Using GIS modeling and experimental trials to assess the suitability of Selected conifers on Mambilla Plateau NE Nigeria

Salako Gabriel A
PhD/GY/11/0424

Presentation outline

- Title
- The Study Area
- Background and research questions
- Analysis of objectives
- Methodology and analytical Techniques
- Results an discussions
- Summary and conclusions
- Recommendations

Study Area

Latitude: 6° 20'15'' and7° 30' 15 ''N

Longitude: 10° 14' 10'' and 11° 30' 10''E

Average Alt: 1600m *(5000ft)*

Average annual Temperature:

18˚C *(68˚F)*

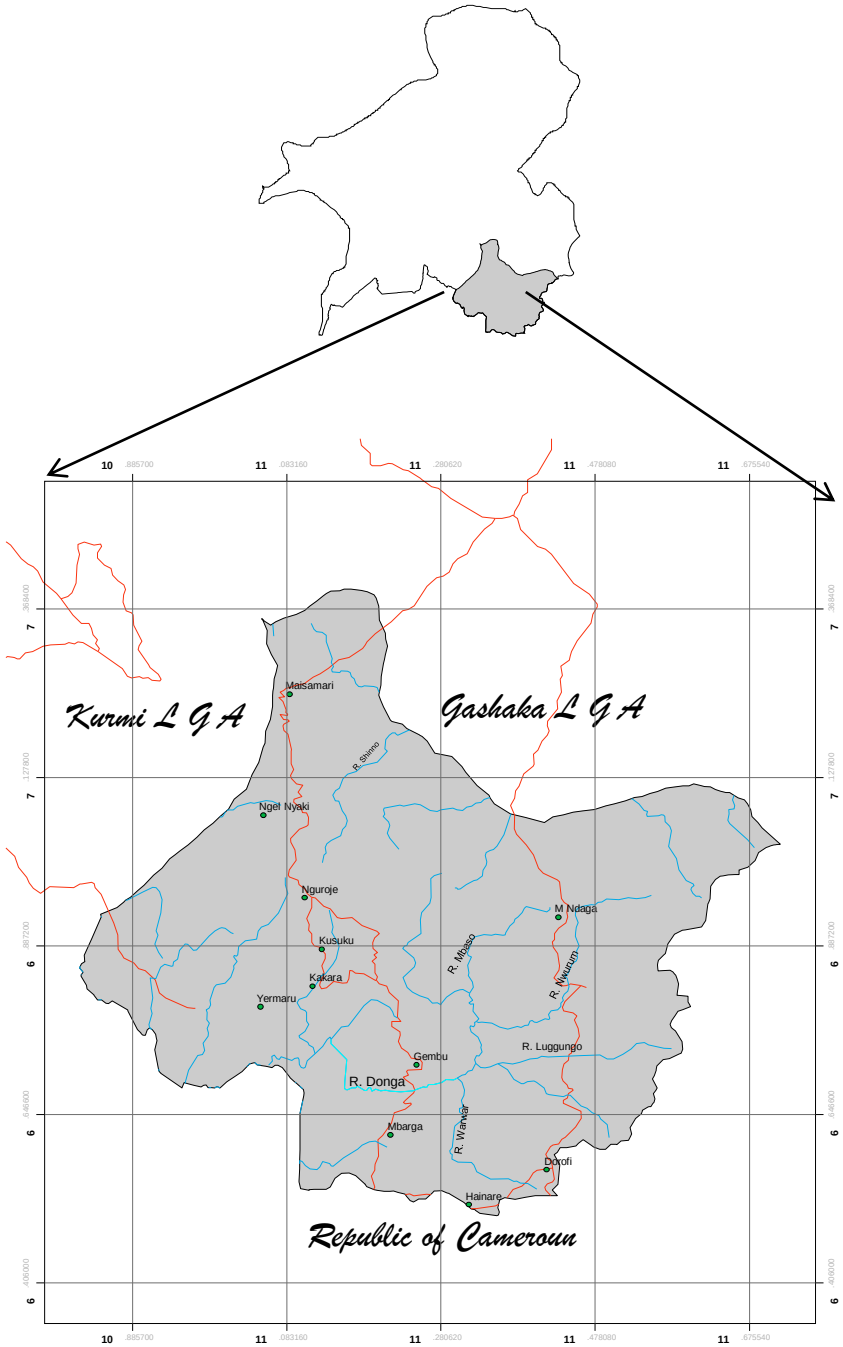
January and December:

9-10ºC (48.2-50ºcC

Mean annual Rainfall:

1700mm *(70 in)*

Vegetation: grasses, shrubs, planted forests (eucalyptus) and crops apples, pears)



Background to the study and Research Questions

- **The unique geographic environment of the Mambilla Plateau presents a great potential that can be harnessed for both socio economic development of the community and protection of the ecosystem**
- **It is imperative that a fairly comprehensive ecosystem classification of the plateau is done to aid effective natural resources management and general socio economic development.**
- **What are the biogeoclimatic characteristics features of the Mambilla plateau?**
- **Is the entire plateau suitable for planting conifers?**
- **Which conifer species are suitable for planting on the plateau and which areas?**
- **What are the socio economic and cultural perceptions of the people on developing conifers plantation on the plateau?**

S/No	Objective	Types of Data	Sources of Data	Analytical Techniques	Product
1	To develop a biogeoclimatic ecosystem classification (BEC) map of the Mambilla plateau	DEM, Climatic data, Vegetation survey	Satellite images (ETM+ 2013), WorldClim database, UBRBDA, 2013	GIS Analysis (overlay, NDVI) Classification PCA CA	BEC Map
2	Use the BEC to match conifers species to potentially suitable sites	Climatic and Bioclimatic data	WorldClim and FAOClim database	Climate Envelope Model (CEM)	Suitability map
3	Assess the early performance of the selected species in field trials	Plant growth parameter: height cover, stem diameter survival rate	Field experiment from September 2014 to March 2015	Bar chart, Total, %, Average, ANOVA, and Student t test	Graphical Display of species performance
4	Assess socio economic and cultural perception of the people on the impact of conifer Plantation on the communities on the plateau	Perception to planted forest	Interview	Total and Percent (%)	Perception analysis table

Mapping of physiographic regions

- **A 90M SRTM Digital Elevation Model was used to reclassify the Plateau into classes at an interval of 250m.**

- **Slope and contour classes were further processed from SRTM -Digital Elevation Model and were combined with the relief classes using map algebra in Arc GIS to produce 7 distinct physiographic (landform) regions**

- **namely: Irregular lowlands, ridge, hills escarpments, dissected escarpments /stream valley, mountains and high mountains**

Bioclimatic classification: PCA Analysis

Bioclimatic variables

- **To classify the Plateau into bioclimatic zones, Lon, Lat and Alt with the following bioclimatic data sets of 30 randomly selected points were obtained)**
- **(BIO1)= mean annual temperature,**
- **BIO2 = Mean Diurnal Range (max temp – min temp) (monthly average),**
- **BIO5 = Max Temperature of Warmest Period,**
- **BIO6 = Minimum Temperature of Coldest,**
- **BIO7= Temperature Annual Range**
- **BIO10 = Mean Temperature of Warmest Quarter,**
- **BIO11= Mean Temperature of Coldest Quarter,**
- **BIO12 = Annual Precipitation**
- **BIO13 = Precipitation of Wettest Period,**
- **Bio 14 = Precipitation of Driest period**

