Forest cover and Childhood Infections: Analysis of Geospatial and Health Survey Data from Nepal.

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Background: Forest and Human Health

- Infectious diseases causes major disease burden in children – diarrhea and respiratory infections are the leading cause in developing countries (Murray et al 2020).
  - E.g., 14% premature death due to respiratory infection, 13% due to diarrheal diseases
- Environmental risk factors attributable to causes of childhood mortality in low-income countries (Vos et al 2020).
  - 15% due to water and sanitation
  - 8% due to air pollution in low-income countries
- Forest as an ecological source to maintain the environmental determinants of health and disease .

Background: Forest and Human Health

- Ecological perspective - forest provide medium (air and water) for host and disease agent (Bunch 2016).
  - Retain biodiversity – ecosystem balance – reduced pathogenic impact on human.
- Generates ecosystem services such as clean air and water – positive externalities - protection from diseases related to environmental risk (Johnson, Jacob, and Brown 2013).
- Reduced forest cover - migration, urbanization, overcrowding and poor air quality (Berazneva and Byker 2017).
- Reduced forest cover – non forest based low quality biomass fuel, indoor air pollution (Jagger and Shively 2014) .

Background: Forest and Human Health

- Global forest cover extends to 4Bha - 30% of land area .
  - 4.8Mha (33% of land area) in Nepal
- 9.7% (386Mha) decrees in forest cover in the past two decades
  - 1% (46.4Kha) in Nepal
- 27% of forest loss due to urbanization and commodity- driven deforestation
  - 12% of loss due to deforestation in Nepal
- Major infectious disease among children declining as well
  - 19% of premature death due to respiratory infection, 4% due to diarrhea
  - Sharpe decline in the disease burden in the past two decades

Previous Related Work

- Forest and vector born diseases (e.g., malaria): Represent tropical countries with mixed results.
  - E.g., reduced probability of malaria incidence in Indonesia (Garg 2019) vs no effect in Africa (Bauhoff and Busch 2020).
- Forest and other health issues: Negative impact of deforestation, still mixed results.
  - E.g., Poor nutrition status among children living in deforestation areas (Johnson et al 2013) vs no effect on infectious diseases (Berazneva and Byker 2017).
- Additional new evidence from Nepal with focus on childhood infection.

