FOREST ECOSYSTEM SERVICES AND DRIVERS OF DEFORESTATION IN YAYU COFFEE FOREST BIOSPHERE RESERVE, SOUTHWEST ETHIOPIA

By
Ferede Abuye Jeldu
PhD Candidate at Hawassa University, Ethiopia

03 – 07 July 2023
NAIROBI, KENYA

Introduction and rational for the study

❖ Tropical forest host the richest terrestrial biodiversity, provide local and global benefits.

❖ Worldwide, several billion people are depends on biodiversity for their livelihoods.

- 31 % (4.06 billion ha)- covered by forests (IPCC, 2022).
- Absorb 15.6 billion tonnes of CO_2 every year.

❖ However, a loss of tropical forests has a significant effects for GHGs concentrations (IPCC, 2022).

✓ 1990– 2020 period > 420 Mha lost,

✓ > 90% in tropical areas.

✓>15 billion trees cut down annually,

✓> 2,400 trees/minutes are cut down (FAO, 2020).

Introduction….

- Previous findings argue that REDD+ will not be effectively implemented until the understanding the known drivers of deforestation (FAO, 2020).
- Therefore, understanding the driving forces of deforestation is the 1st step for ecosystem conservation and forest management.
  - However, there is lack of studies on the assessment of ecosystem services and drivers of deforestation.
  - Therefore, this study aims to assess levels of biodiversity, carbon, and examining biodiversity contributions for above-ground carbon.

Objectives of the study

1) To assess woody species diversity across zonation;

2) To assess level of carbon stock variation across zonation

3) To examine the relationship between biodiversity and above-ground carbon

4) To identify the drivers of deforestations and its solutions in the Yayu Coffee Forest Biosphere Reserve

Data Collection Methodology and Analysis

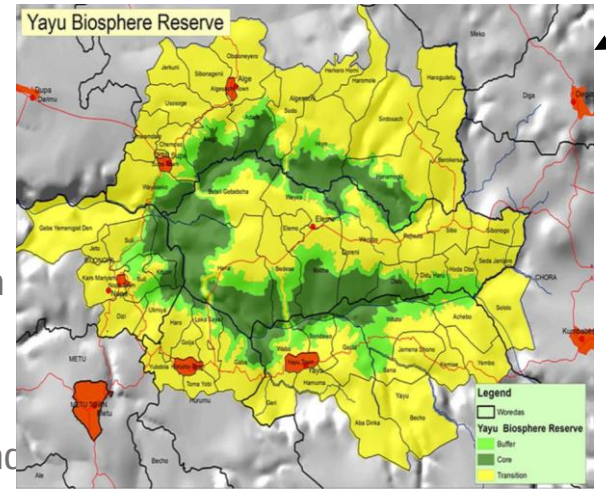
- This study was conducted at YCFBR, Southwest Ethiopia.
- Located at 582 Km in Southwest of Addis Ababa.
- The biosphere covers six districts.
- Geographically, it lies between latitude 8° 0′42″ to 8°44′23″ N and longitude 35°20′31″ to 36°18′20″ E.
- Registered in 2010 as BR.
- Total area 167,021 ha
- Classified in to 3 zones:

➢ Core (27,733ha)-Allowed management and research do not affect natural processes and wildlife-

- kept free from human pressures

➢ Buffer (21,552ha) – Recreation, tourism, fishing and permitted to a limited extent

➢ Transitional zone (117,736ha)- Zone of cooperation (conservation, knowledge and management skills (settlement, crop land, etc.) are applied together).