Bioclimatic classification

- **i. The application of principal component analysis (PCA) was used to reduce the no of Bioclimatic variables in the analysis and derive the 2 principal factors that account for the variation on the Plateau.**

- **ii. Factor loading was used to describe correlation between factors and the original variables acquired for analysis (iii. The hierarchical cluster analysis for classification and grouping.**

- **Kriging of principal factors (F1 and F2)**

Land cover/vegetation map

- **We ran an unsupervised classification on the processed images using Iso Cluster and Maximum Likelihood Classifier (MLC)**
- **To improve our visual and quantitative assessment of the study area land cover pattern, an NDVI** = $\frac{NIR-R}{NIR+R}$ **was also performed on the images.**

Species Suitability index

- **Climate envelope model of Bioclim and Maxent algorithms was used to determine the suitability of selected species across different biogeoclimatic ecosystem zones.**
- **occurrence data or geographic data (latitude and longitude) of the species, name, seed source or provenance and background data were obtained.**
- **Occurrence data were prepared on spread sheet and converted to shape file (shp) format to be imported into GIS environment.**
- **The output of the model display the ecological niche and suitability index of the species under study across the landscape**

Specie performances: Experimental design

- **An experimental site was established in each of the three sites: Kakara, Gembu and Upper Mayo Selbe**
- **seeds of the selected species were planted on a Randomized Complete Block design**
- **The experimental site was divided into 3 equal blocks of 20m x 6m where each block is a replicate; each block was further subdivided into 3 plots of 20m×2m.**
- **The two species which passed germination tests, *Pinus ponderosa, Pinus caribaea* and Cypress (as control) were planted in a potted polythene bags where each occupy a plot**

Pinus ponderosa
Pinus caribaea
Cypress

Pinus ponderosa
Pinus caribaea
Cypress

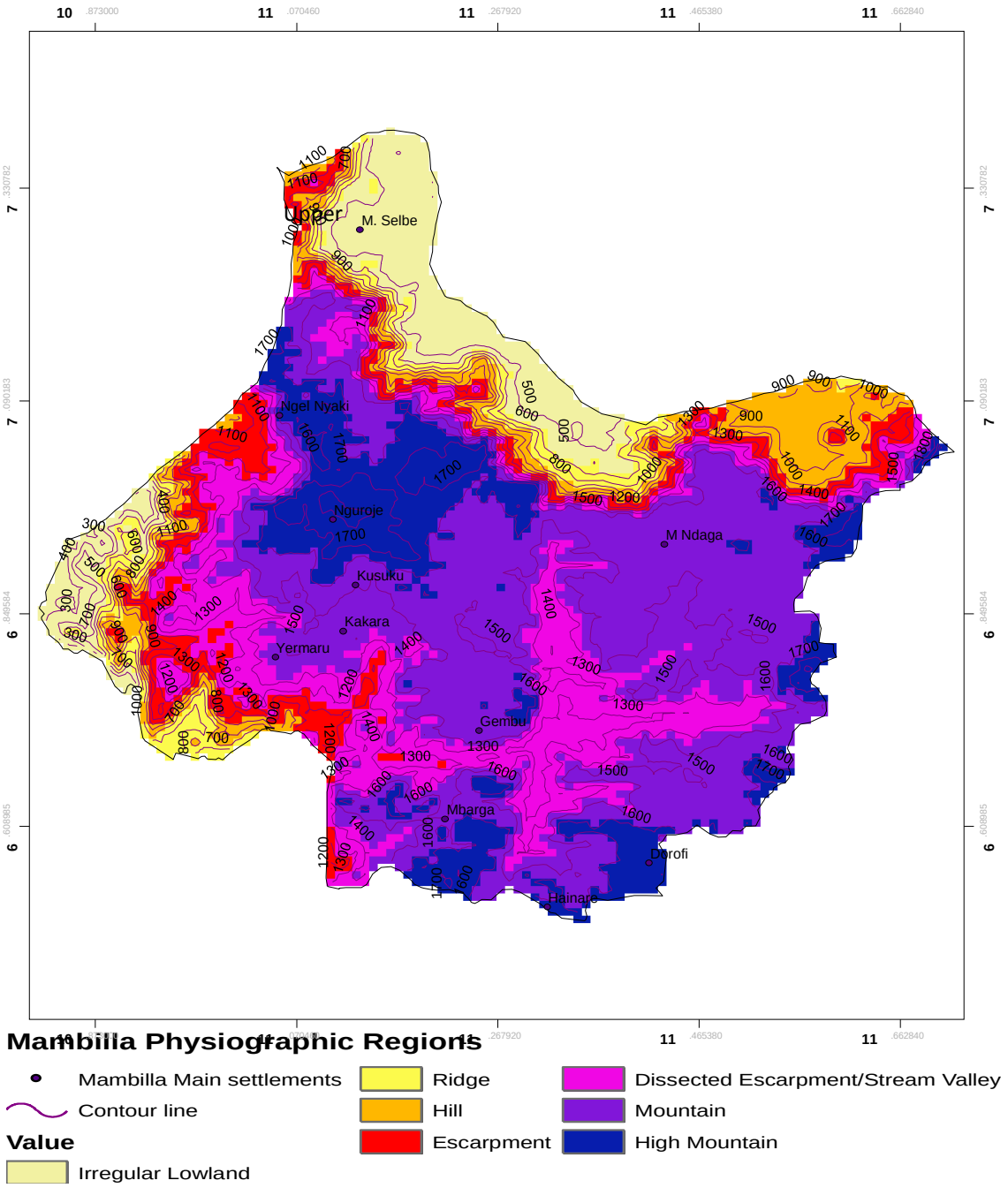
Pinus ponderosa
Pinus caribaea
Cypress

Results and Discussions

- **Physiographic regions of MP**
- **Bioclimatic zones of MP**
- **Land cover/vegetation map of MP**
- **Final biogeoclimatic zones of MP**
- **Specie suitability index on MP**
- **Species performances across biogeoclimatic zones**