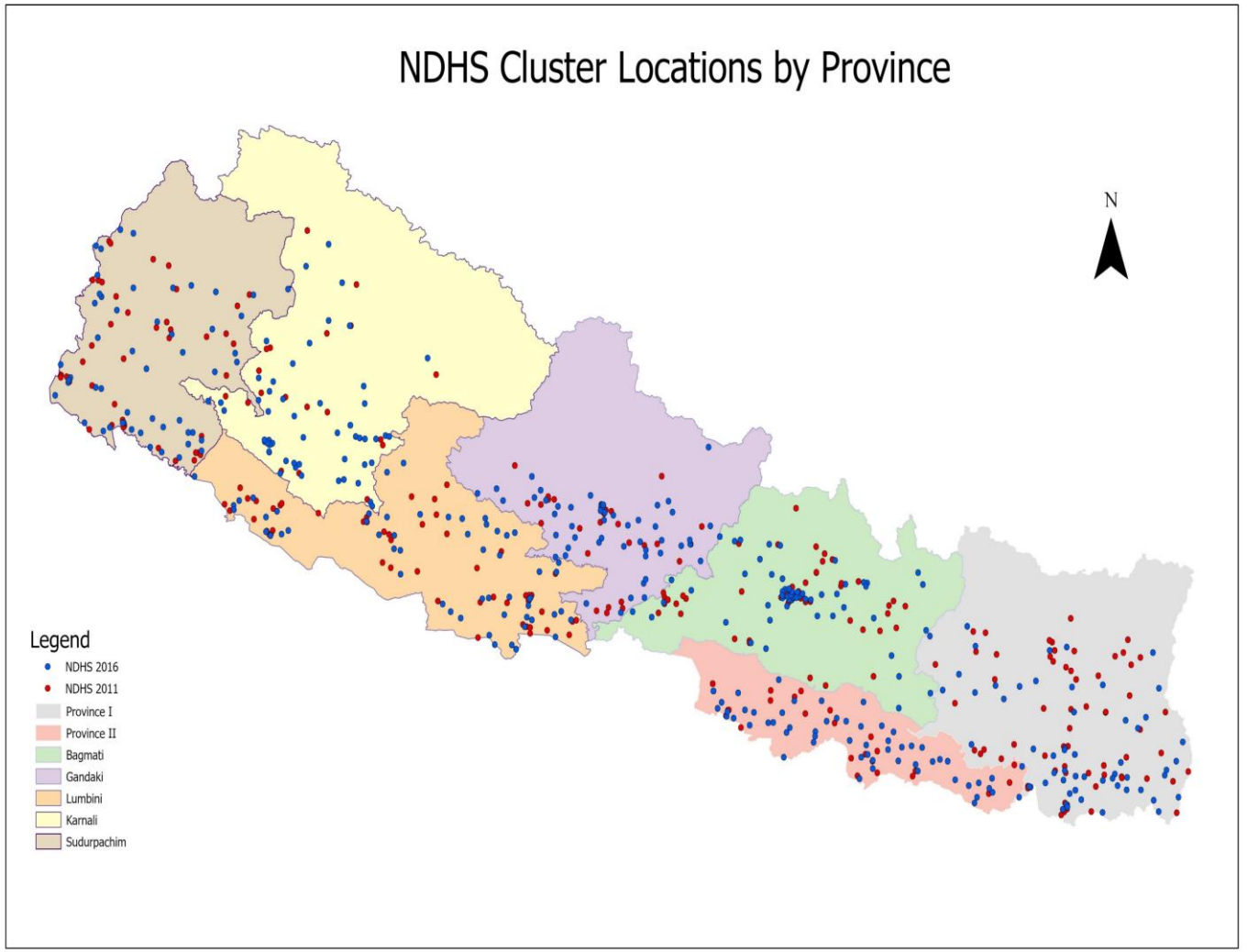
Objective

This study applied DHS dataset along with GIS tools to examine how forest cover contribute to infection symptoms (fever, diarrhoea and respiratory infection) among under 5 children in Nepal. The study objectives were to;

- Examine whether forest cover reduces infection symptoms among under 5 children in the year 2011 and 2016.
- Ascertain if the probability of infection symptoms changed between 2011 and 2016

