Testing Relationship between Forest Cover and Social Inequality

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Motivation

- The purpose of this project is to empirically test the relationship between Environmental Degradation through Forest Resource Quality and Power Inequality.
- Power Inequality Variables taken are - a. difference in literacy rates between males and females; b. the number of NGOs working for the betterment of forests and forest dwelling communities.

Motivation

- Forest Resource Quality indicated as a measure of Canopy Cover where:
    - Very Dense Forested Area - Canopy Cover of Over 70%
    - Moderately Dense Forested Area - Canopy Cover between 40-70%
    - Open Forested Area - Canopy Cover between 10-40%

Motivation

- Significant Difference between the male and female literacy rates for urban vs rural areas. (Literacy and Education, 2014)
- We want to correlate this to increase in forest density implying a more rural area and vice versa.
- A higher education implies more income related opportunities alternative to forest resource extraction.

Motivation

- A higher education level for the head of a household also implies a negative correlation with forest dependency. (Fisher, 2004)
- Education of males is often prioritised over education of females in rural India. (Literacy and Education, 2014)
- Hence there must exist a relationship between the literacy rate between males and females and the forest density.

Motivation

- As stated by (Biswas, 2003), the introduction of the JFM programme saw an influx of forest related NGOs which was one of the positive impacts of the JFM programme.
- We were buoyed by the positive impact of the JFM programme and we believed that the increase in NGO had a hand in that. Thus we hypothesized that the a higher representation of forest based NGOs would imply higher dense forest cover.

Environmental Kuznets Curve (EKC)

- The Environmental Kuznets Curve (EKC) suggests that economic development initially leads to a deterioration in the environment, but after a certain level of economic growth, the relationship between a society and the environment improves and environmental degradation reduces. This is posited by an inverted U-shaped curve.

Environmental Kuznets Curve (EKC)

- Economic development comes with a cost to environment (Shafik, 1992).
- EKC Hypothesis (Dinda, 2004):
  - Initial phase of economic development triggers environmental degradation.
  - Further increase in income(economic development), improve the environment quality in long run.
  - Resulting in a U- shaped graph of Environmental degradation with respect to Income.

Environmental Kuznets Curve

- (Bhattarai & Hammig, 2001; Culas, 2007; Lantz, 2002) considered deforestation as an indicator of environmental degradation and estimated EKC between economic growth and deforestation.
- (Bhattarai & Hammig, 2001) confirmed the EKC relationship for deforestation in Latin America and Africa but not in Asian countries.
- (Chen et al., 2019; Seppälä et al., 2001; Stern, 2004) discuss the limitations of EKC and report the cases where it fails.

Environmental Kuznets Curve

We're taking forest cover density as our variable for environmental degradation, any decrease in very dense + moderately dense forest cover can be seen as a sign of deforestation or alternatively an increase in open forested area can be seen as a sign of urbanization or economic development when seen with a decrease in very dense and moderately dense forest cover in the same time period

Environmental Kuznets Curve

We posit that when measured against SDP, this decrease in forest cover should show some correlation with both densely forested (very dense + moderately dense) and open forested areas

We posit that we might see a positive correlation for very dense + moderately dense forested area and a negative correlation for openly forested area given a change in very dense and moderately dense forested area with sdp.

Literature Review

- (Agarwal, 1992) talks about the lower literacy rate of women due to forest degradation.
- (T, 1993) shows the existence of an inverted U shaped curve when rate of deforestation is plotted against income per capita.

Literature Review

- (Bernard, 2011) case study talks about how illiteracy is the root cause of degradation of biodiversity.
- (India Forestry Outlook Study, 2009) concludes that the deficit of forest products is way more than its demand and hints that this gap would further increase with increase in literacy rate and population.

Literature Review

- Higher education usually provides alternative income earning opportunities that divert from forest resources extraction. While the educational level of the head of the household more often than not has a negative correlation with forest dependance(Fisher, 2004; Inoni, 2009; Kabubo-Mariara, 2013; Vedeld et al., 2007; Yemiru et al., 2010).

Data Summary

- Removed outliers
- No of states: 19 (Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Himachal Pradesh, Punjab, J&K, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttrakhand, West Bengal)
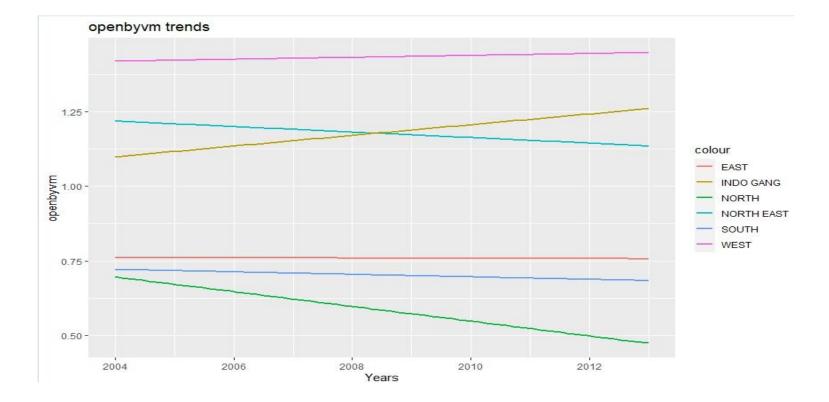- Time duration: 10 years (2004 to 2013)