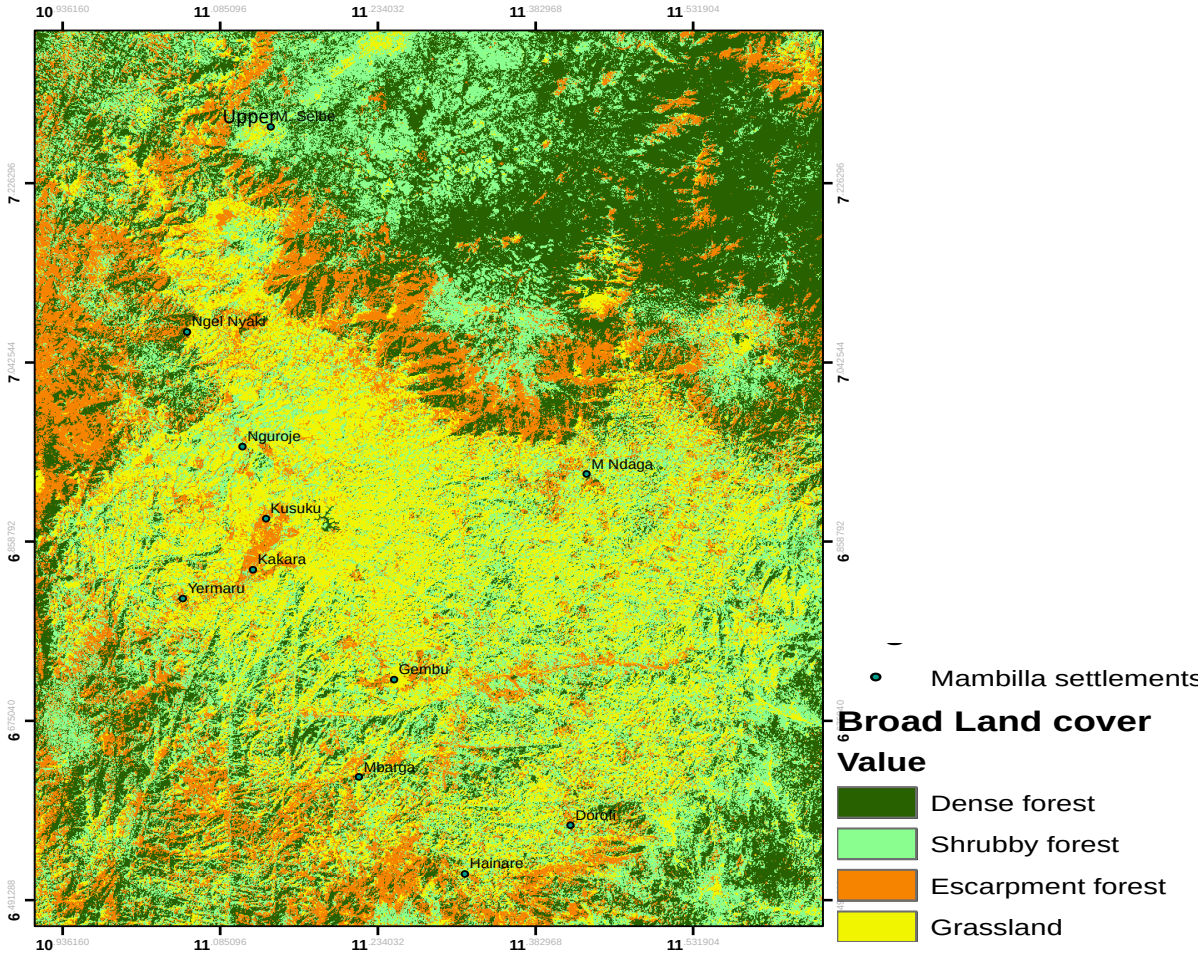
Physiographic regions of Mambilla plateau

- 7 distinct physiographic (landforms) regions were mapped
- namely: Irregular lowlands, ridge, hills, escarpments, dissected escarpments /stream valley, mountains and high mountains



Broad land cover map

- **The result of NDVI was combined with the unsupervised classification which produced 4 broad land cover: dense forest, shrubby forest escarpment forest, and grassland.**



Bioclimatic classification: PCA

F1: Temperature factor and F2: Locational factor (F Values ≥0.5)

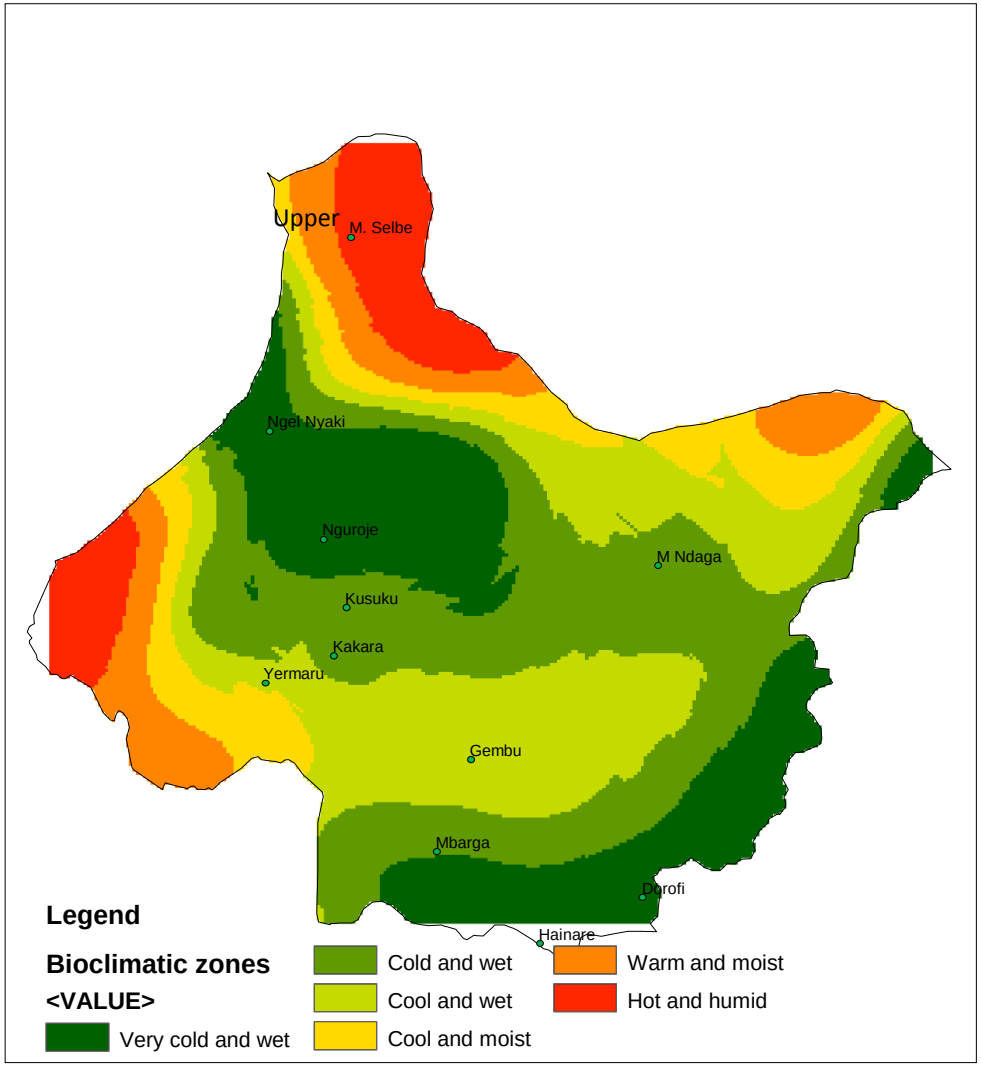
Factor Scores

	F1	F2
Lon	-0.363	0.485
Lat	0.576	0.596
Bio1	0.976	-0.143
Bio2	-0.227	0.916
Bio5	0.977	-0.096
Bio6	0.938	-0.312
Bio10	0.982	-0.130
Bio11	0.925	-0.236
Bio12	-0.854	-0.356
Bio13	-0.609	-0.638
Bio14	-0.925	-0.214
Alt	-0.966	-0.024