Method: Dataset

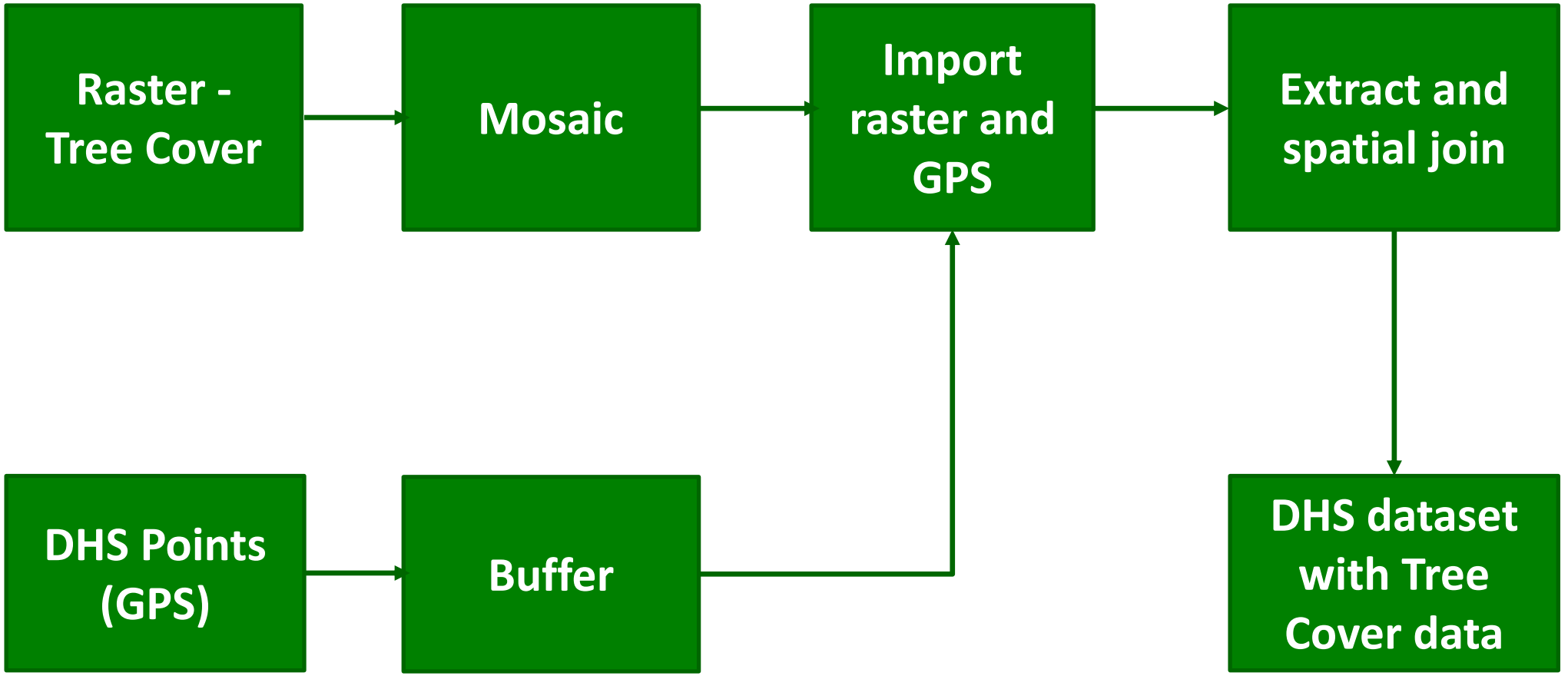
- Dataset: Nepal Demographic and health Survey (NDHS) 2011 and 2016: nationally representative cross-sectional survey conducted using two staged cluster sampling design
- NDHS 2011 - 289 clusters from 13 sub-region, 10826 household interviewed, 12674 eligible women, 5054 under 5 children.
- NDHS 2016 – 383 clusters from 7 province, 11040 households interviewed, 12862 eligible women, 4861 under 5 children.
- Mothers were asked to recall if their child had symptoms of infection (fever, respiratory illness and diarrhoea) within past two weeks preceding the survey.



Method: GIS Tool

- DHS data combined with GIS tools
- GIS data from satellite images
- Tree cover raster available from NASA Earthdata Search. – 30m resolution
- Raster available for 2011 and 2016.
  - Based on Global Land Survey Data, Digital Elevation Model and MODIS VCF tree cover layer (Townshend 2016: Sexton et al 2016).
- Other GIS covariates available from the DHS GIS data.

