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The Link between Poverty Incidence, Forest Factors, and Non-Forest Factors in the Prek Thnot Watershed within Kompong Speu, Cambodia

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Abstract: **The Prek Thnot Watershed is in danger of losing its protective role and ability to alleviate poverty due to the harmful activities it is facing. This paper was conducted to determine the link between poverty incidence, Forest Factors, and Non-Forest Factors, which could be a basis for policy implementation. All 49 communes in the Prek Thnot Watershed within Kompong Speu were involved. The Commune Database, Open Development Cambodia, and Google Earth were used to collect data for computing poverty incidence using a modified multidimensional poverty index; conducting a Sign Test; determining the spatial autocorrelation of poverty incidence, and the condition of communes in terms of Forest and Non-Forest Factors; and producing an OLS regression model. Interestingly, results showed that forest area reduces poverty incidence by 0.08 counts, whereas community-based natural resource management and infrastructure density raises poverty incidence by 0.38 and 0.51 counts, respectively. The effects of: *forest area* was attributed to the behavior that forest-based enterprises are situated in the Southeast but acquire their resources from the West; *CBNRM* indicates a problem on policy-implementation; and *infrastructure density* denotes that the abundant infrastructures in the East and Southeast failed to offset poverty due to the presence of several landless migrants situated in the same area. In conclusion, there is a need to properly implement forestry, land concession, and CBNRM policies; and provide training to farmers, business-owners, and prospecting entrepreneurs. However, applying these suggestions does not guarantee full effectiveness due to the presence of strong spatial autocorrelation of poverty incidence.**

Keywords: **Cambodia, OLS regression, poverty incidence, Prek Thnot Watershed, spatial autocorrelation.**

I. INTRODUCTION

Safeguarding the Prek Thnot Watershed is vital for it is rich in natural resources, which benefit communities that are located downstream through ecosystem goods and services, as well as sources of livelihood. The basin is currently in danger of deforestation due to persistent logging and migration of people, which hamper its protective role [1]. Furthermore, the Global Environmental Facility (GEF), together with the Ministry of Agriculture, Forestry, and Fisheries (MAFF) in 2011 emphasized that the on-going destruction of the watershed´s resources impedes its ability to alleviate poverty [2].

Forest degradation and poverty in the site can be separately or jointly addressed. However, finding the more effective method requires determining the link between forests and poverty beforehand. The forest-poverty nexus has been justified through studies in Indonesia [3], Brazil [4], and Malawi [5]. Previous papers also included factors that influence poverty, such as forest canopy cover and forest proximity [3]; forest area [6]; land used by farmers [5]; land used by concessioners

[7],[8]; forest-based enterprises [9]; community-based natural resource management [10],[11]; and infrastructures, services, vulnerable residents, and landless migrants [4]. Despite the attempt to link forests and poverty, past works contained some gaps that should be considered in future research. These include the lack of robust data to support the observations and claims that deprived individuals are situated in forests [3]; the unsolved uncertainty on the causality of "forest loss and forest poverty" [12]; and the failure to properly differentiate "forest canopy cover" and "forest area". More so, there is little literature available regarding the topic in Cambodia. The frameworks of the studies are only limited to the effects of economic land concessions on the livelihoods of community members. To some extent, this study complements the shortfall and widens the understanding of the relationship between poverty incidence (calculated by means of a modified multidimensional poverty index formula), Forest Factors (characteristics of communes in terms of forest canopy cover, forest area, and proximity to a forest), and Non-Forest Factors (characteristics of communes in terms of land used by farmers and concessioners, involvement of families in forest-based enterprises, presence of community-based natural resource management, presence of infrastructure and services, and presence of vulnerable residents and landless migrants) in the Prek Thnot Watershed within Kompong Speu by determining the significant difference among communes, measuring spatial autocorrelation, determining the forest and non-forest characteristics of the communes, and conducting an OLS regression analysis.

II. OBJECTIVES

The overarching goal of this paper is to measure the relationship between poverty incidence, Forest Factors, and Non-Forest Factors in the Prek Thnot Watershed within Kompong Speu. It specifically aims to determine the poverty condition of communes; determine the characteristics of the communes in terms of Forest Factors and Non-Forest Factors; and quantify the association between poverty incidence, Forest Factors, and Non-Forest Factors of the site.

