological Weather Services, Directorate of Forestry (DoF) (manuscript 3)
- **Data types:**
  - ✓ Survey data
  - ✓ Precipitation
  - ✓ Temperature
  - ✓ Harvesting permits
- **Time frame:** 11 years (2011-2021)



2. Research methods

Approaches, data collection & analysis

- **Statistical analysis (Quantitative):** Statistical Package for the Social Sciences (IBM SPSS version 26, IBM Corp., Armonk, NY, USA) with a p-value less than 0.05 ($p < 0.05$)
- **Qualitative analysis**: ATLAS.ti version 22.2 and Thematic Content Analysis (TCA)
  - ✓ Experts' perceptions
  - ✓ Local communities' perceptions



The procedure flow for qualitative data analysis

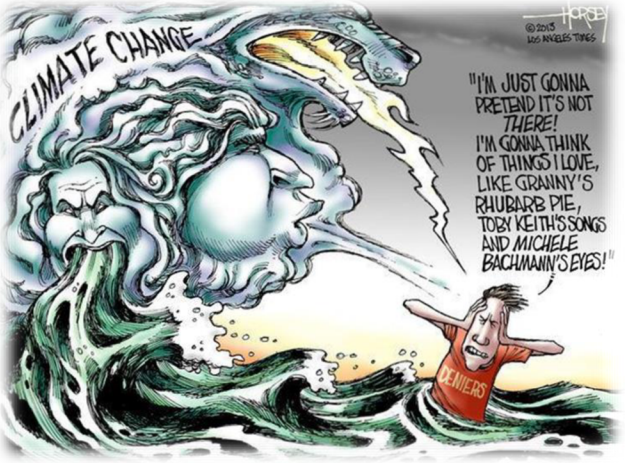
2. Research methods

Limitations

- Lack of data and lack of literature
- Poor understanding of forest ecosystems and climate change - ignorance
- Poor interest in research
- Unique climatic and vegetation conditions of Namibia

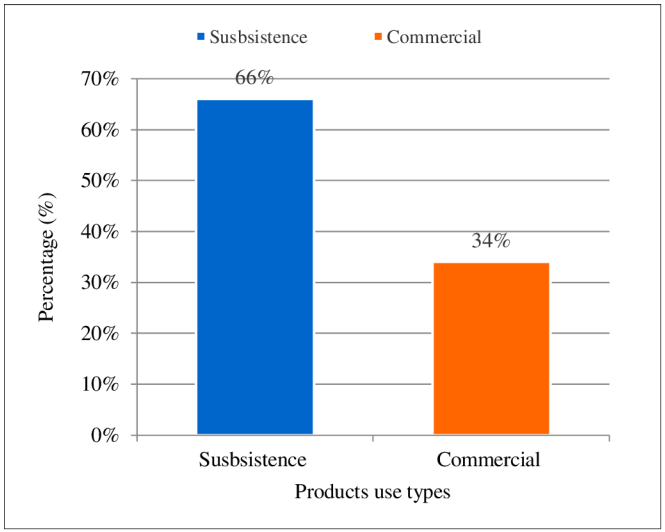
Ethical considerations

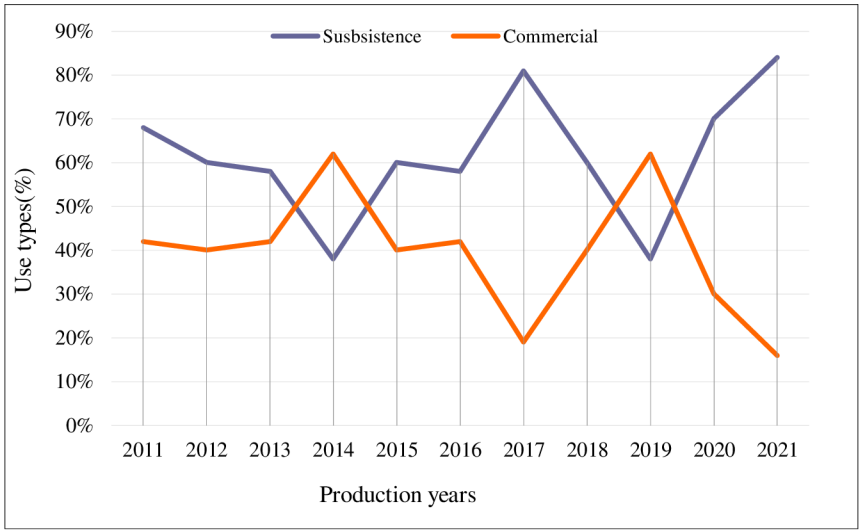
- Ethical conduct of the National Commission on Research Science and Technology (NCRST)
- Ethical clearance by MEFT and approved by DoF
- Anonymity of the respondents
- Rights to refuse or withdraw from the research were respected
- No data leakage – data will be kept in a safe place