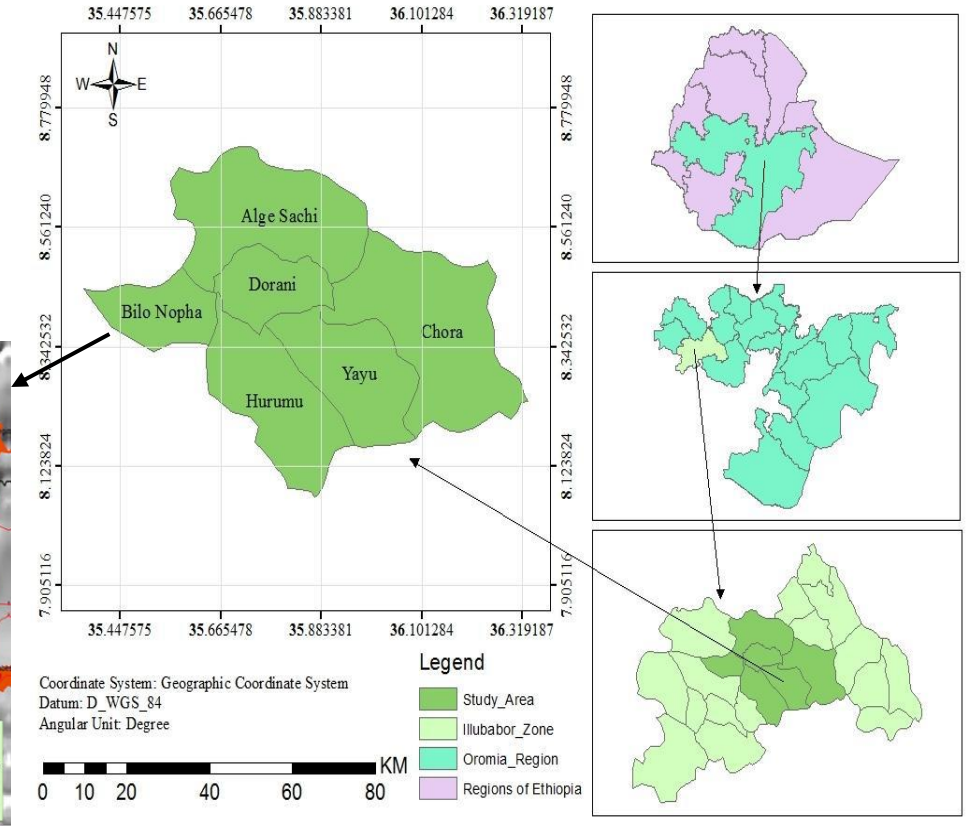
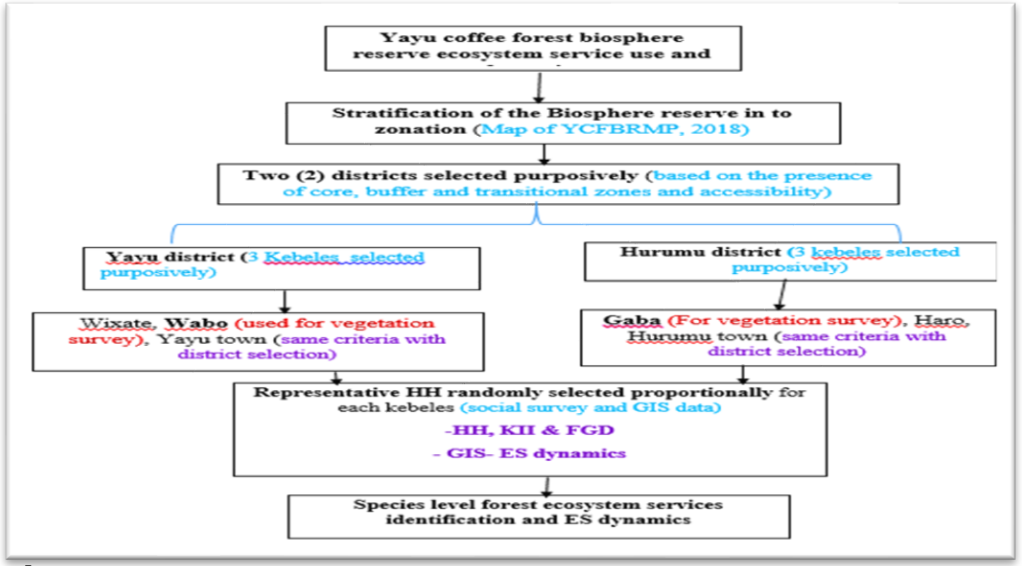
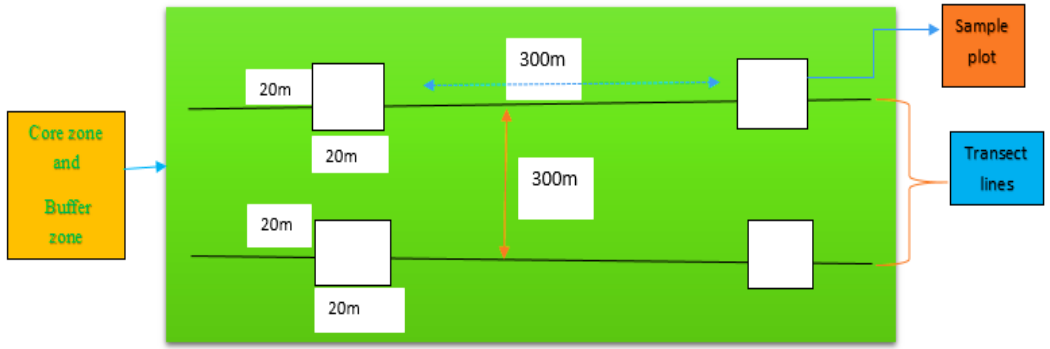
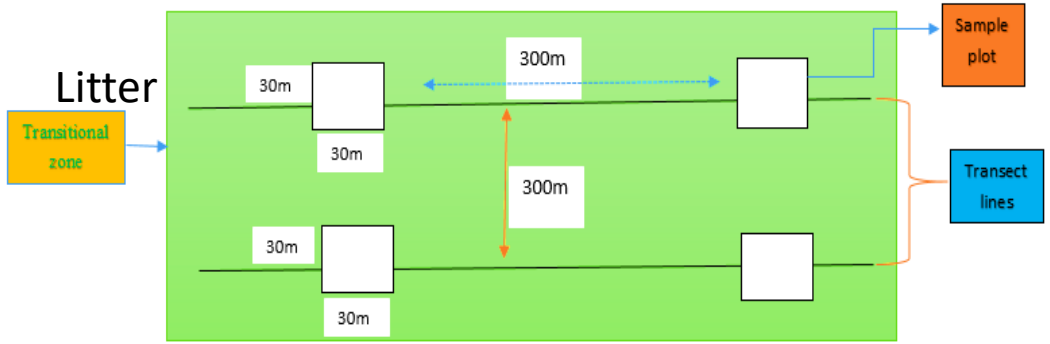


Figure 1: *Map of study area (Yayu Coffee Forest Biosphere Reserve)*
Source: http://ethio.geoportal.org, accessed 08 March 2022.