III. RESEARCH METHODOLOGY

This study included all 49 communes in the Prek Thnot Watershed within Kompong Speu for the reason that the province covers the majority or 77.8% of the basin. Prior to proceeding to the data analysis, the poverty incidence of each commune was calculated by modifying the multidimensional poverty index (MPI) formula developed by the Oxford Poverty and Human Development Initiative (OPHDI) and the United Nations Development Programme (UNDP). The tailored formula comprised of eight indicators (child mortality, upper secondary level unenrolment, lower secondary level enrolment, sanitation, water, electricity, roofing, and assets) -- it should be noted that such procedure is acceptable since the OPHI highlighted that different indicators may be used, given that it is "appropriate to the society and situation" [13]. Each MPI indicator was divided into quartiles then were recoded into scores that ranged from zero to three (zero for "not deprived", one for "mildly deprived", two for "moderately deprived", and three for "severely deprived"). The quartiles of the indicators that increase poverty incidence (child mortality, upper secondary unenrollment, houses without latrines, and houses with thatched roofs) were recoded as "4" to "3", "3" to "2", "2" to "1", and "1" to "0". This is because as the quartile increases, the more deprived a commune is. On the other hand, the quartiles of the indicators that decrease poverty incidence (lower secondary enrollment, water, electricity, and assets) were recoded as "4" to "0", "3" to "1", "2" to "2", and ""1 to "3". The scores were then multiplied with their designated weights (child mortality, 0.222; upper secondary level unenrolment, 0.222; lower secondary level enrolment, 0.222; sanitation, 0.067; water, 0.067; electricity, 0.067; roofing, 0.067; and assets, wherein its five components were weighted with 0.013 each). The assigned weights were calculated by first, adding the original weights of all indicators under Education and Health, then dividing the sum by three and assigning the result to *child mortality, upper secondary level unenrolment,* and *lower secondary enrolment.* Second, the original weights of the indicators under Standard of Living were added, then divided by five and assigning the result to *sanitation, water, electricity, roofing,* and *assets.* The weights of the five components under *assets,* however, were calculated by dividing 0.067 by 5. Afterwards, the weighted scores of each indicator per commune were added together to determine the poverty incidence. Lastly, the boundary for classifying the communes was calculated by subtracting the lowest poverty incidence value from the highest then divided by two. Communes with poverty incidence greater than or equal to 1.0725 were categorized as "MPI Poor", and "Not MPI Poor" if otherwise.

The significant difference among the communes in terms of poverty incidence was identified using the Sign Test (also known as the binomial sign test), which is a non-parametric test to verify if the observations are normally distributed. Afterwards, it was only fitting to apply Tobler´s First Law of Geography, which states that, "Everything is related to

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everything else, but near things are more related than distant things". This was done by measuring the spatial autocorrelation among communes in terms of poverty incidence using SAGA GIS.

Spatial data for: (1) forest canopy cover, categorized into the amount of forest area with canopy cover of less than 50% and amount of forest area with canopy cover of above 50%; (2) forest area; and (3) proximity of a commune to a forest were obtained using Google Earth Pro and SAGA GIS. All these factors are known to aggravate poverty [4],[5],[6],[12]. Secondary data in 2010, on the other hand, were collected for land used by farmers and concessioners, forest-based enterprises (FBEs), community-based natural resource management (CBNRM), infrastructures and services, vulnerable residents, and landless migrants from the Commune Database (CDB) and Open Development Cambodia (ODC). Land used by farmers is the amount of land area covered for crop production, whereas land used by concessioners are areas operated by land concessioners. These activities are known to worsen poverty since they hamper forests from serving as safety nets and providing revenue [9], and hinder locals in accessing to natural resources [8], respectively. Participation of families in FBE´s, the granting of CBNRM, and the presence of infrastructures and services in the communes alleviate poverty. This is because forest products hold high economic value for income generation [9]; and CBNRMs provide land tenure to the communities [7], as well as enhance their bargaining power and create economies of scale [4]. More so, Sunderlin, et al. (2008) stated that infrastructure and services are uncommonly located in remote areas, which cause people to be deprived. Lastly, the presence of vulnerable residents and landless migrants do not aid in resolving poverty based on the study conducted by Sunderlin, et al. (2008), since the association of these forest-dependents and poverty are due their perception of forests as a means of last resort and agricultural purposes.