Method: Analysis Approach

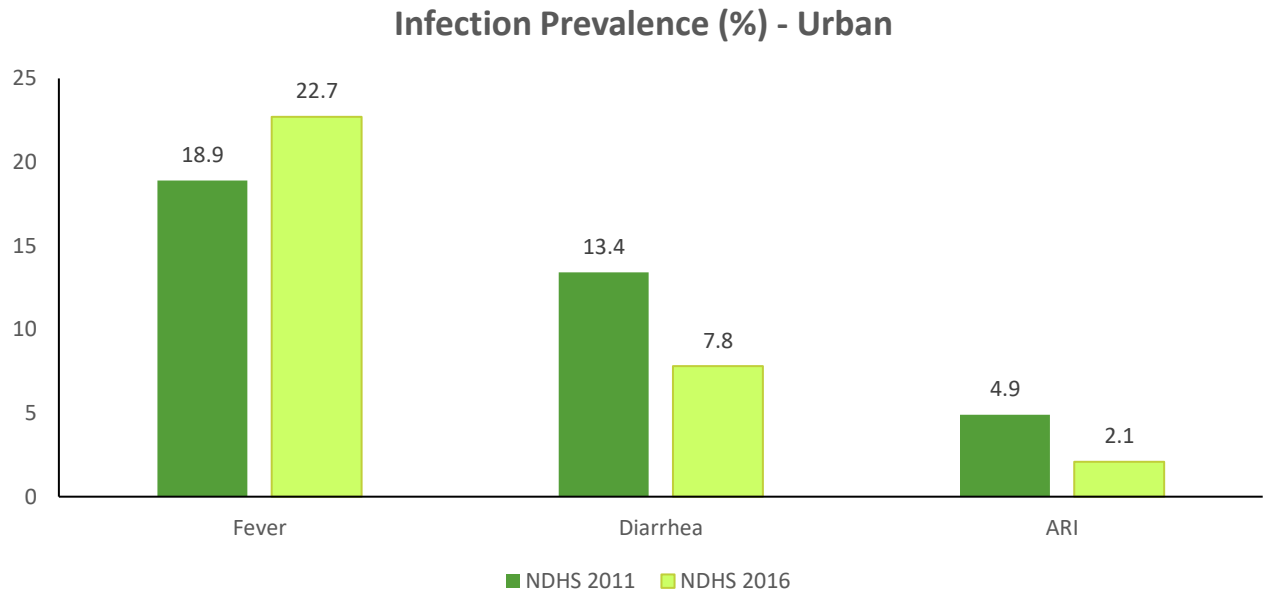


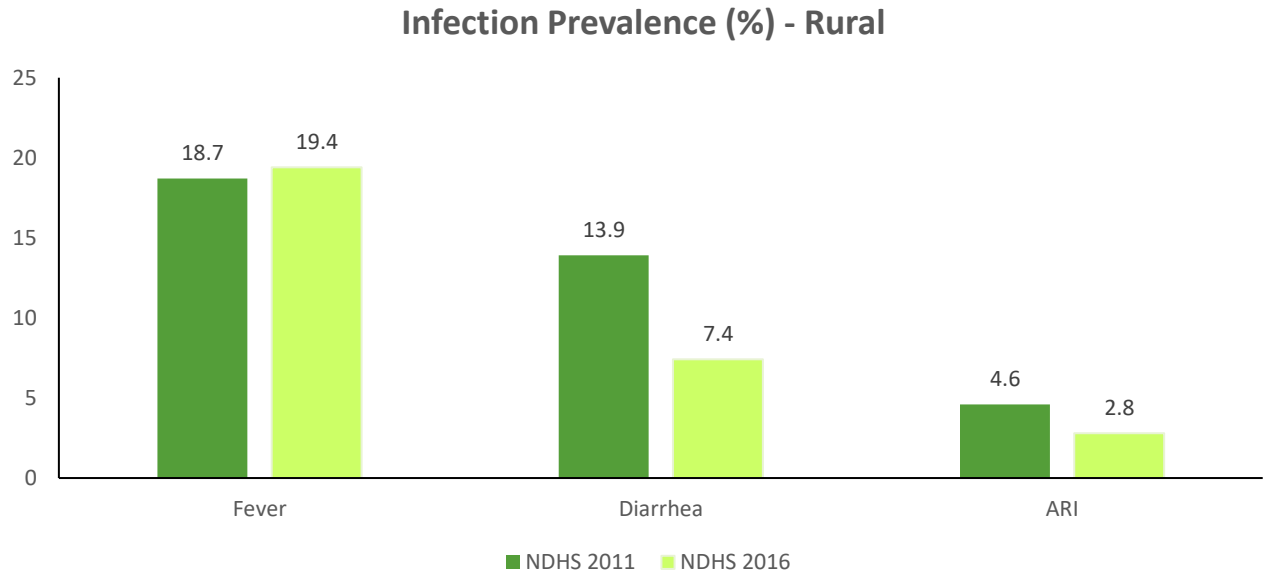
Outcome variable	
Fever	Had fever in the past 2 weeks preceding the survey
Respiratory symptoms	Had cough difficulty in breathing and shortness of breath in the past 2 weeks preceding the survey
diarrhoea	Had diarrhoea in the past 2 weeks preceding the survey
Explanatory Variable	
Forest Cover	Tree cover percentage within DHS buffer of 2km for rural and 10km for rural buffer
Control Variables	
Household (HH) Characteristics	Place of residence, ethnicity, religion, family size, own animal, wealth index and ecological region
Mother & child (MCH) characteristics	Child age, child sex, mother's education, mother's access to media, birth order and birth size
HH Environment	Improved source of drinking water, improved sanitation facility, water treatment, handwashing facility, no of rooms for sleeping, indoor smoking, indoor cooking, firewood cooking and floor type