Bioclimatic variables

- **BIO1 = Annual mean temperature**
- **BIO2 = Mean diurnal range (max temp – min temp) (monthly average)**
- **BIO5 = Max Temperature of Warmest Period**
- **BIO6 = Min Temperature of Coldest Period**
- **BIO10 = Mean Temperature of Warmest Quarter**
- **BIO11 = Mean Temperature of Coldest Quarter**
- **BIO12 = Annual Precipitation**
- **BIO13 = Precipitation of Wettest Period**
- **BIO14 = Precipitation of Driest Period**

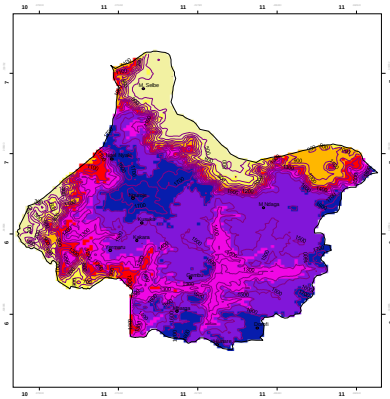
Bioclimatic Map of MP



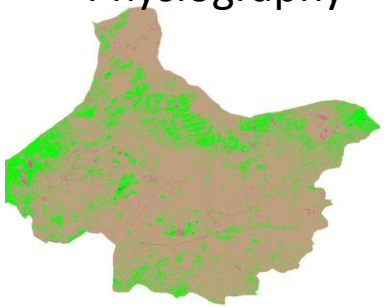
Bioclimatic descriptions

Bioclimate Zones on Mambilla Plateau	Sites	Average Elevations (m)	Latitudes (°N) DD	Longitudes (°E) DD	Mean Annual Temperature (°c)	Annual Total Rainfall (mm)
Very cold and wet	Nguroje	>1700	6.983	11.084	18 (10)	1800
Cold and wet	Kakara	1500	6.823	11.258	19 (12)	1600
Cool and wet	M. Ndaga	1300	6.704	11.269	20 (14)	1500
Cool and moist	Kan Iyaka	800	6.876	10.956	21 (14)	1450
Warm and moist	Upper Mayo Selbe	550	6.861	10.881	25 (16)	1400
Hot and humid	Mayo Selbe	500	7.335	11.258	27 (18)	1400