The characteristics of the communes in terms of Forest Factors and Non-Forest Factors were determined using descriptive statistics, which was then followed by an OLS regression analysis.

IV. RESULTS AND DISCUSSIONS

A. Health, Education, and Living Standards:

The interesting characteristics of the study site are the small number of recorded deaths of children below five years of age, which implies that it was generally safe to raise a child in the area; and that several youths had managed to obtain lower secondary education. Despite these, there were still a large number of teenagers that failed to have the level of education they should have acquired, which could imply that parents of those minors prioritized other matters over the academic development of their children; the quantity of houses without latrines were large, indicating the communes´ disregard for proper sanitation; and the numerous recorded television sets more than possible income-generating vehicles indicated that the communes value leisure over efficiency.

TABLE I: DESCRIPTIVE STATISTICS FOR HEALTH, EDUCATION, AND LIVING STANDARDS

Variable	obs	Mean	Std. Dev.	Min	Max
HealthMortality	49	1.306122	1.341704	0	5
UpSecUnenrol	49	165.3469	90.20314	23	491
LowSecEnrol	49	579.9184	249.1396	180	1321
Sanitation	49	1198.082	602.7784	49	3155
Water	49	156.3469	370.8795	0	2211
Electricity	49	268.9388	443.3302	0	2225
Roofing	49	266.7551	286.8402	27	1716
TV	49	1227.98	621.6011	219	2758
Bikes	49	1163.347	558.2087	268	2491
Motorbikes	49	853.6327	445.088	218	2102
Tricycles	49	1.795918	2.415053	0	13
Trucks	49	27.73469	21.09974	1	93

B. Poverty Incidence:

The results showed that 83.67% of the communes are MPI Poor and that the five most destitute were Tang Samraong (2.419), Thommada Ar (2.315), Chambak (2.151), Sangkae Satob (2.151), and Khtum Krang (2.119).

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TABLE II: POVERTY INCIDENCE AND MPI CLASSIFICATION

Code	Commune	Poverty Incidence	MPI Classification	Code	Commune	Poverty Incidence	MPI Classification
38	Tang Samraong	2.419	MPI Poor	46	Tumpoar Meas	1.614	MPI Poor
40	Thommoda Ar	2.315	MPI Poor	26	Roleang Chak	1.588	MPI Poor
2	Chambak	2.151	MPI Poor	23	Reaksmei Sameakki	1.552	MPI Poor
31	Sangkae Satob	2.151	MPI Poor	21	Prey Nheat	1.538	MPI Poor
9	Khtum Krang	2.119	MPI Poor	47	Veal	1.510	MPI Poor
43	Trapeang Chour	2.093	MPI Poor	45	Tuek L'ak	1.474	MPI Poor
13	Krang Dei Vay	2.029	MPI Poor	44	Trapeang Kong	1.466	MPI Poor
49	Yea Angk	1.977	MPI Poor	29	Saen Dei	1.463	MPI Poor
36	Ta Sal	1.895	MPI Poor	19	Preah Nipean	1.424	MPI Poor
28	Rung Roeang	1.830	MPI Poor	11	Krang Ampil	1.399	MPI Poor
18	Prambei Mum	1.809	MPI Poor	41	Toap Mean	1.397	MPI Poor
30	Samraong Tong	1.776	MPI Poor	16	Pechr Muni	1.392	MPI Poor
32	Skuh	1.745	MPI Poor	5	Dambouk Rung	1.384	MPI Poor
6	Haong Samnam	1.740	MPI Poor	22	Prey Rumduol	1.371	MPI Poor
42	Traeng Trayueng	1.734	MPI Poor	1	Angk Popel	1.340	MPI Poor
17	Pneay	1.672	MPI Poor	39	Tang Sya	1.293	MPI Poor
27	Roleang Kreul	1.667	MPI Poor	33	Sopoar Tep	1.214	MPI Poor
37	Tang Krouch	1.649	MPI Poor	4	Chumpu Proeks	1.196	MPI Poor

TABLE II: (CONTINUED)