Data Collection Methods







❖ **Sampling design**:

- ❑ In forest inventory, stratified systematic sampling with a random start is a commonly used sampling design (UNFCCC, 2015) and this approach also used for this study.
- ❑ **The Common plot size** for biodiversity and C stock assessment are 200 m2, 400m2, & 500m2,
- ✓ **but any size can possibly be used (UNFCCC, 2015).**
- **Using this standard range-**
  - ➢ 20 m × 20 m - for core and buffer zone, &
  - ➢ 30 m x 30 m- for transitional **Based on expected density of woody sps in each zonation.**

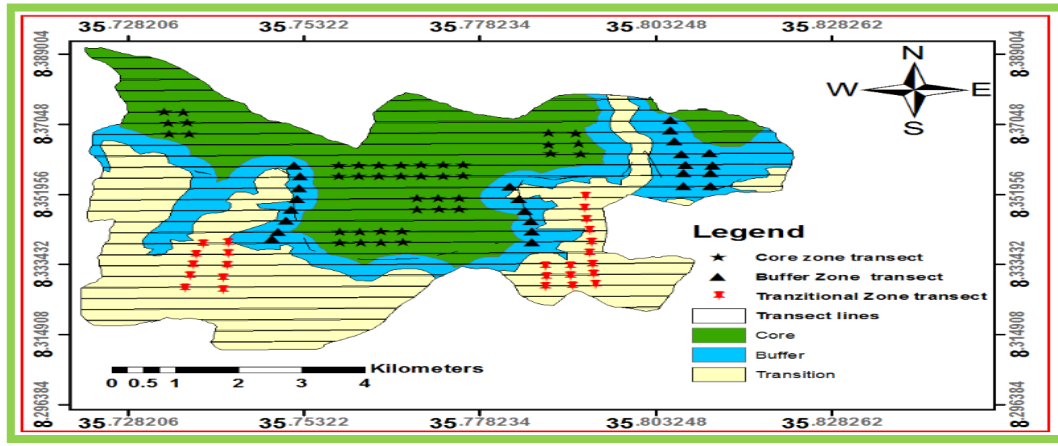


Figure3: Sampling design.

Trait data:

- ✓ **WD** obtained from **EFRL** (EFRL, 2017).
- ✓ ***SLA, seed size,* & PHm** from **TRY database** (www.try-db.org).

Statistical analysis

Objective 1.

To assess woody species diversity across zonation: FD indices calculated -FDiversity software.

-Spearman correlation- r/ships of FD with species diversity, disturbance & topographic factors.

-polynomial regression model -patterns of FD along disturbance &richness.

Mixed effects M- fixed factors (disturbance and environmental variables) on FD (response).

Objective 2.

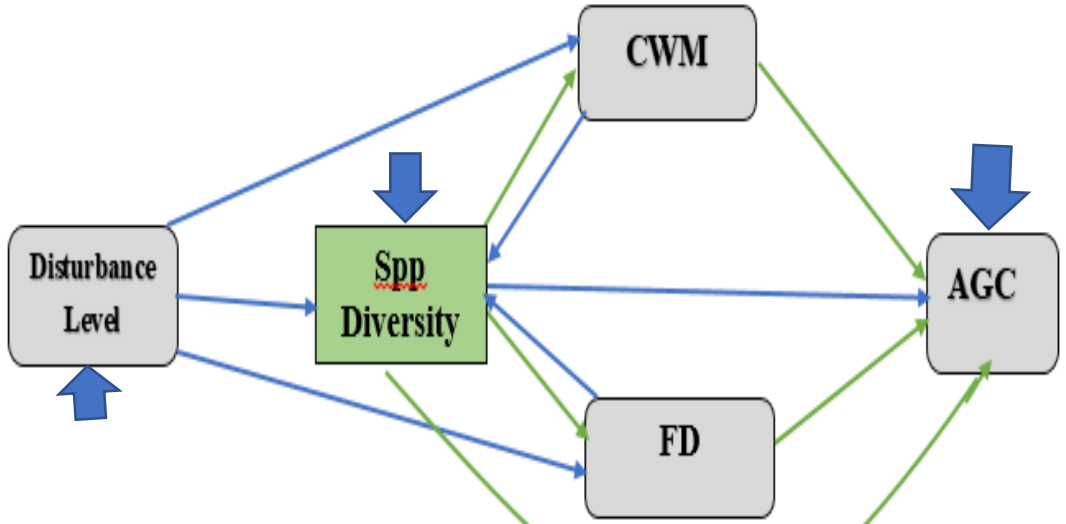
Level of carbon stock variation across zonation

ANOVA were used to compare carbon pools among 3 zones
- SOC across depth wise (0-30 cm and 30-0cm).

3. Examining the R/ships between Biodiversity & above-ground carbon.

❖ **Structural Equation Models (SEMs):**

- full mediation-diversity fully transmitted through FD&FDom
- partial mediation-test direct & indirect diversity effects through FD & FDomin.



❑ R software and Amos-SPSS.

Figure 3: Hypothetical framework for direct & indirect **effects of disturbance** sps diversity & AGC &**sps diversity** on AGC through FD and CWM
Sources: Adopted and modified from (Mensah *et al.*, 2021).

Where: FD= functional diversity for: FDp, FRic,, FEve, FDiv, FDis, and
CWM= Community weight mean or functional dominance for: CWM..WD, CWM.SLA, CWM.Hmax and CWM.SM

Main findings

1. Levels of Woody Species Diversity Across Zonation of Yayu Coffee Forest Biosphere Reserve

Table 1: Diversity information across forest zonation of YCFBR.

Zonation	species richness (S)	Genus number	Number of Family	BA (m^2/ha)	Density (individuals/ha)
Core zone	**54**	**45**	**30**	**78.5**	**664**
Buffer zone	44	40	24	72.5	597
Transitional zone	43	37	24	38.3	500
Total	83	67	42	65.3	601