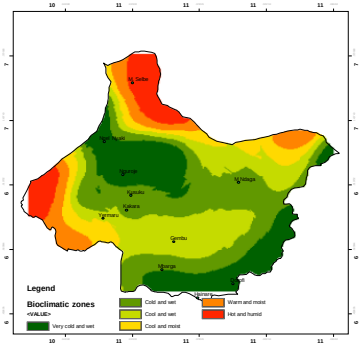
Biogeoclimatic zones construction



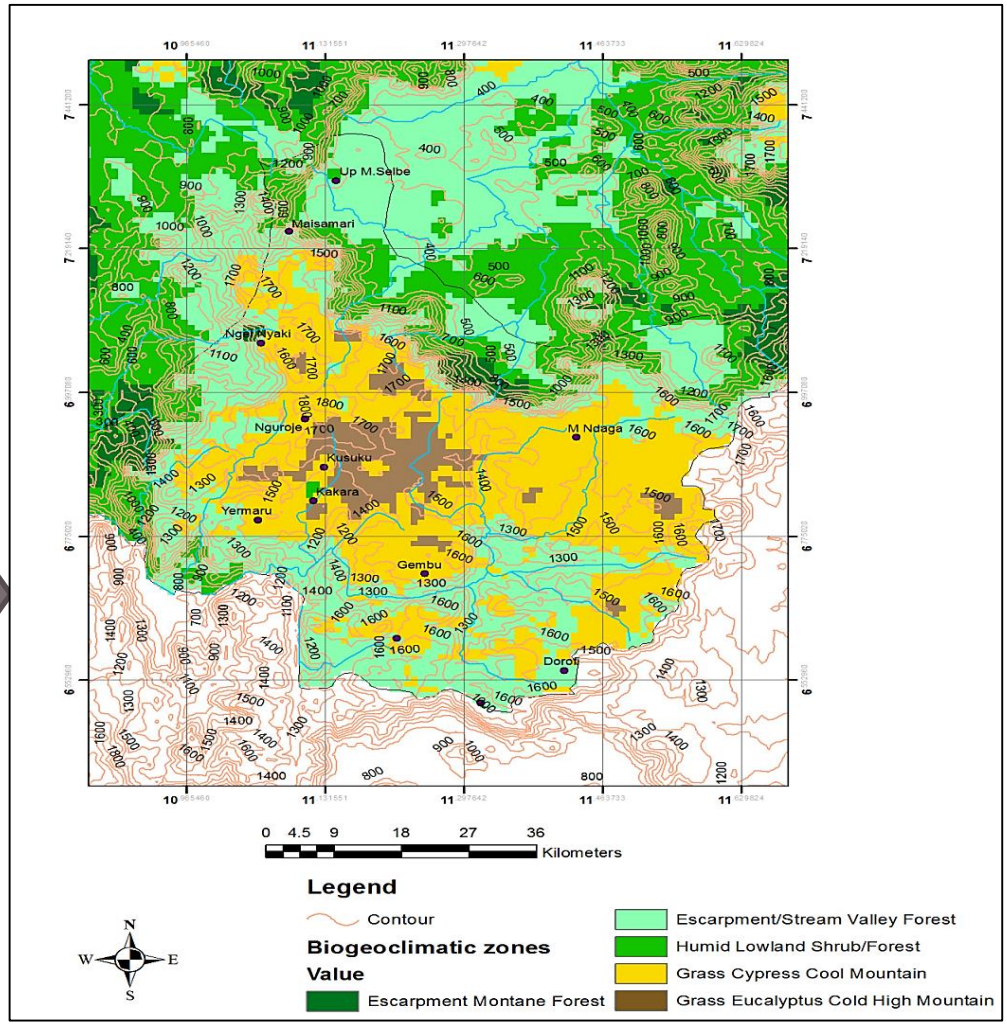
Physiography



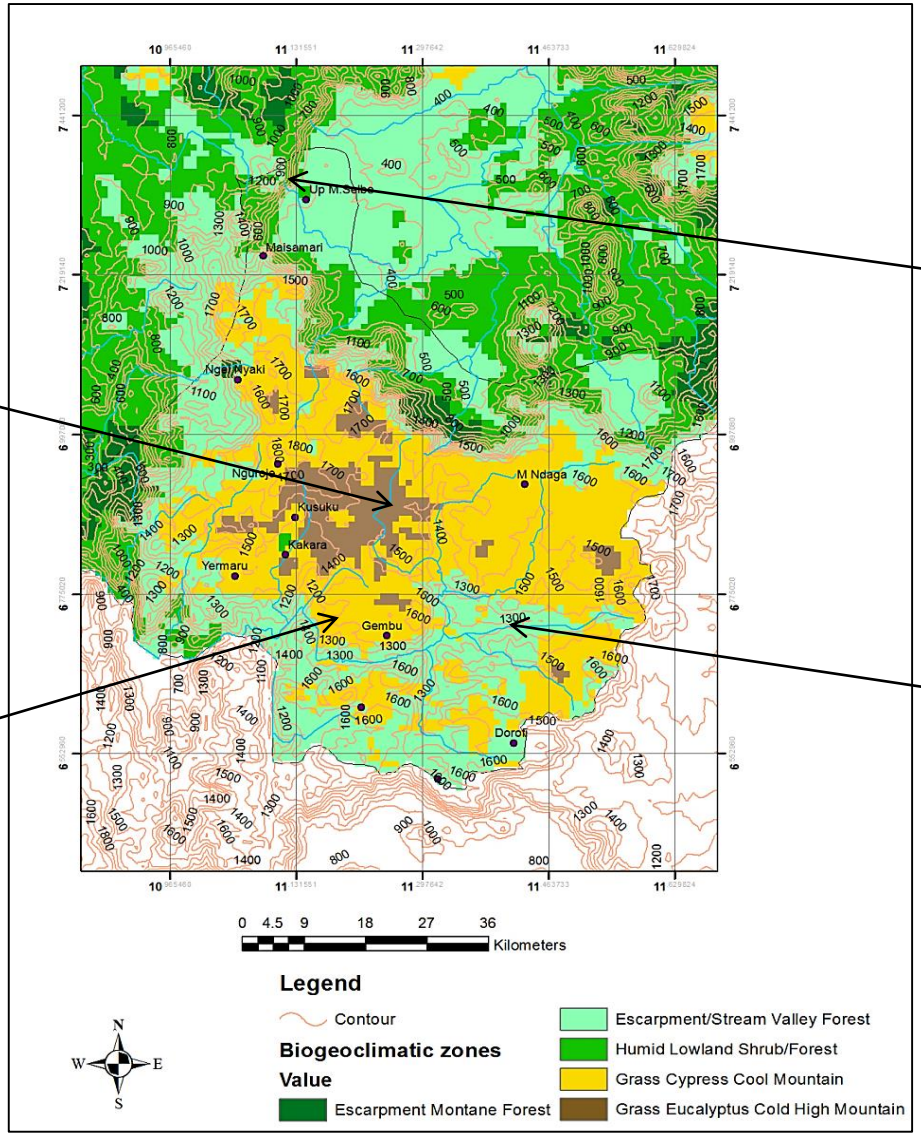
NDVI

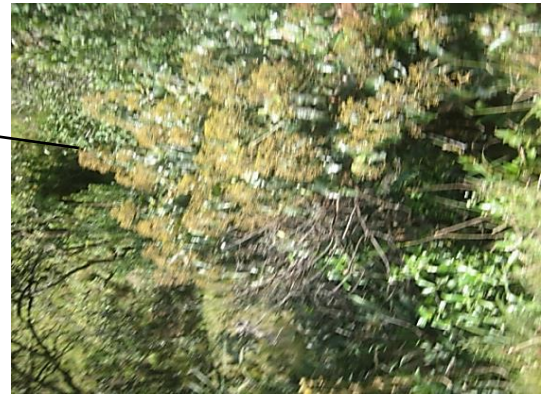


Bioclimatic



Biogeoclimatic Ecosystem zones on the Mambilla Plateau





Biogeoclimatic zones data/descriptions

Bioclimate Zones on Mambilla Plateau	Sites	Average Elevations (m)	Latitudes (°N) DD	Longitudes (°E) DD	Mean Annual Temperature (°)	Annual Total Rainfall (mm)	Associated Vegetation
Grass eucalyptus cold high mountain	Nguroje	>1700	6.983	11.084	18 (10)	1800	Grass eucalyptus
Grass cypress cool mountain	Kakara	1500 - 1650	6.823	11.258	19 (12)	1600	Grass cypress eucalyptus
Escarpment Montane forest	Ngel Nyaki	1300 -1600	7.0826	11.0552	20 (14)	1500	Grass/Montane forests
Escarpment stream valley	Donga Valley	1200 - 1450	6.7133	11.3214	21 (14)	1450	Grass/Shrub forests
Humid shrub forest	Sarkaka	550	6.8271	10.881	25 (16)	1400	Shrubby forests
Humid lowland forest	Upper Mayo Selbe	500	7.335	11.258	27 (18)	1400	Forests

Species Suitability Index

-

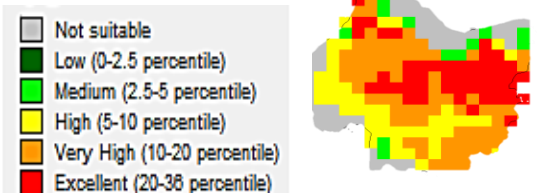
Pinus ponderosa **has high suitability index in the cool and wet mountain (GCM) and cold and wet high mountains regions (GCHM, but poor on warmer and lower elevations.**

High suitability index for *Pseudotsuga menziesii* in both MAXENT and BIOCLIM but was restricted to colder regions of high mountains (GCHM) and high index in western sections of cooler low mountains region but with high rainfall (GCM).

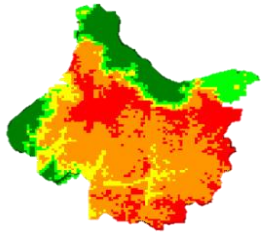
Pinus caribaea **on BIOCLIM showed a broader ecological niche and high suitability index as most part of the study area are potentially suitable, excellent suitability index (20-43 percentile on BIOCLIM, and 0.7908-1.00 in MAXEN**

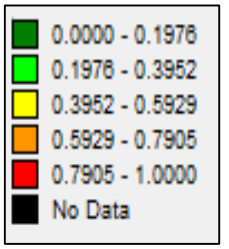
Thuja plicata **suitability index was very poor as over 98% of the study area was designated as not suitable however; a tiny potential suitable spot was found within**