Code	Commune	Poverty Incidence	MPI Classification	Code	Commune	Poverty Incidence	MPI Classification
14	Moha Sang	1.195	MPI Poor	10	Kiri Voan	0.850	Not MPI Poor
8	Kandaol Dom	1.175	MPI Poor	34	Srang	0.836	Not MPI Poor
15	Ou	1.174	MPI Poor	25	Roka Thum	0.679	Not MPI Poor
20	Prey Krasang	1.110	MPI Poor	3	Chbar Mon	0.576	Not MPI Poor
12	Krang Chek	1.073	MPI Poor	35	Svay Kravan	0.274	Not MPI Poor
48	Voa Sa	1.035	Not MPI Poor				
7	Kahaeng	0.997	Not MPI Poor				
24	Roka Kaoh	0.857	Not MPI Poor				

C. Significant Difference Among Communes:

The Sign Test results (TABLE III) show that the number of observations located positive and negative to the median poverty incidence of 1.466 are 25 and 24, respectively, implying non-normal distribution. The significance of this outcome can be verified by referring to the p-values of the one-sided and two-sided tests, of which are all greater than an alpha of 0.05. Thus, we cannot reject the null hypothesis that poverty incidence among communes are normally distributed.

TABLE III: SIGN TEST RESULTS

sign	observed	expected
positive	25	24.5
negative	24	24.5
zero	0	0
all	49	49

One-sided tests:
Ho: median of PovInc - 1.466 = 0 vs.

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```
  Ha: median of PovInc - 1.466 > 0
       Pr(#positive >= 25) =
            Binomial(n = 49, x >= 25, p = 0.5) =  0.5000

  Ho: median of PovInc - 1.466 = 0 vs.
  Ha: median of PovInc - 1.466 < 0
       Pr(#negative >= 24) =
           Binomial(n = 49, x >= 24, p = 0.5) =  0.6123

Two-sided test:
  Ho: median of PovInc - 1.466 = 0 vs.
  Ha: median of PovInc - 1.466 != 0
       Pr(#positive >= 25 or #negative >= 25) =
           min(1, 2*Binomial(n = 49, x >= 25, p = 0.5)) =  1.0000
```

D. Spatial Autocorrelation:

Since the Sign Test results assert that poverty within the study site does not vary, it is best to complement the outcome with a deeper investigation by measuring the spatial autocorrelation of poverty incidence. The Moran´s I of 0.986 in Table IV indicate that poverty incidence is, in fact, highly clustered.

TABLE IV: SPATIAL AUTOCORRELATION RESULTS

GRID	CONTIGUITY	MORAN_I	NEIGHBORS	NCELLS	MEAN	VARIATION	SUM
Poverty Incidence (2017-06-04) [PovInc]	Queen's case	0.986197	4315962	2076481	1.763678	251711.2	515959.7

E. Condition of the Communes in Terms of Forest Factors and Non-Forest Factors:

Forest Factors. The results in TABLE V showed that there are more dense forests than open forests in the study site; and that the commune situated nearest to a forest has a proximity of 95.86 kilometers, whereas the commune farthest to a forest has a distance of 31,519.69 kilometers.

Non-Forest Factors. TABLE VI and TABLE VII indicate that despite the modest number of operating business establishments in the study site, the overall condition of the communes in terms of Non-Forest Factors is still alarming. This is because the land occupied by the concessioners was more than five times than that of the farmers; the families involved in forest-based enterprises were low, indicating the unattractiveness of FBEs to the people; the high number of communes that did not have CBNRMs; the minimal density of infrastructures present in the communes, implying the lack of government projects or investments in the study site; and the large number of landless migrants.

TABLE V: DESCRIPTIVE STATISTICS FOR FOREST FACTORS

Variable	Obs	Mean	Std. Dev.	Min	Max
R1	48	3371.482	7353.213	0	45613.77
R2	48	2735.289	10222.09	0	67928.23
FA	47	6236.702	17479.84	1	113542
FP	48	13441.84	10164.17	95.86	31519.69

TABLE VI: DESCRIPTIVE STATISTICS FOR NON-FOREST FACTORS

Variable	Obs	Mean	Std. Dev.	Min	Max
LUF	49	246.3918	1279.147	0	8888.8
LUC	49	2148.898	7737.029	0	49913
FBE	49	7.632653	41.50135	0	291
TIF	48	3.145833	1.091351	2	6
SP	49	108.7551	93.10691	9	585
tvr	49	18.38776	4.256448	11	26
LM	49	15.65306	33.58171	0	205

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TABLE VII: DESCRIPTIVE STATISTICS FOR CBNRM