Variables and their Descriptions

For 19 States over
11 Years (2004-13)

Variable	Type	Description	Acronym
Very Dense Forest + Moderately Dense Forest	Dependent Variable	Percentage of very dense and moderately dense forest in a state	vm
Open Forest	Dependent Variable	Percentage of open forest in a state	o
Open Forest / (Very Dense Forest + Moderately Dense Forest)	Dependent Variable	Ratio of area of open forest to very dense and moderately dense forest in a state	o/vm
Number of ngos	Power Inequality	State-wise number of ngos in forest sector	ngo
Literacy gap between male and female (%)	Power Inequality	State-wise Gap in the Literacy rates of Males and Females	gender_gap
GINI Index (Urban + Rural combined)	Income Inequality	Measure of Inequality Higher value indicates higher inequality	gini
Per capita state domestic product(INR per person)	Income level	Total value of all goods and services produced within a state in a year	sdp
Actual Rainfall in mm	Control	The actual rainfall(in mm) of each state	rainfall

Variable Acronym	N	Mean	Median	SD	Min	Max
vm	190	0.12	0.11	0.09	0.01	0.35
o	190	0.08	0.08	0.04	0.01	0.18
o/vm	180	0.86	0.77	0.32	0.29	1.61
ngo	189	17.40	16.00	11.01	1	45
gender_gap	187	0.19	0.19	0.05	0.06	0.31
gini	175	0.34	0.33	0.07	0.24	0.51
sdp	190	31927	29089	13667.17	7588	69097
rainfall	181	1201.9	1099.0	1102.0	313.6	2534.2

o/vm trend graph for states grouped according to their geographical location

Model

- **Equation 1 (very dense forest + moderately dense forest [vm])**

$$y_{vm,i,t} = \beta_{0,vm,i,t} + \beta_{1,vm,i,t}sdp + \beta_{2,vm,i,t}sdp^2 + \beta_{3,vm,i,t}sdp^3 + \beta_{4,vm,i,t}rainfall +$$
$$\beta_{5,vm,i,t}rainfall^2 + \beta_{6,vm,i,t}gender\_gap + \beta_{7,vm,i,t}gini + \beta_{8,vm,i,t}ngo + \varepsilon$$

- **Equation 2 (open forested area / (very dense forest + moderately dense forest) [o/vm])**

$$y_{\frac{o}{vm},i,t} = \beta_{0,\frac{o}{vm},i,t} + \beta_{1,\frac{o}{vm},i,t}sdp + \beta_{2,\frac{o}{vm},i,t}sdp^2 + \beta_{3,\frac{o}{vm},i,t}sdp^3 + \beta_{4,\frac{o}{vm},i,t}rainfall +$$
$$\beta_{5,\frac{o}{vm},i,t}rainfall^2 + \beta_{6,\frac{o}{vm},i,t}gender\_gap + \beta_{7,\frac{o}{vm},i,t}gini + \beta_{8,\frac{o}{vm},i,t}ngo + \varepsilon$$

- **Equation 3 (open forested area [o])**

$$y_{o,i,t} = \beta_{0,o,i,t} + \beta_{1,o,i,t}sdp + \beta_{2,o,i,t}sdp^2 + \beta_{3,o,i,t}sdp^3 + \beta_{4,o,i,t}rainfall +$$
$$\beta_{5,o,i,t}rainfall^2 + \beta_{6,o,i,t}gender\_gap + \beta_{7,o,i,t}gini + \beta_{8,o,i,t}nga + \varepsilon$$

Where i and t represents state and year respectively. ε represents the error term.

Hypothesis

H_0:

- $\beta_{6,vm} > 0,\ \beta_{6,o/vm} < 0,\ \beta_{6,o} < 0$
- $\beta_{8,vm} > 0,\ \beta_{8,o/vm} < 0,\ \beta_{8,o} < 0$

H_A:

- $\beta_{6,vm} \leq 0,\ \beta_{6,o/vm} \geq 0,\ \beta_{6,o} \geq 0$
- $\beta_{8,vm} \leq 0,\ \beta_{8,o/vm} \geq 0,\ \beta_{8,o} \geq 0$

*Explanation in next slide

Hypothesis Explained

We hypothesize that there exists a relationship between the density of forest cover and the difference in the literacy rate between males and females:

- Increase in Forest density implies a more rural setting and thus a greater literacy rate difference between males and females in patriarchal societies (Literacy and Education, 2014). Thus we hypothesize a greater vm (very dense + moderately dense forest) should positively correlate to a higher gender based literacy gap

Hypothesis Explained

- Meanwhile an increase in open forested area implies a more urban setting and thus an increase in open forested should have a negative correlation with the gender based literacy gap.