the cold highland mountains zone

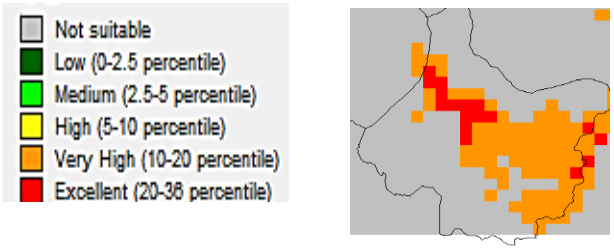


Bioclim for *Pinus ponderosa*

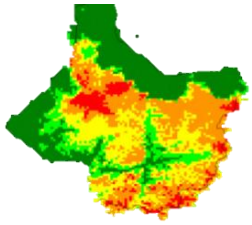


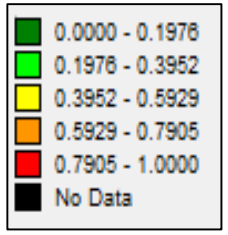


Maxent for *Pinus ponderosa*

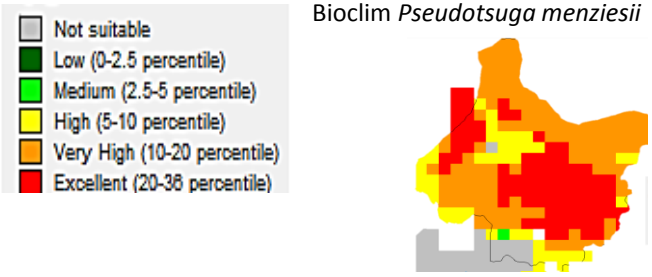


Bioclim *Pseudotsuga menziesii*

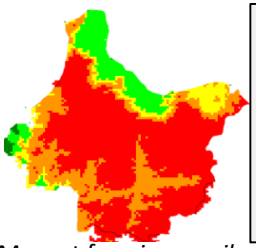


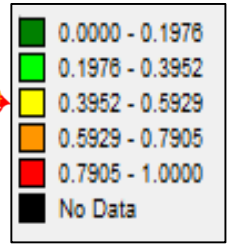


Maxent for *Pseudotsuga menziesii*

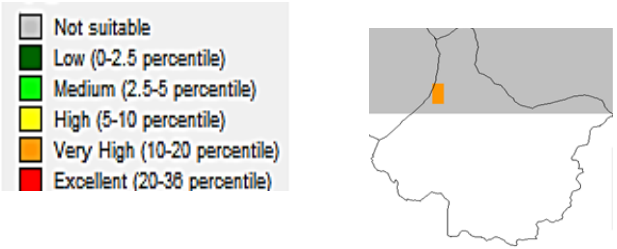


Bioclim for *Pinus caribaea*





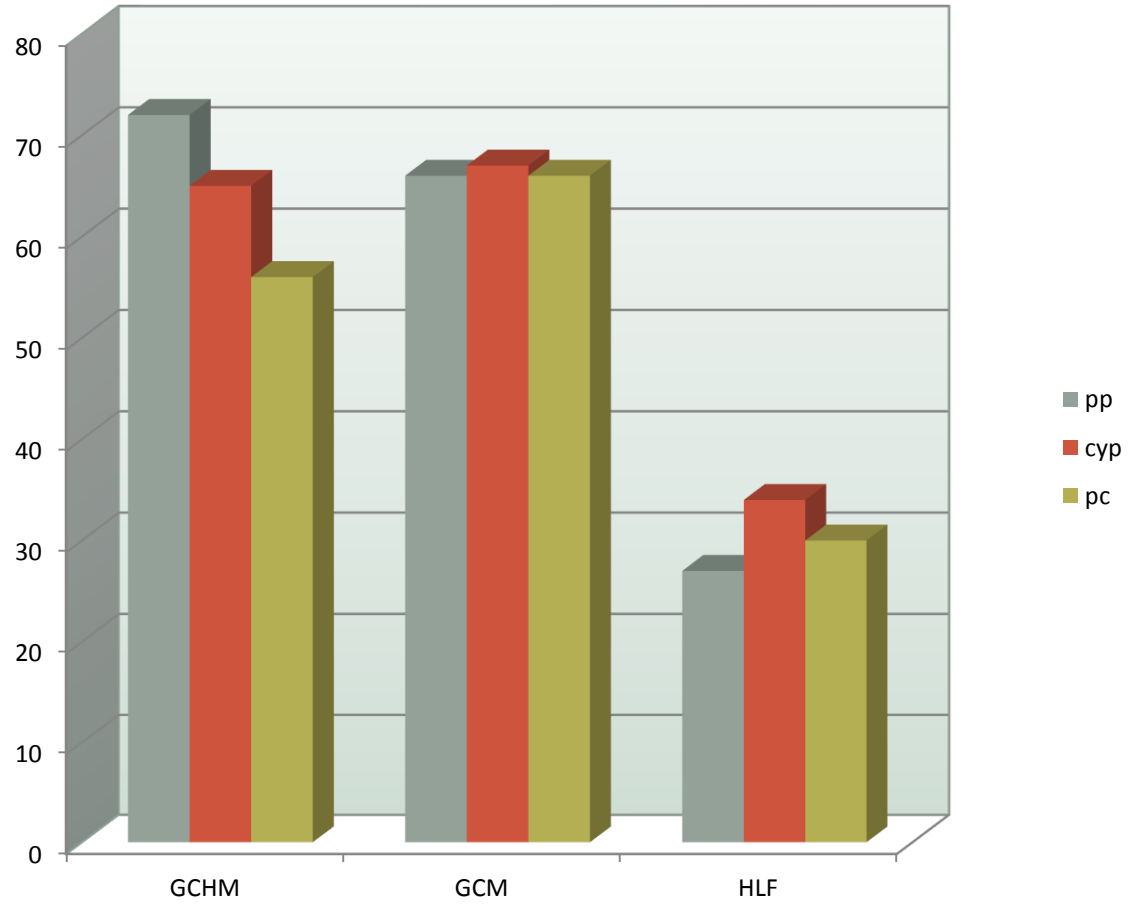
Maxent for *pinus caribaea*



Bioclim for *Thuja plicata*

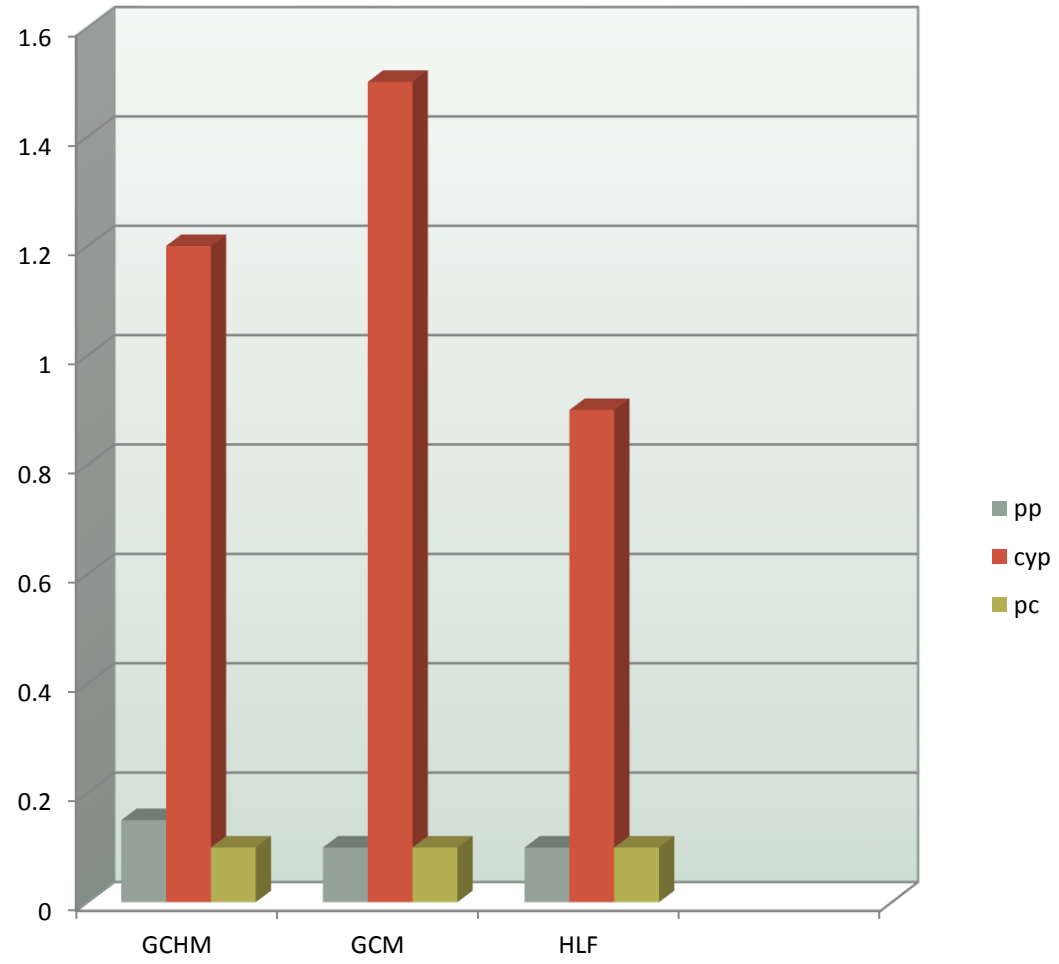
Species Survival rate