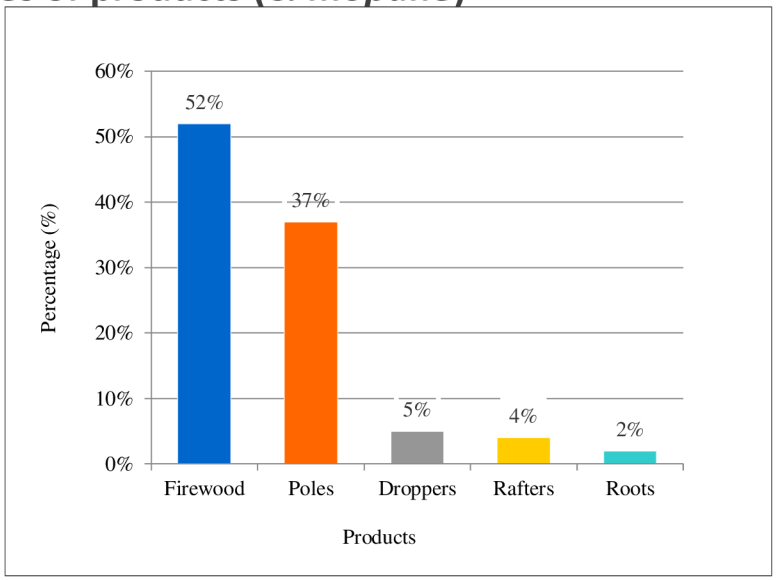
3. Results synthesis

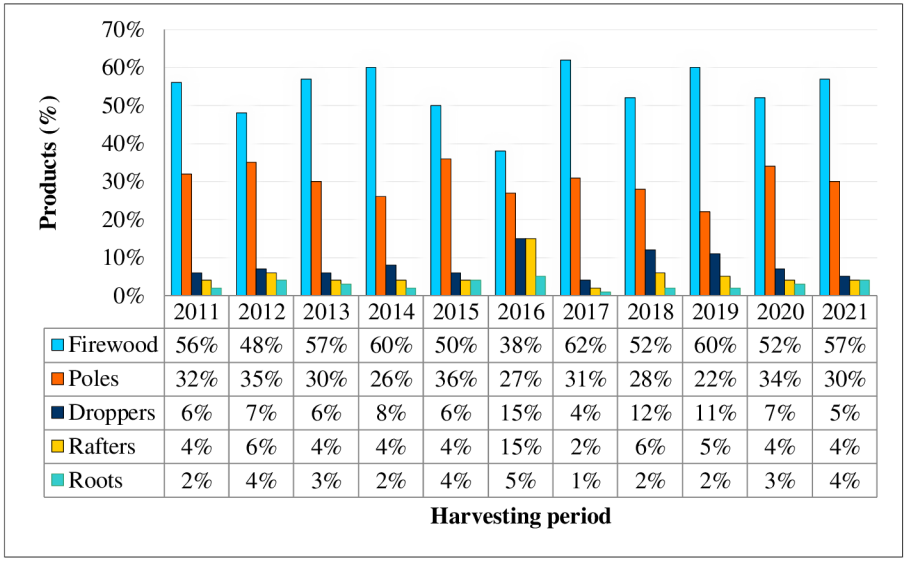
3.1 Forest products (*C. mopane*)