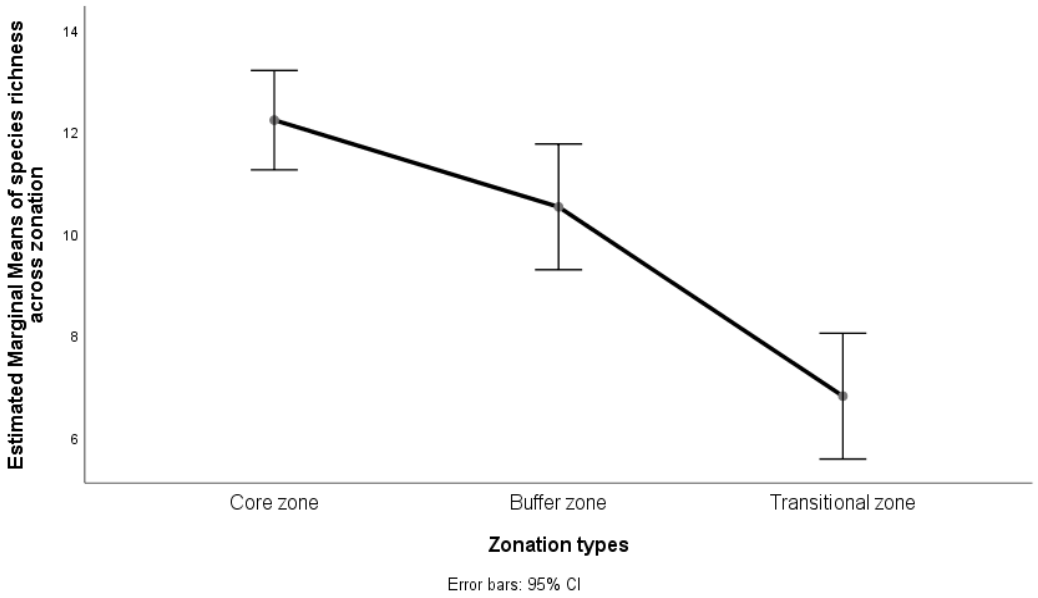
Table 2: Multiple comparisons for species richness across zonation using LSD at 95% confidence interval

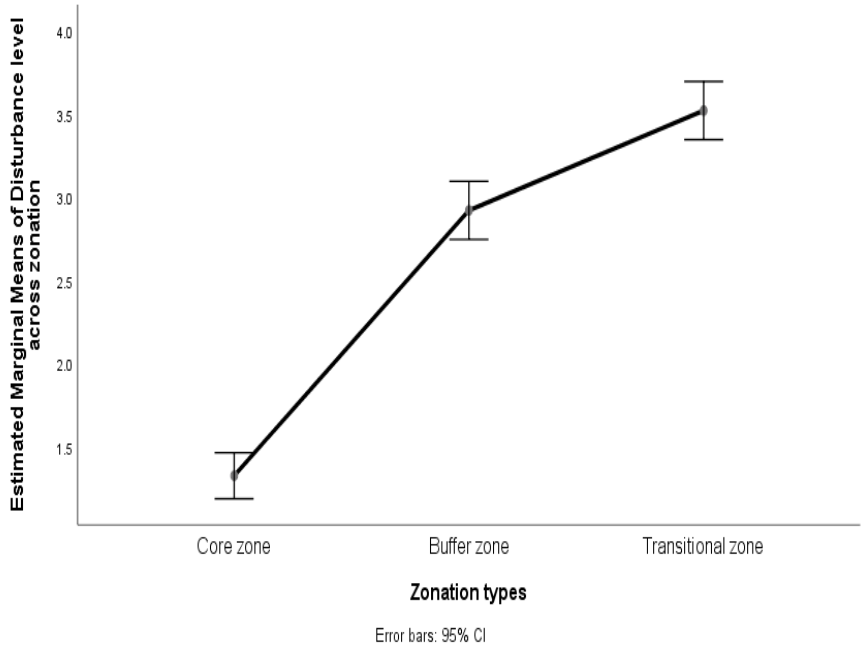
Zonation types (i)	Zonation types (J)	Mean difference (i-j)	Std.Error	95% confidence interval (95%CI) Lower bound	Upper bound
Core zone	Buffer zone	1.705*	0.793	0.13	3.28
	Transitional zone	5.425*	0.793	3.85	7.00
Buffer zone	Core zone	-1.705*	0.793	-3.28	-0.13
	Transitional zone	3.720*	0.880	1.97	5.47
Transitional zone	Core zone	-5.425*	0.793	-7.00	-3.85
	Buffer zone	-3.720*	0.880	-5.47	-1.97

Table 3: Spearman correlation coefficients between zonation, disturbance, species richness and BA

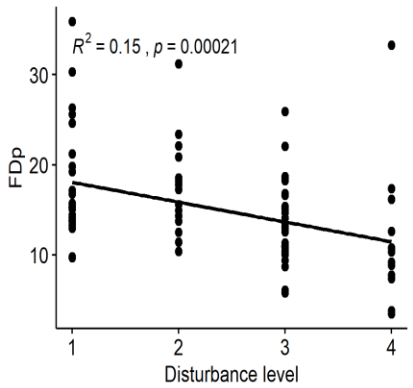
Variables	Zonation	Disturbance level	Species richness across zonation	Basal area (BA)
Zonation	1			
Disturbance level	0.889**	1		
Species richness across zonation	-0.581**	-0.473**	1	
Basal area (BA)	-0.363**	-0.270*	0.547**	1

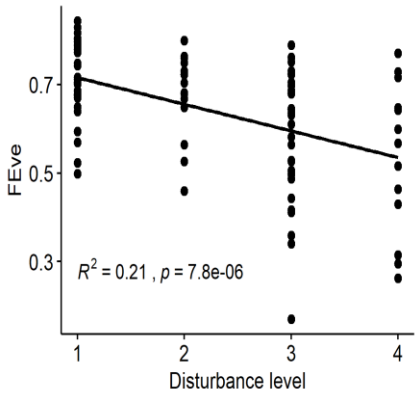
Woody Species Diversity Across Zonation…….