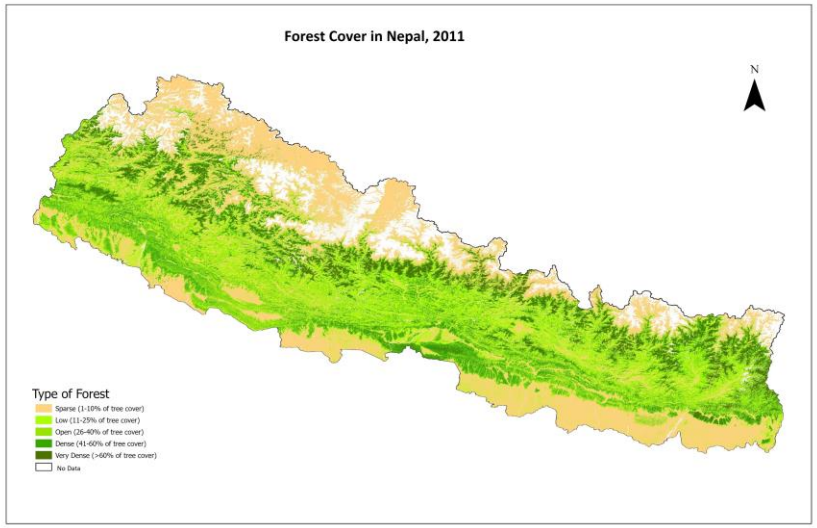
Method: Probit Model

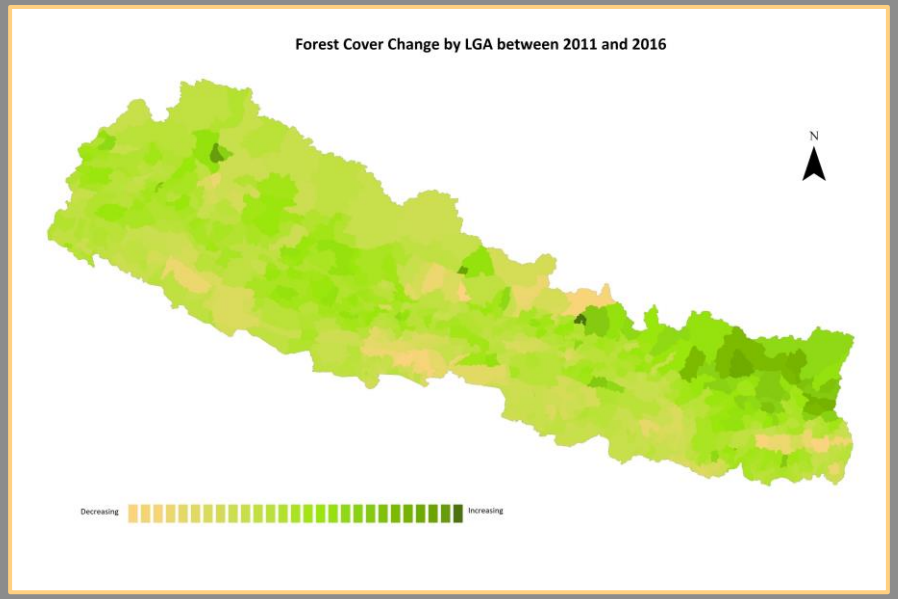
- $\mathrm{P}(\mathrm{Infection} = 1|\mathrm{X}) = \Phi(\beta_0 + \beta_1 \mathrm{fcover} + \beta_2 \mathrm{hhc} + \beta_3 \mathrm{mch} + \beta_4 \mathrm{hhenvironment})$
  - Infection is a binary outcome which takes a value of 1 for infection symptoms: i.e., respiratory infection (cough with short rapid breathing), diarrhoea, fever; and 0 otherwise
  - *fcover* is the % of tree cover within 2km (Urban) and 10km (Rural) buffer of DHS cluster
  - *hhc* is a vector of household socio-demographic characteristics
  - *mch* is a vector of maternal and child health characteristics
  - hhenvironment is a vector of household environmental characteristics