```
count if CBNRM==0
38
count if CBNRM==1
11
```

F. Relationship Between Poverty Incidence, Forest Factors, and Non-Forest Factors:

An OLS regression diagnostics was used to create a model that could strongly determine the factors that influence poverty incidence. During the analysis, there was a need to create two interaction variables, namely, "Total Infrastructure Density" (TIF) (combination of road density and bridge density) and "Total Vulnerable Residents" (TVR) (all types of vulnerable people merged together) to maintain the components under infrastructure and forest-dependents in the model. The process ruled out problems on multicollinearity; outliers, leverage, and influence; non-linearity; non-normality; heteroskedasticity; and model misspecification.

$$Poverty\ Incidence = 0.42 - 0.08FA + 0.02FP + 0.10LUF + 0.03\ LUC + 0.38\ CBNRM + 0.51\ TIF - 0.09\ SP \quad (1)$$

TABLE VIII: OLS REGRESSION RESULTS

Source	SS	df	MS		Number of obs	=	10
Model	0.229132	7	0.032733		F (7, 2)	=	147.1
Residual	0.000445	2	0.000223		Prob > F	=	0.0068
Total	0.229577	9	0.025509		R-squared	=	0.9981
					Adj R-squared	=	0.9913
					Root MSE	=	0.1492
lnPovInc	Coef	Std. Err.	t	P>|t|	[95% Conf. Interval		
lnFA	-0.07899	0.014199	-5.56	0.031	-0.14008		-0.0179
lnFP	0.01821	0.005227	3.48	0.073	-0.00428		0.040699
lnLUF	0.104699	0.00872	12.01	0.007	0.067179		1.422199
lnLUC	0.031543	0.006673	4.73	0.042	0.002831		0.060254
_ICBNRM_1	0.381509	0.013775	27.7	0.001	0.322241		0.440777
lnTIF	0.51342	0.035643	14.4	0.005	0.360062		0.666779
lnSP	-0.09065	0.009097	-9.97	0.01	-0.12979		-0.05151
_cons	0.421076	0.102681	4.1	0.055	-0.02072		0.862876

The OLS regression results state that:

- *The proximity of commune to a forest increases poverty incidence by 0.02 counts*. Although forests are known to contain resources that can yield economic benefits, other inputs are also needed. Therefore, the outcome that a commune´s distance from a forest aggravates poverty incidence could be an indicator of the meager supply of assets for production in zones proximate to forested areas. It should also be noted that poverty incidence is rampant in the Western part of the site, where forests are located.

- *The area of farmlands in a commune increases poverty incidence by 0.10 counts*. Deforestation caused by agricultural activities is attractive to farmers due to the belief that they can profit from investing in agricultural crops. This will only hold true if the deforested areas are ideal for establishing farmlands. However, the result that the farms in a commune increase poverty incidence indicates that farming is an unproductive type of livelihood in Ou, Prey Nheat, Srang, Sopoar Tep, and Tang Sya.

- *The land area operated by concessioners increases poverty incidence by 0.03 counts*. In principle, land concessions provide employment to the locals. This, however, does not hold true in Cambodia [8], in which the inaccessibility of the communities to the resources negatively affected their income. The result also indicates that the granting of land concessions threatens the standard of living amongst individuals.

- *The number of business establishments reduces poverty incidence by 0.09 counts*. Commercial establishments are ideally located in urbanized areas, which can be sources of immediate or direct income for business-owners and

employees. Thus, an area with a good number of business establishments operating is inherently expected to have locals that are well-off.