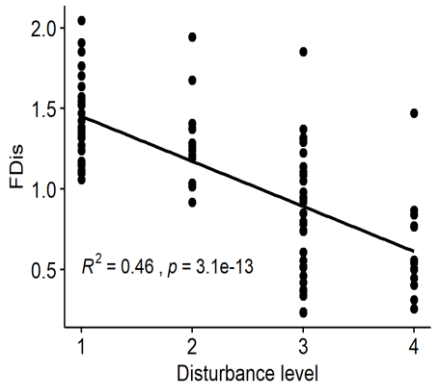


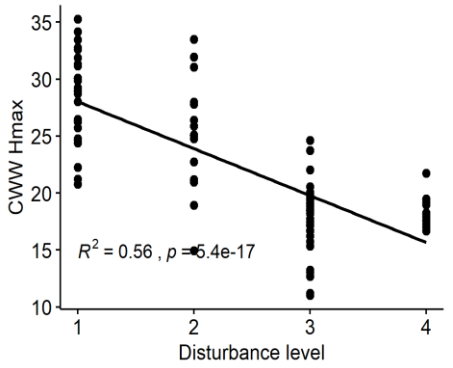


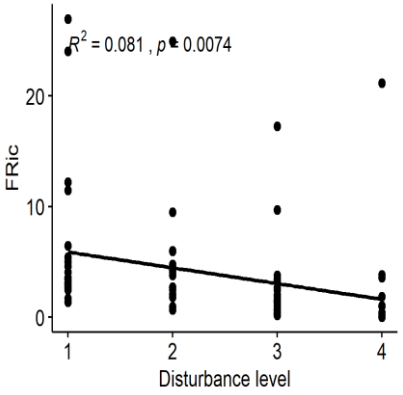
Patterns of FD along disturbance levels in the YCFBR

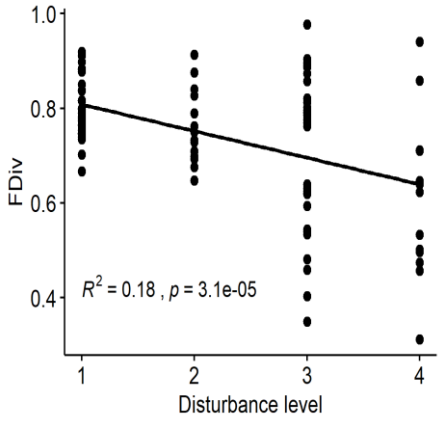


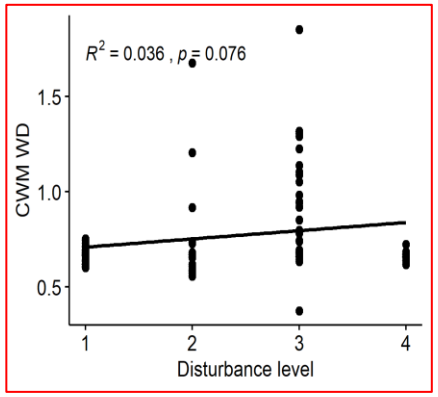


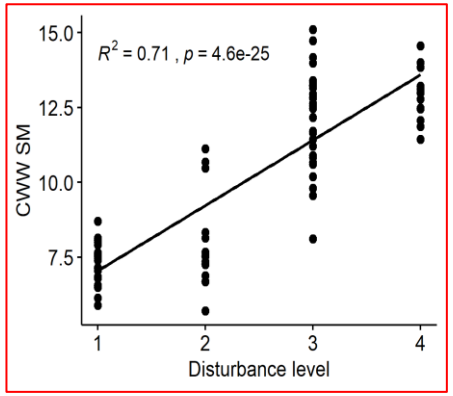












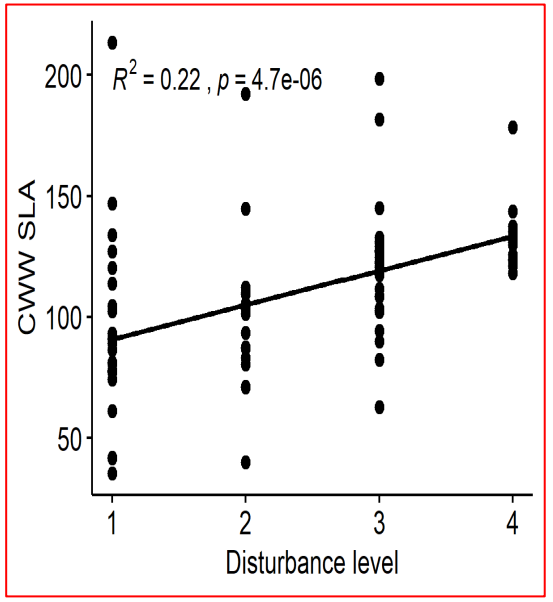


Figure4: Patterns of FD along disturbance levels in the YCFBR

Effects of disturbance and topographic factors on FD

Table3: Spearman correlation coefficients between functional diversity indices and environmental factors.

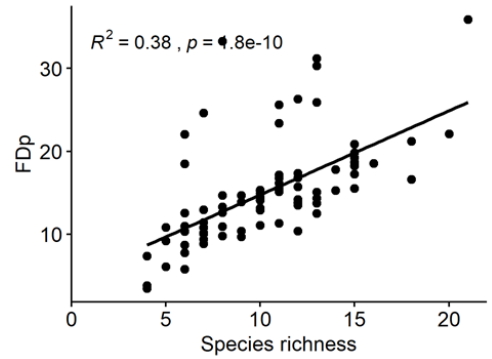
	FDp	FRic	FEve	FDiv	FDis	CWM WD	CWM SLA	CWM Hmax	CWM SM
Disturbanc	-0.46***	-0.54***	-0.51***	-0.44***	-0.70***	0.11	0.61***	-0.75***	0.81***
Slope	0.19	0.20	0.03	0.15	0.25*	0.10	-0.00	0.11	-0.12
Aspect	0.00	-0.02	0.02	0.09	-0.02	0.13	0.01	-0.03	-0.02
Elevation	-0.44***	-0.49***	-0.34**	-0.43***	-0.52***	-0.016	0.39***	-0.44***	0.52***