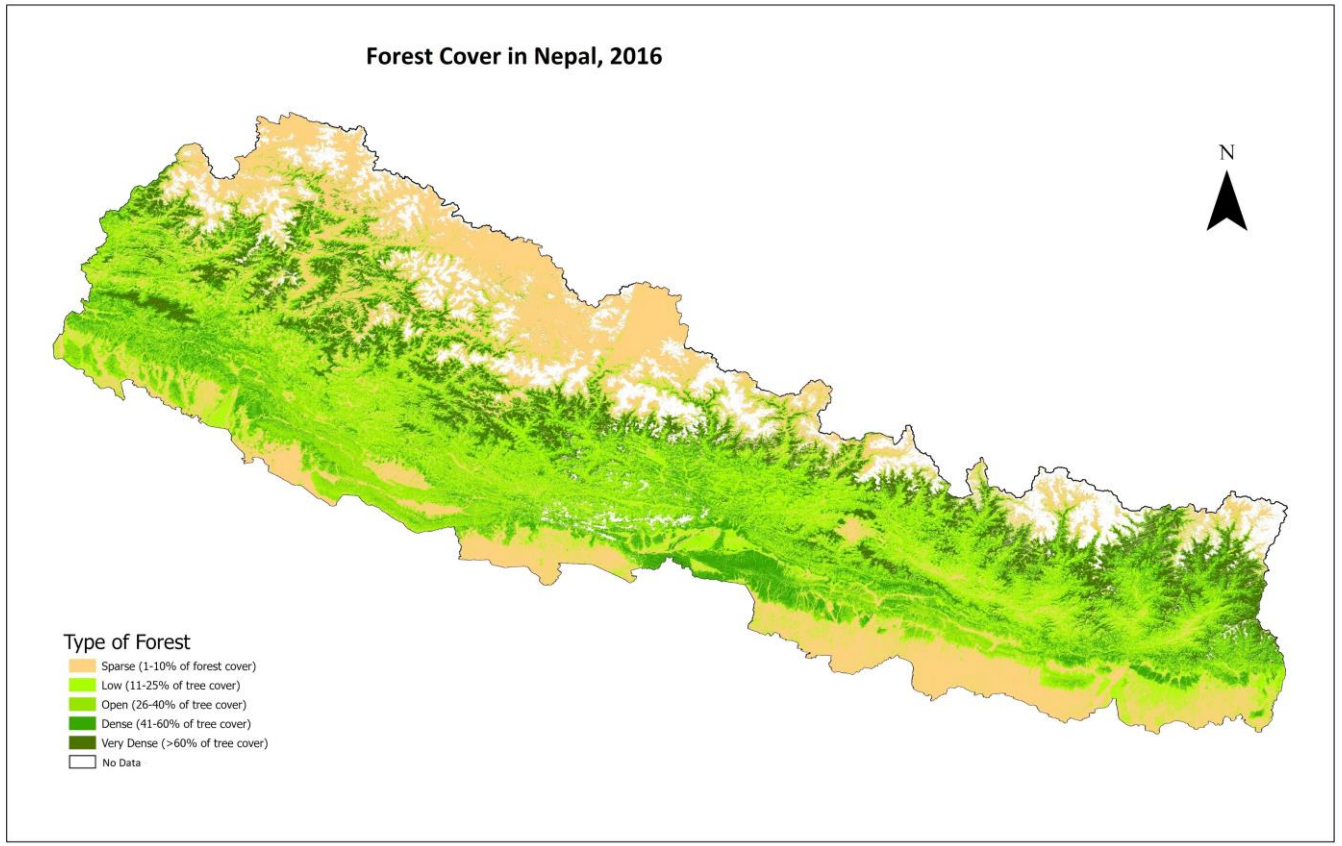
Major Findings






Forest Cover in Nepal, 2011
N
Type of Forest
Sparse (1-10% of tree cover)
Low (11-25% of tree cover)
Open (26-40% of tree cover)
Dense (41-60% of tree cover)
Very Dense (>60% of tree cover)
No Data


Forest Cover Change by LGA between 2011 and 2016
N
Decreasing
Increasing


Forest Cover in Nepal, 2016
N
Type of Forest
Sparse (1-10% of forest cover)
Low (11-25% of tree cover)
Open (26-40% of tree cover)
Dense (41-60% of tree cover)
Very Dense (>60% of tree cover)
No Data

Major Findings

- Forest cover is associated with the likelihood of reduced diarrhoea symptoms
- Holding other variables at their mean, an addition to forest cover reduces the probability of diarrhoea symptoms in children by 3.39%, ($f'(x)$: -0.0339, 95%CI -0.0141, -0.0535, p-value: 0.001).
- Forest cover is negatively associated with the likelihood of fever and positively associated with the likelihood of respiratory symptoms, but the associations are not statistically significant.
- Probability of symptoms decreased by 6.5% and 2.8% for diarrhoea and respiratory infection respectively between the year 2011 and 2016. Significant at 0.01.