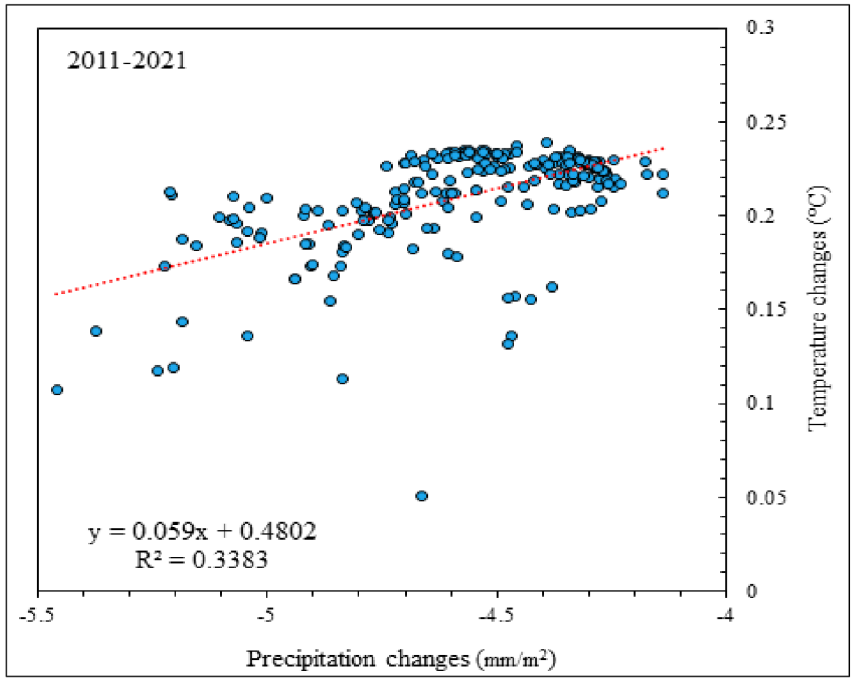
3.2 Types of products (*C. mopane*)





	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Firewood	56%	48%	57%	60%	50%	38%	62%	52%	60%	52%	57%
Poles	32%	35%	30%	26%	36%	27%	31%	28%	22%	34%	30%
Droppers	6%	7%	6%	8%	6%	15%	4%	12%	11%	7%	5%
Rafters	4%	6%	4%	4%	4%	15%	2%	6%	5%	4%	4%
Roots	2%	4%	3%	2%	4%	5%	1%	2%	2%	3%	4%

3.3 Total precipitation and temperature changes



3.4 Various policy instruments

Policy instruments	Extremely ineffective	Very ineffective	Ineffective	Not sure	Effective	Very effective	Extremely effective	Total
Namibia's Climate Change Strategy and Action Plan	4 (3%)	5 (4%)	23 (18%)	51 (40%)	37 (29%)	5 (4%)	3 (2%)	**128 (100)**
National Policy on Climate Change for Namibia	4 (3%)	4 (3%)	20 (16%)	49 (38%)	41 (32%)	9 (7%)	1 (1%)	**128 (100)**
National Environmental Education and Education for Sustainable Development Policy	4 (3.1%)	3 (2%)	24 (19%)	39 (31%)	43 (34%)	10 (8%)	5 (4%)	**128 (100)**
The Nature Conservation Ordinance No. 4 of 1975	4 (3%)	5 (4%)	14 (11%)	41 (32%)	44 (34%)	16 (13%)	4 (3%)	**128 (100)**
The Communal Land Reform Act	3 (2%)	2 (2%)	17 (13%)	36 (28%)	54 (42%)	14 (11%)	2 (2%)	**128 (100)**
Namibia National Forest Policy	3 (2.3%)	2 (2%)	14 (11%)	53 (41%)	35 (27%)	18 (14%)	3 (2%)	**128 (100)**
Forestry Strategic Plan	4 (3%)	4 (3%)	14 (11%)	58 (45%)	36 (28%)	10 (8%)	2 (2%)	**128 (100)**
The Forest Act	4 (3%)	2 (2%)	11 (9%)	45 (35%)	51 (40%)	13 (10%)	2 (2%)	**128 (100)**