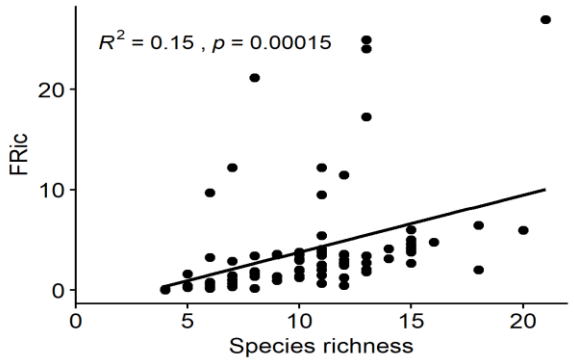
Table 4: Mixed effects model

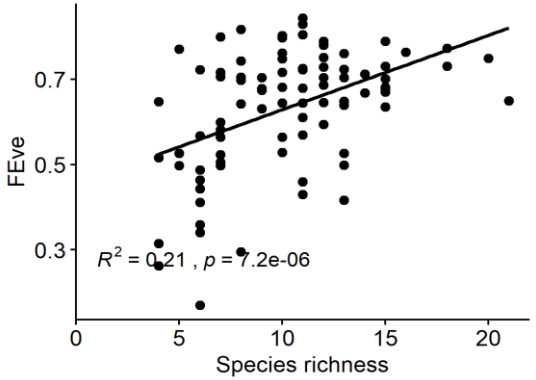
Functional diversity component	Effect	Estimate	d.f.	SE	*P* value
FDp	Aspect	0.015	81.615	0.007	0.0288 *
	Disturbance	2.311	83.147	0.565	$9.84e^{-05}$ ***
FRic	Disturbance	1.400	83.104	0.520	0.00859 **
FEve	Aspect	0.001	82.947	0.0004	0.02651 *
	disturbance	0.069	16.181	0.029	0.03121 *
FDiv	Aspect	0.002	82.960	0.0007	0.047444 *
FDis	disturbance	0.277	83.05	0.032	$2.38e^{-13}$ ***
CWM WD	disturbance	-0.079	83.928	0.030	0.0105 *
CWM Hmax	Disturbance	1.541	74.251	0.758	0.04555 *
CWM SM	Disturbance	-2.196	83.033	0.144	$< 2e^{-16}$ ***

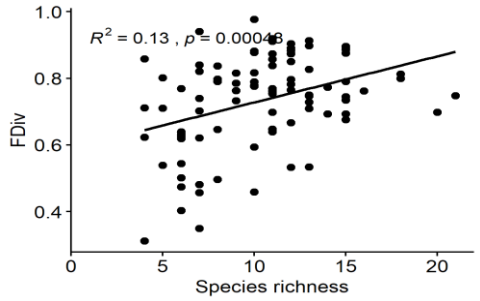
Table 5: Spearman correlation coefficients between species diversity and FD indices.

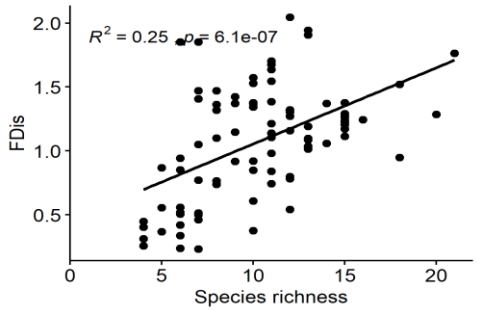
Functional diversity components	Species richness (S)	Shannon Weiner diversity (H')	Evenness index (E)
FDp	0.70 ***	0.48***	0.40***
FRic	0.64 ***	0.51***	0.52***
FEve	0.41***	0.50***	0.37***
FDiv	0.33**	0.39***	0.33**
FDis	0.46***	0.63****	0.72***
CWM SLA	-0.36***	-0.56***	-0.51***
CWM WD	-0.036	-0.30**	0.028
CWM Hmax	0.42***	0.71***	0.59***
CWM SM	-0.55***	-0.86***	-0.57***