Table 2: Predicted Probability of infection symptoms due to forest cover, NDHS 2011 and NDHS 2016

	NDHS 2011			NDHS 2016		
	Fever	Diarrhea	ARI	Fever	Diarrhea	ARI
Forest Cover	-0.0011	-0.0618**	0.0082	-0.0126	-0.01**	0.0049
	(0.017)	(0.018)	(0.007)	(0.016)	(0.008)	(0.007)
HH Control	Yes	Yes	Yes	Yes	Yes	Yes
MCH Control	Yes	Yes	Yes	Yes	Yes	Yes
Environmental Control	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R2	0.0313	0.0571	0.0421	0.0146	0.0316	0.0388
Correctly Classified %	82	86.48	95.27	79.51	93.04	97.46
No of Observation	5022	5023	5049	4822	4814	4848

Table 3: Predicted Probability of infection symptoms due to forest cover, Pooled Analysis

	(1)	(2)	(3)
Forest Cover	-0.0026	-0.0339***	0.0045
	(0.011)	(0.010)	(0.007)
2016-2011	0.0081	-0.0646***	-0.0238***
	(0.001)	(0.007)	(0.005)
HH Control	Yes	Yes	Yes
MCH Control	Yes	Yes	Yes
Environmental Control	Yes	Yes	Yes
Pseudo R^2	0.021	0.0592	0.0413
Correctly Classified %	80.78	89.69	96.34
No of Observation	9844	9837	9897

Estimates reported for (1) fever, (2) for diarrhoea, (3) respiratory infection, *** significant at p-value <0.01, ** at p-value <0.05. Values in the parenthesis are robust standard error.