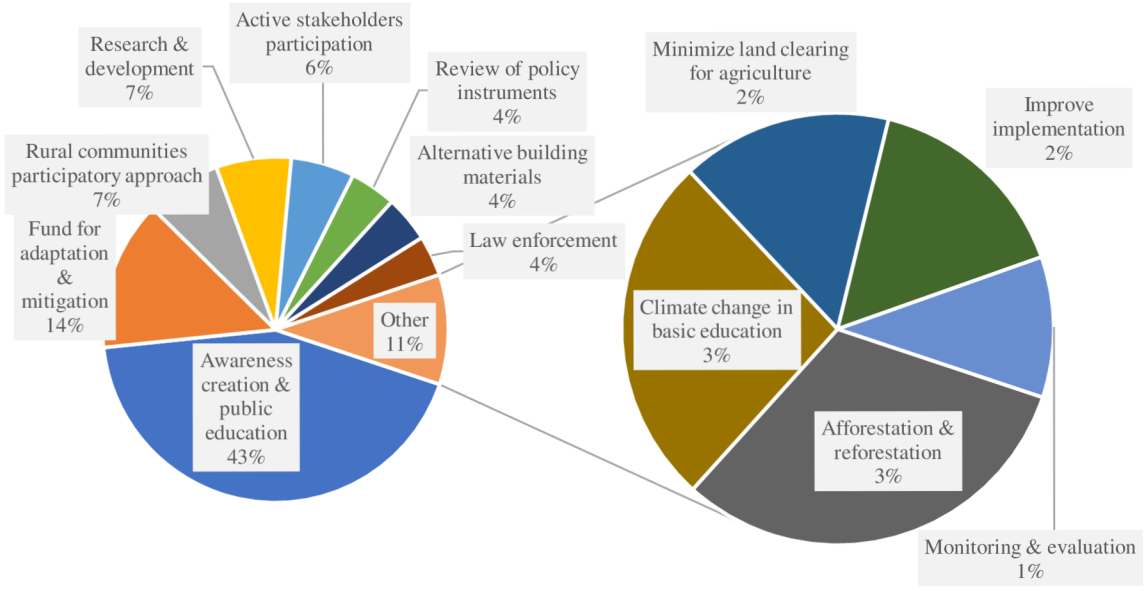
3.6 NPCC per Forest Ecosystem Service

Forest ecosystem services	Before NPCC (N=36)	After NPCC (N=36)	p-value[2]
Biodiversity	3.11±0.92	4.36±1.52	<0.001
Carbon sequestration	2.75±1.34	3.06±1.35	0.338
Soil conservation	3.08±1.32	3.39±1.29	0.324
Socio-economic benefits	3.25±1.20	3.44±1.34	0.519
Recreational and cultural values	3.72±1.09	3.39±1.34	0.249
Watershed services	3.31±0.89	3.17±1.23	0.585
High conservation values	3.56±1.40	3.14±1.25	0.187

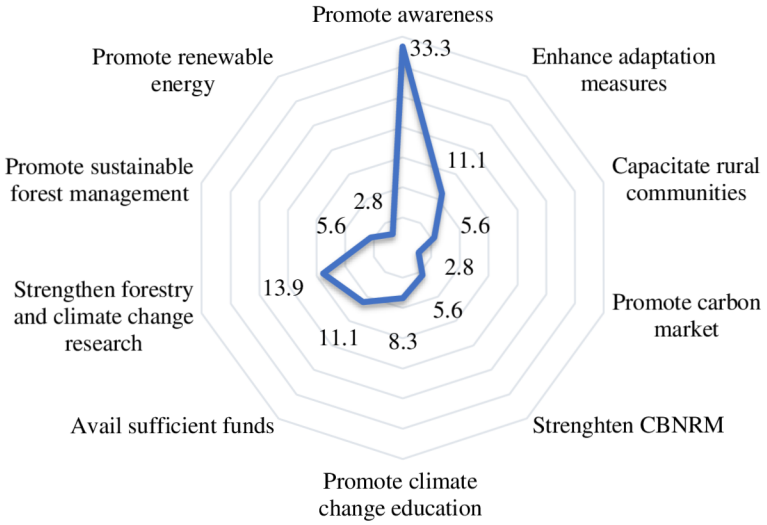
[1]Data are presented as mean ± standard deviation (sd); Independent t-Test was applied to compare mean scores before and after NPCC implementation.
[2]Significantly different at $p<0.05$