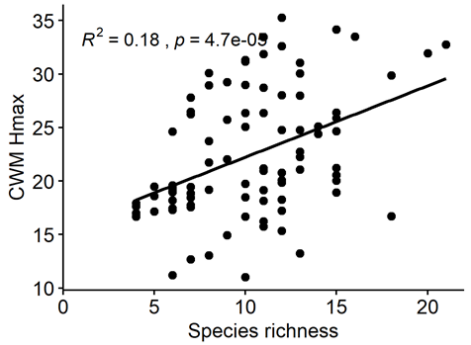


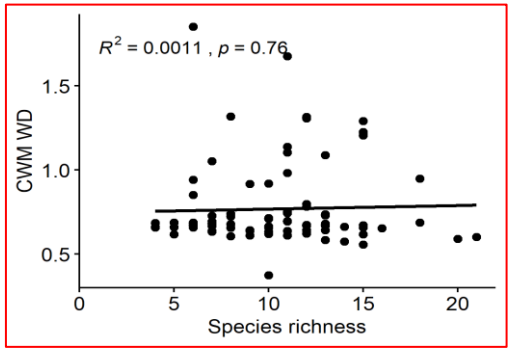


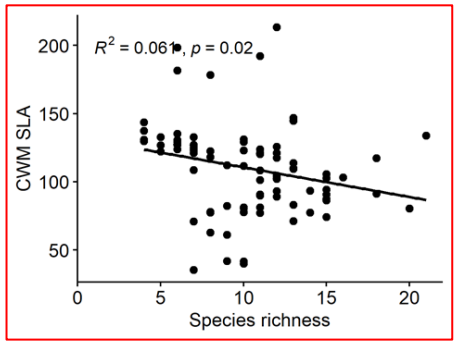












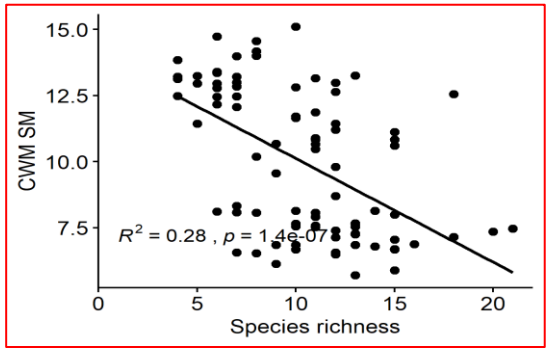


Figure5: Patterns of FD across Species richness

Carbon Stock Across Zonation of Yayu Coffee Forest Biosphere Reserve

Table 6: Carbon stocks in various carbon pools across zonation in the case of Yayu Coffee Forest Biosphere Reserve.

Carbon pools (Mg C ha^{-1})	Forest zonation			Grand mean
	Buffer	Core	Transitional	
AGC	403.21±285.8a	525.42±28.7a	82.56±98a	368.06
BGC	108.87±77.2a	141.86±76.3a	22.29±26.5b	99.38
AGC+BGC	512.1±362.8a	667.28±358.9a	104.85±124.5b	467.44
LC	0.97±0.5a	0.89±0.4a	0.75±0.3a	0.88
SOC (0-30 cm)	96.96±76.6b	191.02±91.6a	76.73±25.8bc	133.6
SOC (30-60 cm)	39.19±19.02c	76.48±74.7bc	31.41±18.8c	53.85
SOC (0-60 cm)	128.38±82.9a	267.50±144.8b	115.92±32.5a	187.4
Total carbon stock	641.42±370.8a	935.68±413.4b	221.52±122.9c	655.72

Relationships Between Biodiversity & AGC of the YCFBR

- Full mediation model of SEM showed that, S richness mediated through FD had a significant effect on AGC.
- Partial mediation model revealed that, causal path from sps richness to AGC- direct effect of sps diversity.

Table 7: Results of structural equation modeling done to evaluate the effects of species richness on above-ground carbon stock through functional diversity and functional dominance.

Predictor	Response variable	Partial mediation model			Full mediation model		
		Est.std	SE	P value	Est.std	SE	P value
S	FDiv	0.401	0.004	***	0.37	0.004	0.001
S	FEve	0.62	0.004	***	0.56	0.004	***
S	FRic	0.651	0.142	***	0.77	0.148	***
S	FDis	0.737	0.011	***	0.82	0.011	***
S	CWM.Hmax	0.578	0.154	***	0.66	0.159	***
S	CWM.SLA	-0.361	0.913	0.017	-0.27	0.945	0.084
S	AGC	0.57	26.642	0.081	-	-	-
FRic	AGC	-0.156	20.068	0.466	0.04	14.801	0.814
FEve	AGC	-0.07	469.221	0.666	-0.09	483.457	0.569
FDiv	AGC	0.068	306.272	0.598	-0.03	266.738	0.815
FDis	AGC	0.159	281.657	0.568	0.55	143.541	***
CWM.SLA	AGC	0.114	1.761	0.379	0.13	1.757	0.293
CWM.Hmax	AGC	0.143	10.616	0.34	0.29	7.788	0.014
Fit statistics							
Chi-square = 61.885(p=0.000)						Chi-square = 63.789 (p=0.000)	
DF= 11				DF = 12			
SRMSR: 0.231					SRMSR: 0.223		
GFI: 0.883					GFI: 0.817		