- **At age 180 days, *Pinus ponderosa* and *Pinus caribaea* recorded a very good survival percentage of 72% and 65% respectively. The survival rate was almost uniform for all species at Gembu sites; an average of 66% was recorded for all the seedlings.**
- **However, less than 25 percent of germinated seedlings (mostly *Pinus caribaea*) survived at Upper Mayo Selbe after 60 days and they were in poor condition as many of the seedlings suffer from either wilting and or stem rot.**



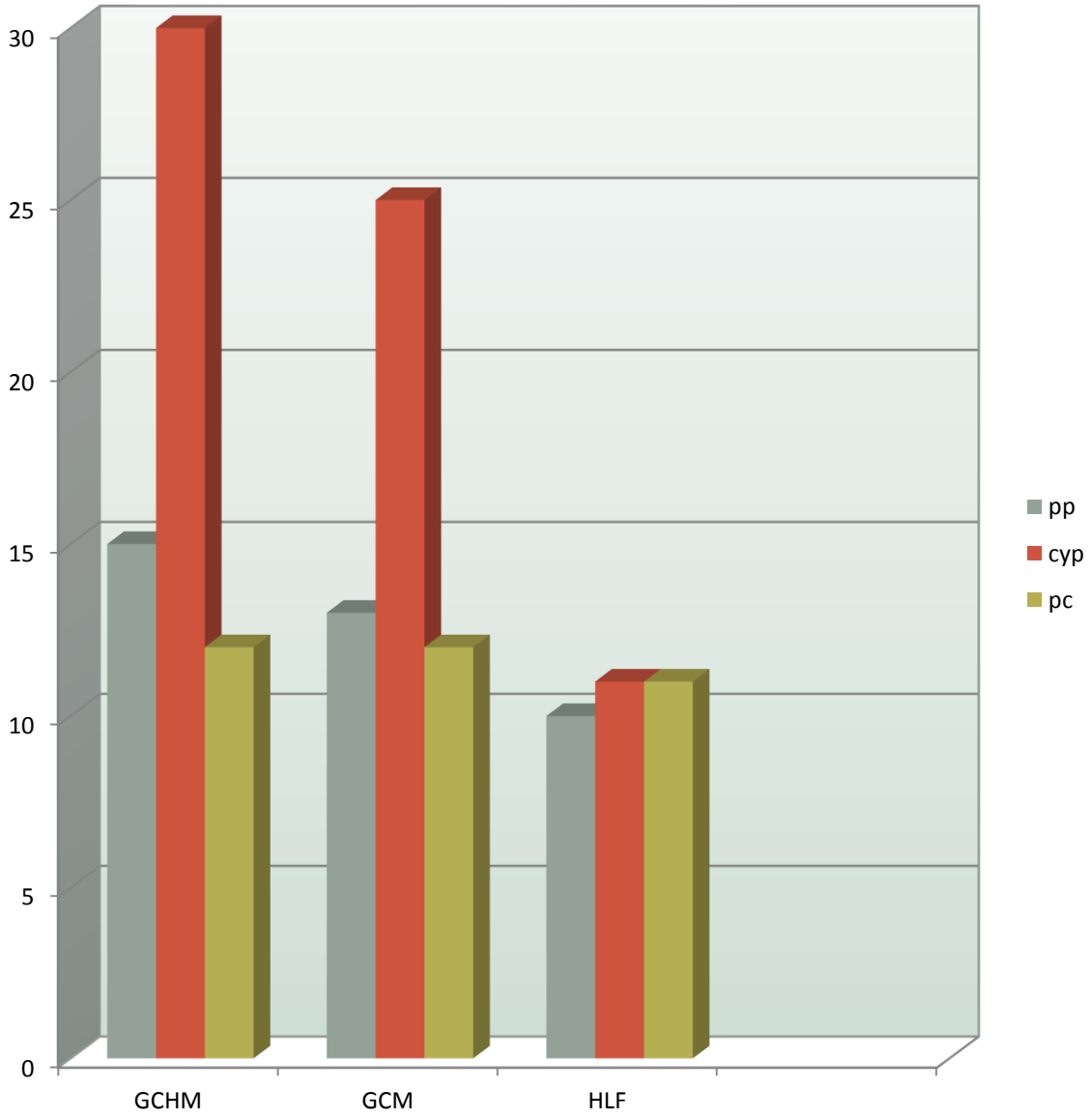
Species stem circumference

- **Except the cypress that recorded high stem circumference in all sites. An average of 0.1cm was recorded for both *pinus ponderosa* and *pinus caribaea* in all the three sites.**
- **This therefore means site condition does not significantly affect the stem circumference at least at seedling stage.**