3.9 Proposed improvements for policy instruments

Collective instruments



NPCC



4. Discussion

- Local rural communities have a tendency of resorting to forest products as a survival mechanism due to the effects of climate change. - subsistence and commercial uses.
- Forest products, i.e., firewood, roots, droppers, poles, wild berries, and mopane worms, are a significant component of the rural communities' livelihoods, i.e., coping with climate variability and extreme weather events that affect agricultural productivity in some ways (Paumgarten and Shackleton, 2011).
- The results further identified that local rural communities use forest products mainly in the form of NTFPs (fuelwood, poles, rafters, droppers, and roots).
- The high demand for firewood is attributed to the area being primarily rural, where most residents depend on firewood for lighting and heating (Munyayi, 2015; Vrabcová et al., 2019).
- Effective law enforcement is one strategy to harmonize adaptation and sustainably manage forest ecosystems to avoid illegal operations, such as unlawful harvesting.
- The results showed that the most effective policy instruments were the Communal Land Reform Act, the Forest Act, Namibia National Forest Policy, and Forestry Strategic Plan.
- Biodiversity showed the most significant adaptation actions after the introduction of NPCC (4.36 ± 1.52) than before NPCC (3.11 ± 0.92) ($p < 0.001$). In addition, carbon sequestration was also more significant after NPCC (3.06 ± 1.35) than before NPCC (2.75 ± 1.34).

5.2 Recommendations

Practical Applications of the Findings

- It is critically vital to monitor the utilization of forest resources sustainably due to their importance for both livelihoods and ecological purposes.
- There must be an emphasis on altering rural communities' reliance on forest resources for their livelihood by improving their awareness of the impacts of climate change - awareness creation.
- It is also essential to incorporate climate change topics in primary education to equip future generations with the necessary knowledge of climate change adaptation actions.

Future research

- Predictive analysis for extreme weather events, including forest fires, droughts, floods, and other climate-related hazards that affect goods and services provided by forest ecosystems in the northern regions and the entire country.
- SWOT analysis of the policy instruments' framework for forest ecosystem services-based adaptation actions in the policy to improve adaptation actions.

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THANK YOU!

Record of the department's defense of the dissertation

Dissertation topic:	Analysis of the Effects of Climate Change on Forest Ecosystem Services: Effects on Socio-Economic Benefits in the North-Central Region of Namibia
Doctoral student:	Ing. Andreas Nikodemus
Přítomní:	doc. Ing. Miroslav Hájek, Ph.D., doc. Ing. Martin Jankovský, PhD., Ing. Radim Löwe, Ph.D.

1. The doctoral student presented his dissertation in a 15-minute presentation.

2. The discussion was conducted on both a professional and formal side. The structure of the dissertation thesis meets the requirements of a scientific work.

3. Comments and recommendations were made for editing the final version of the dissertation.

The meeting participants agree to submit the dissertation for a proper defense.

In Prague on February 21, 2023

doc. Ing. Miroslav Hájek, Ph.D. (head of the department and supervisor of the doctoral student)

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doc. Ing. Martin Jankovský, PhD. .....

Ing. Radim Löwe, Ph.D. .....