Relationships Between Biodiversity and AGC of the YCFBR

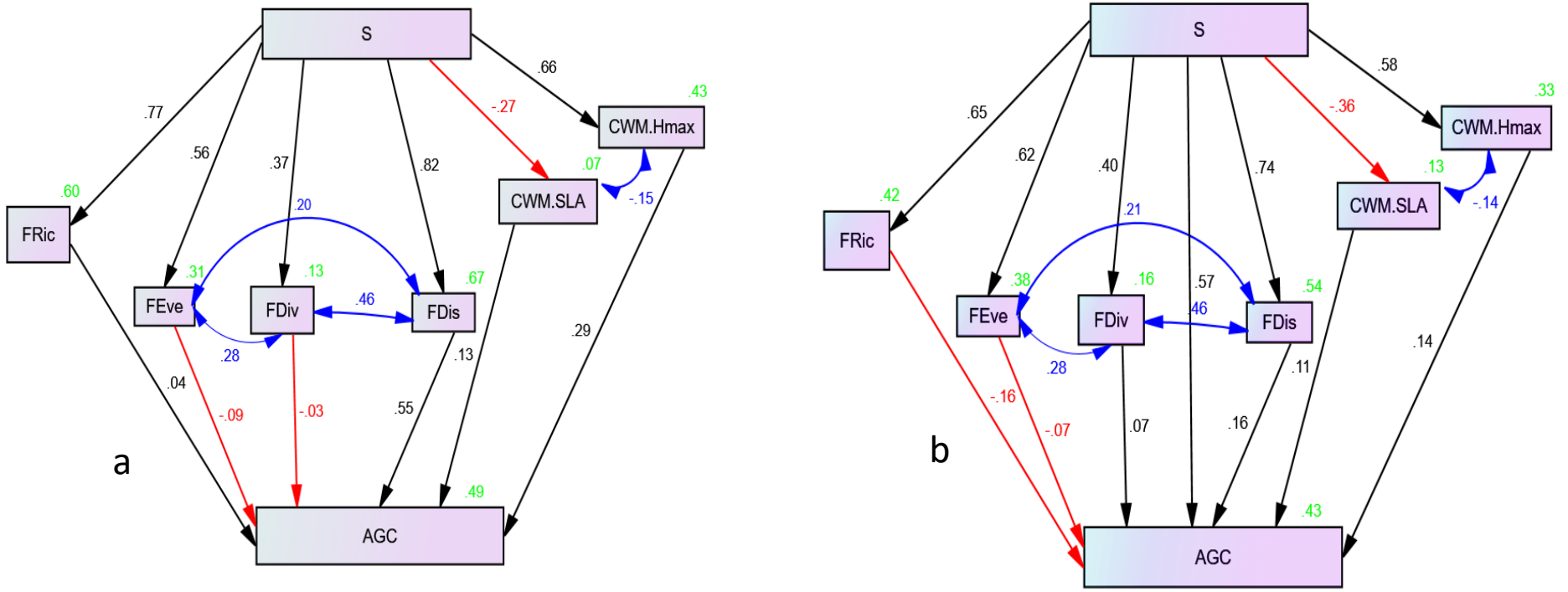


Figure 9: Full & Partial mediation model for the effects of species diversity on AGC through FD& FDo.

Table 10: The combined effects of FD &FDo on AGC of YCFBR.

Model			Est.	SE	df	Pr (>|t|)
Functional diversity + Functional dominance	Fixed effect	(Intercept)	94.63	61.68	43.81	0.130
		FDis: CWM.Hmax	9.09	1.87	85.65	5.2e-06
	Random effects (variance)	Sites				
		Rsd.	12.82			
		Marg. R2	**0.21**			

Note: The figures on the lines are the standardized path coefficients. The green numbers represent coefficient of determination (R2). Blue arrows with blue color numbers represents residual errors to show correlations between each functions (Ɛ). Red arrows with numbers denote negative effect paths (-β) and black arrows with numbers denote +ve effect paths (β).

Results showed that FD &FDo significant predictors of AGC **(21 %)**.

Effects of disturbance and environmental variables on AGC

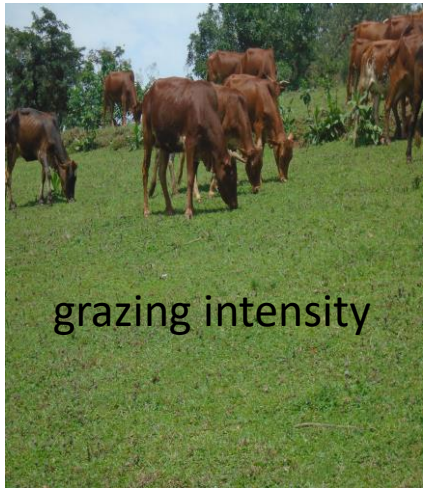
Factors		Estimate	Std.Error	tvalue	Pr(>|t|)	Marg.R2
Topography	(Intercept)	1260.41	389.60	3.24	0.00175**	0.335
	Elevation	-0.61	0.24	-2.59	0.01142*	
	Slope	-5.55	2.75	-2.02	0.04659*	
	c(Aspect)	-11.99	16.60	-0.72	0.47195	
Disturbance level	Moderately distyurbed	207.77	91.04	2.28	0.02507*	0.341
	Sligntly disturbed	334.80	105.78	3.17	0.00218**	
	Low disturbed	352.24	106.68	3.30	0.00142**	

Drivers of deforestation in Yayu Coffee Forest Biosphere Reserve.

Field observation in the study sites for the causes of deforestation

Major drivers of deforestation in YCFBR


farm land expansion


grazing intensity


logging and lumber production


Coffee mngmt

development without EIA


Introduction of invasive species

Rock and coal mining


Debarking

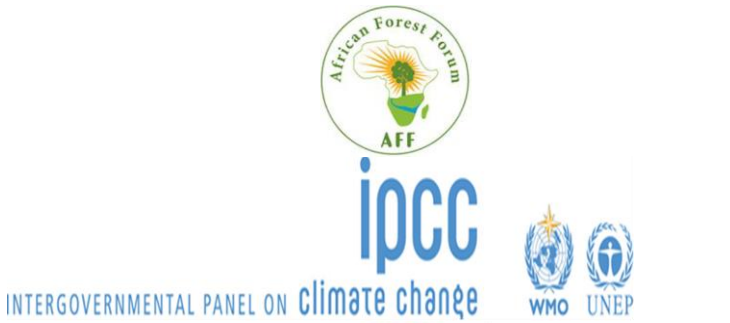
Conclusion

- Anthropogenic disturbance and elevational gradients are the most important factors influencing species and functional diversity in the YCFBR.
- Both selection effects and niche complementarity are important for AGC prediction.
- Conserving species diversity would be the alternative measures for maintaining higher AGC for climate mitigation in the case of YCFBR.
- Major drivers of deforestation in the YCFBR are agricultural farm land, over grazing, logging, coffee management, mining activities etc.

Recommendations

- Core zone protection is highly essential to sustain high plant diversity,
- Mitigating anthropogenic disturbances in transitional zone.
- Zonation-based and communities' livelihood assessments to modify forest management to suit unique needs of each forest zone,
- Introducing PFM and promoting SFM in the area.
- Social and EIA before project implementation in the area
- Alternative livelihoods
- Awareness creation for local communities and
- top level government- to see our findings on the grounds (implementation)

Special Thanks and Acknowledgments:



-Ilu Aba Bora Zonal and District administrators

-EEFCF

-Supervisors

GOD BLESS AFRICA AND ITS PEOPLE!

Thank you all!