Conclusion

- Forest cover is associated with the likelihood of reduced diarrheal symptoms, but the probability around 3.4%- this is a naïve estimation
- Several limitations – infection symptoms are self reported subjected to bias. E.g., diarrheal morbidity higher in children of literate and socioeconomically better-off women – due to symptoms reporting (Manesh et al 2008).
- DHS point displacement and its influence on raster analysis – based on assigning spatial variables to the survey participants due to positioning errors (Thomson et al 2019: Grace et al 2019).
- Ways forward: use forest data from other source (Hansen et al 2013) – includes yearly forest loss and forest gain data, combined with provincial/district level panel data on morbidity rates

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Thank You !

Table 1A:Summary Statistics of variables used in the study

	NDHS 2011 (N = 5054)		NDHS 2016 (N = 4861)		Pooled (N = 9915)			
Variables	mean	Std Error	mean	Std Error	mean	Std Error	mean diff	Std Error
Fever	0.18	0.0054	0.20	0.0058	0.19	0.0040	-0.024	0.0079
Diarrhea symptoms	0.14	0.0048	0.07	0.0037	0.10	0.0031	0.065	0.0061
ARI symptoms	0.05	0.0030	0.03	0.0023	0.04	0.0019	0.022	0.0037
Tree cover percentage	21.14	0.1370	19.34	0.1588	20.25	0.1050	1.792	0.2089
Place of residence	1.79	0.0057	1.43	0.0071	1.61	0.0049	0.364	0.0091
Ethnicity (Disadvantaged)	0.60	0.0069	0.64	0.0069	0.62	0.0049	-0.048	0.0097
Religion (Non-Hindus)	0.15	0.0050	0.13	0.0049	0.14	0.0035	0.013	0.0070
Family size	6.14	0.0390	6.20	0.0421	6.18	0.0287	-0.067	0.0571
Households have animal	0.78	0.0059	0.80	0.0057	0.79	0.0041	-0.028	0.0082
Wealth Index	1.79	0.0125	1.84	0.0126	1.81	0.0089	-0.048	0.0177
Ecological region	2.22	0.0105	2.41	0.0093	2.31	0.0071	-0.191	0.0139
Child sex	0.52	0.0071	0.53	0.0072	0.52	0.0050	-0.010	0.0100
Child age (months)	29.83	0.2440	29.59	0.2492	29.63	0.1743	0.244	0.3475
Mother education	3.63	0.0572	5.01	0.0620	4.30	0.0427	-1.376	0.0841

Table 1B:Summary Statistics of variables used in the study

	NDHS 2011 (N = 5054)		NDHS 2016 (N = 4861)		Pooled (N = 9915)			
Variables	mean	Std Error	mean	Std Error	mean	Std Error	mean diff	Std Error
Mother access to Media	0.58	0.0070	0.52	0.0072	0.55	0.0050	0.059	0.0100
Birth order	2.59	0.0253	2.27	0.0219	2.43	0.0169	0.324	0.0333
Birth size	1.99	0.0085	2.02	0.0083	2.01	0.0059	-0.025	0.0118
Water source (improved)	0.83	0.0053	0.94	0.0033	0.89	0.0032	-0.116	0.0062
Sanitation facility (Improved)	0.47	0.0070	0.81	0.0056	0.64	0.0048	-0.346	0.0090
Water treatment	0.13	0.0048	0.19	0.0056	0.16	0.0037	-0.055	0.0074
Handwashing facility	0.37	0.0068	0.39	0.0070	0.38	0.0049	-0.020	0.0098
No of sleeping rooms	2.13	0.0163	2.45	0.0195	2.29	0.0128	-0.317	0.0254
Food cooked in firewood	0.77	0.0059	0.69	0.0067	0.73	0.0045	0.082	0.0089
Indoor cooking	0.43	0.0070	0.31	0.0067	0.37	0.0049	0.125	0.0096
Indoor smoking	0.60	0.0069	0.49	0.0072	0.55	0.0050	0.113	0.0099
Floor material (dirt)	0.75	0.0061	0.71	0.0066	0.73	0.0045	0.047	0.0089