PROFESSIONAL CURRICULUM VITAE

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Marital status	: Single
Gender	: Male
Criminal Record	: None
Health	: Good

LANGUAGE PROFICIENCY

English	-	Good
Oshiwambo	-	Good (native speaker)

EDUCATIONAL BACKGROUND

PhD in Global Change and Forestry
Czech University of Life Sciences, Prague
2020 – Present

Bachelor of Business Management (Honours)
Namibia University of Science and Technology
2018

Master of Science in Forestry, Water and Landscapes Management
Czech University of Life Sciences, Prague
2012 – 2014

Higher Diploma in Natural Resource Management
University of Namibia, Ogongo Campus
2009 – 2011

SKILLS AND ABILITIES

- Networking
- Research
- Computer literate (Microsoft Office package: Microsoft Word, Excel, Access)
- Data entry, analysis, and Summary Reporting
- Professionalism & Punctuality
- Innovation

WORKING EXPERIENCE

Forester	Division of Forest Management, National Forest Inventories Section, Ministry of Environment, Forestry, and Tourism, Windhoek (February 2015 to date)
Founder & Consultant	Nico Research Institute (registered and fully operational Namibian CC company)
National Focal Point	Forest Genetic Resources for the Food and Agriculture Organization at the Ministry of Environment, Forestry and Tourism (February 2019-2022)
Relief Teacher	▪ Pendukeni Iivula Iithana High School (April – August 2012; January – February 2015) ▪ Shedile Junior Secondary School (September – December 2014)
Students Representative Council	Students Parliament Secretary General – the University of Namibia, Ogongo Campus (2011)
Chairperson	Christian Students Fellowship, University of Namibia, Ogongo Campus (2010–2011)
Student Exchange Programme	International North-South-South Exchange Programme (CIMO) at Mikkeli University of Applied Sciences, Finland (August – December 2010)
Research and Publications	**Article:** Nikodemus, A. and Hájek, M., 2015. Namibia's National Forest Policy on Rural Development – A Case Study of Uukolonkadhi Community Forest. *Agricultura Tropica et Subtropica*, 48(1–2), pp.11–17. https://doi.org/10.1515/ats-2015-0002. **Article:** Nikodemus, A. and Hájek, M., 2022. Implementing Local Climate Change Adaptation Actions: The Role of Various Policy Instruments in Mopane (Colophospermum mopane) Woodlands, Northern Namibia. *Forests*, 13(10), p.1682. https://doi.org/10.3390/f13101682. **Article:** Nikodemus, A., Hájek, M., Ndeinoma, A. and Purwestri, R.C., 2022. Forest Ecosystem Services-Based Adaptation Actions Supported by the National Policy on Climate Change for Namibia: Effectiveness, Indicators, and Challenges. *Forests*, 13(11), p.1965. https://doi.org/10.3390/f13111965. **Article:** Vrabcová, P., Nikodemus, A. and Hájek, M., 2019. Utilization of Forest Resources and Socio-Economic Development in Uukolonkadhi Community Forest of Namibia. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 67(1), pp.197–206. https://doi.org/10.11118/actaun201967010197. **Article:** Nikodemus, A., Abdollahnejad, A., Kapuka, A., Panagiotidis, D. and Hájek, M., 2023. Socio-economic benefits of *Colophospermum mopane* in a changing climate in northern Namibia. *Forests*, 14(2), p. 290. https://doi.org/10.3390/f14020290. **Article:** Nikodemus, A., Trubin, A., Bernal, D.C.H., Kapuka, A., Hájek, M., Ndeinoma, A., Purwestri, R.C., 2023. Unveiling the Impact of Climate

	Variability on Forest Fire Occurrence in Namibia: A Modelling Study, Fire (ISSN 2571-6255) – Under review
Peer review	**Manuscript title:** Forest-based Adaptive Capacities and Coping Strategies to Climate Change and Extreme Weather Events in Malawi submitted to Wellbeing, Space & Society (Elsevier, February 2023)
Experience in Consulting Services	Developed a pre-feasibility study report for the JICA/SADC project: Indigenous Forest landscape restoration and climate resilience project in southern Africa dry land ecosystem in the KAZA-TFCA (Angola, Botswana, Namibia, and Zambia)

REFERENCES

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