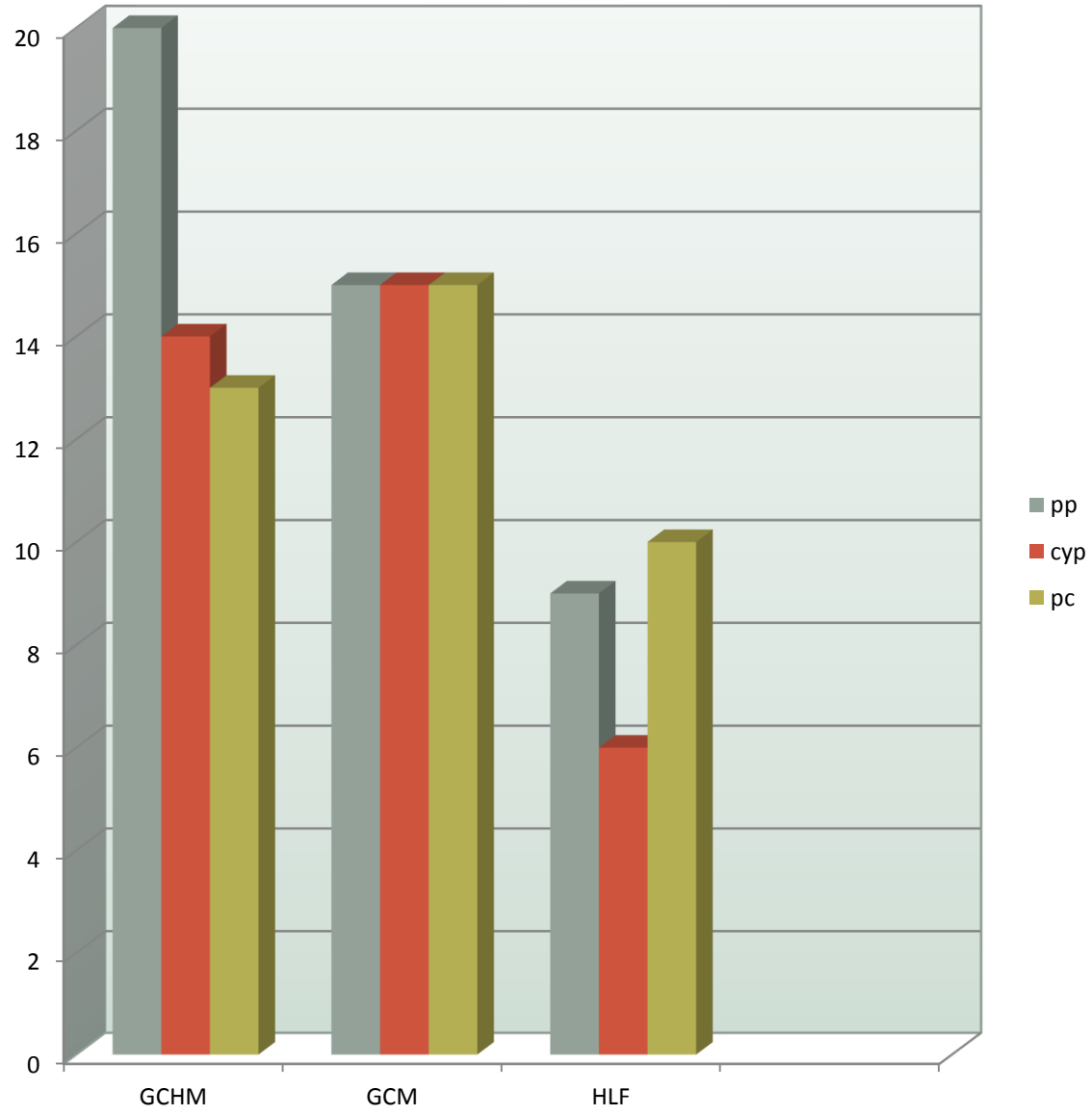
Species Mean heights

- **Mean height of 15cm was recorded for *Pinus ponderosa* at Kakara sites.**
- **The control species Cypress was exceptional high at the two sites.**
- **There was no significant difference in the mean height for all the three species in Upper Mayo Selbe site. at P<0.05.**



Species crown cover

- **The average needle leaves for each species was estimated as crown cover.**
- **A uniform crown cover was obtained for all the 3 species at Gembu site (GCM).**
- ***pinus ponderosa* recorded the most densely crown cover at kakara site (GCHM) while cypress had the lowest crown cover at Upper Mayo Selbe site**.



Damaging agents

- **The principal damaging agents observed during the study were the activities of animals and pests,**
- **harsh weather/climatic conditions,**
- **competition from other plants, and unknown causes of seedling death.**

Damaging Agents	GCHM			GCM			HLF		
	Pp.	Pc	Cyp	Pp.	Pc	Cyp	Pp.	Pc	Cyp
Animals/Pests	00	02	00	08	07	02	05	04	03
Harsh climatic conditions	03	04	02	01	00	00	35	25	30
Vegetation competition	02	03	01	05	04	03	03	03	02
Unknown source	00	01	00	01	00	00	00	00	00

Community perception to planted forests

- **There was an almost equal split on the perception to conifer plantation in the study area.**
- **Although over 53% of the total interviewee (mostly the farmers (68%) and women (67%)) said planted forests was not a new thing in their communities and had positive perception about plantation.**
- **of 67 herdsmen interviewed, about 75% of them expressed fear over their land being taken over by planted trees**

Settlement		Farmers					Herdsmen					Women				
		No	Positive		Negative		No	Positive		Negative		No	Positive		Negative	
Gembu		30	21		09		35	10		25		16	10		06	
Mayo Ndaga		15	09		06		18	04		14		10	07		03	
Kakara		14	10		04		14	03		11		08	06		02	
Total	%	59	40	68%	19	32%	67	17	25%	50	75%	34	23	67%	11	33%

Summary and Conclusions

- **The application of geospatial techniques has enabled us to identify the following biogeoclimatic zones on the plateau with their unique characteristics features:**

  Humid lowland forest
  Humid shrubs/forest
  Montane forest
  Escarpment stream valley forest,
  Grass cypress Cool Mountain
  Grass eucalyptus cold High Mountain

- **Relief plays a prominent role in defining the pattern and landscape characteristics as the biogeoclimatic zones on the plateau.**

- **That modeling and seedling performances test show that *pinus ponderosa* and *Pinus caribaea* had high suitability index and performed well on Grass eucalyptus cold High Mountain and Grass cypress Cool Mountain respectively.**

- **Humid lowland forest and escarpment forest zones does not support cold tolerant conifers but equally does not necessarily require introduction of exotic species as the zone is blessed with several local tree species though under threat by excessive loggings**

Recommendations

- **The biogeoclimatic ecosystem zones on the plateau is hereby recommended to be adopted as framework for natural resources planning and management by both the Taraba state government in particular and Federal Republic of Nigeria in general.**
- **Based on the suitability index and seedlings performance tests, *pinus ponderosa* is recommended for further medium and long trials at Grass eucalyptus cold high mountain while *Pinus caribaea* is potentially best suited and recommend for Grass cypress cool mountains and to some extent in the escarpment stream valley.**
- **Due to challenges associated with cold stratification processes in developing countries, cold tolerant species such as *Pinus caribaea, Pinus patula Pinus ponderosa* which does not require rigorous cold stratification procedure are recommended for trees and afforestation programme trials in Africa**

Photo Gallery

Acknowledgement

- Professor A.A Adebayo
- Dr A. Zemba
- Prof. A.L Tukur
- Asst. Prof Howe Glenn (USA)
- Engr. Abubakar Mohd. (Highland Tea kakara)

END

- Thank you all

Questions time