- In the same vein, the Number of NGOs working on forest related activities and for forest dwellers should positively correlate with increase in very dense and moderately dense forested area while it should be negatively correlated with open forested area

Hypothesis Explained

- Open Forest Density divided by Very + Moderately Dense Forest (o/vm) signifies the transformation of Very+Moderated Dense Forest into Open Forests due to deforestation. Deforestation also signifies urbanisation, increasing demand for agricultural land, etc. (Shanker, 2018) which further justifies an increase in Open Forested over Very + Moderately Dense Forested area should have a negative correlation with the gender based literacy gap.

Regression Results

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

* The asterisks indicate the significance ranking of the P values

Very + Moderately Dense Forest - vm	Estimate (SE)
sdp	2.05e-05 (6.04e-06) ***
sdp square	-5.08e-10 (1.80e-10) **
sdp cube	4.06e-15 (1.63e-15) *
ngo	-1.60e-03 (4.87e-04) **
gender_gap	3.59e-01 (1.61e-01) *
gini	6.30e-02 (9.26e-02)
rainfall	2.92e-04 (5.22e-05) ***
rainfall square	-8.06e-08 (1.94e-08) ***
N = 175| R-squared = 0.369	p-value: 1.388e-12	

Open Forest - o	Estimate (SE)
sdp	1.36e-05 (3.15e-06) ***
sdp square	-4.16e-10 (9.40e-11) ***.
sdp cube	3.71e-15 (8.52e-16) .***
ngo	-3.45e-04 (2.54e-04)
gender_gap	-6.39e-02 (8.41e-02)
gini	-4.10e-03 (4.83e-02)
rainfall	1.12e-04 (2.72e-05) ***
rainfall square	-2.60e-08 (1.01e-08) *
N = 175| R-squared = 0.394	p-value: 7.147e-14	

o/vm	Estimate (SE)
sdp	-5.57e-05 (2.30e-05) *
sdp square	1.20e-09 (6.74e-10) **.**
sdp cube	-9.42e-15 (6.08e-15)
ngo	8.64e-03 (1.81e-03) ***
gender_gap	-2.32e+00 (8.24e-01) **
gini	-5.24e-01 (3.88e-01)
rainfall	-9.55e-04 (2.76e-04) ***
rainfall square	2.81e-07 (1.00e-07) **
N = 175| R-squared = 0.372	p-value: 8.282e-12	

Results Explained

- $\beta_{6,vm}$ was found to be positive and significant conforming with our null and while $\beta_{6,o}$ was negative, it was found to be insignificant. Meanwhile $\beta_{6,o/vm}$ was also found to be negative in line with our null.

- On the other hand both $\beta_{8,vm}$, $\beta_{8,o/vm}$ had opposite signs to what we expected leading us to reject our null for ngos.

Conclusions

- Slope coefficient for the gender_gap variable in our 1st regression equation (see slide 19) is positive and significant which is in line with our hypothesis that as literacy gap between genders increases the very dense and moderately dense forest cover of a forest also increases.

Conclusions

- Slope coefficient for the gender_gap variable in our 2nd regression equation (see slide 19) was negative and significant which is in line with our hypothesis that as the literacy rate between genders decreases very dense and moderately dense forest tend to transform into open forested area (a sign of development and going from rural to semi-urban) due to deforestation.

Conclusions

- The trend line graph for o/vm is also in line with our hypothesis showing that most of the regions in India (barring Northern and North Eastern regions) are transforming from Very Dense + Moderately Dense Forest into Open Forests due to deforestation especially in the Indo-Gangetic Plains.

Conclusions

- The coefficient of NGO defies our null hypothesis for o/vm and vm signifying that the number of NGOs are predominant in areas of deforestation.
- This might be due to the fact that NGOs are reactive rather than proactive which could imply that NGOs gravitate towards crisis-ridden areas rather than areas where preventive measures might be taken to avoid a crisis in the future.

Validity of EKC

- Results:
  - Very dense+Moderately dense forests(vm) and open forets(o) are increasing with sdp and decreasing with sdp2.
  - Open forests/vm (o/vm) is found to be decreasing with sdp and increasing with sdp2.
- Interpretations:
  - The rate of increase of 'vm' is greater than 'o' with respect to sdp.
  - The rate of increase of 'o' is greater than 'vm' with respect to sdp2.
  - Therefore forest degradation is decreasing with sdp and increasing with sdp2
- EKC relationship does not hold true for forest degradation in our model.

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