The OLS regression analysis also produced results that are quite questionable, which are the influences of "forest area" (lnFA), "CBNRM" (_ICBNRM), and "total infrastructure density" (lnTIF).

- *Forest area reduces poverty incidence by 0.08 counts*. Three facts play a role in the explanation of this behavior: (1) Forests are abundant in resources with high economic value and can be used to generate income, given that the necessary capital or assets for production are present; (2) The communes with several registered FBE´s are located downstream (Prey Krasang, Prey Rumduol, Roka Kaoh, Roleang Chak, Roleang Kreul, and Tumpoar Meas); and (3) poverty incidence decreases as it moves from the Western to the Eastern part of the study site. Combining these together, it can be said that those involved in FBEs are residing and doing business in the East but acquire their resources from the West.

- *The presence of CBNRM in a commune increases poverty incidence by 0.38 counts*. CBNRM as a poverty-alleviation scheme has caused several debates. Previous works claimed that CBNRM has features that will allow communities to progress, such as the local management of resources and vertical integration (collaboration between locals and higher entities) [7],[9],[10]. Adversaries, however, refuted that the implementation of CBNRMs are ineffective due to the absence of decentralization, granting of CBNRM in degraded forest areas, mismatch between environmental management and CF goals, and exploitation of shares , as well as its failure to yield economic benefits, worsening of forest degradation, creation of internal conflicts, and exclusion of local authorities [4]. Therefore, the outcome that CBNRMs increase poverty indicates that policy-implementation is a problem. Evidence for this supposition are the registered FBEs in communes located downstream of the site, and not in forests.

- *The infrastructure density in a commune increases poverty incidence by 0.51 counts*. Infrastructures are indicators of development. However, the results showed that infrastructure density aggravates poverty incidence. It should be noted that infrastructures are dense in the East and Southeast, where landless migrants are also abundantly situated. Therefore, it can be said that the presence of infrastructures in the area was unable to offset poverty due to the existence of landless migrants, who are inherently poor.

V. CONCLUSION AND RECOMMENDATION

Given these findings, it is recommended that: (1) forestry, land concession, and CBNRM policies be appropriately implemented to avoid the exploitation of forest resources and instead, increase productivity without causing environmental degradation of any form; (2) livelihood training and technological aid be provided to farmers located in the Eastern part of the site to boost efficiency and avoid the necessity to widen farmlands; and (3) livelihood training be conducted for current and prospecting entrepreneurs to reduce poverty in the area through improved commercial activities. However, implementing these suggestions does not guarantee full effectiveness due to the presence of spatial autocorrelation among the communes in terms of poverty incidence, which implies that a commune´s poverty incidence affects those neighboring to it.

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APPENDIX

List of Figures:

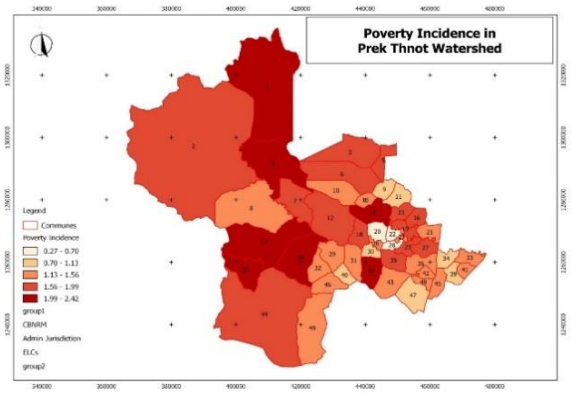

Fig. 1 Poverty Incidence

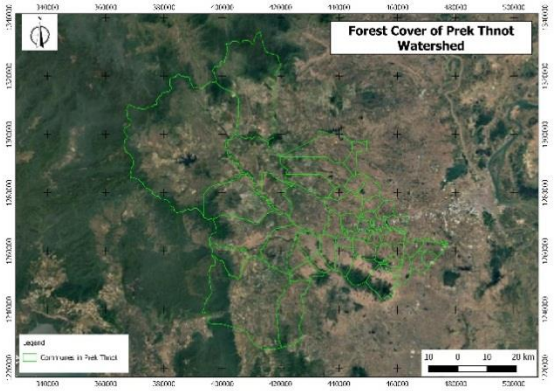

Fig. 2 Forest Cover

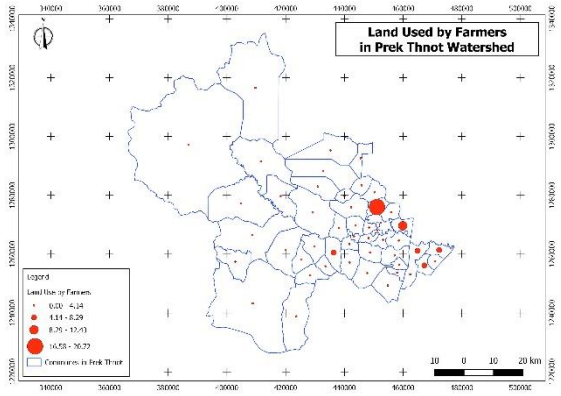

Fig. 3 Land Used by Farmers

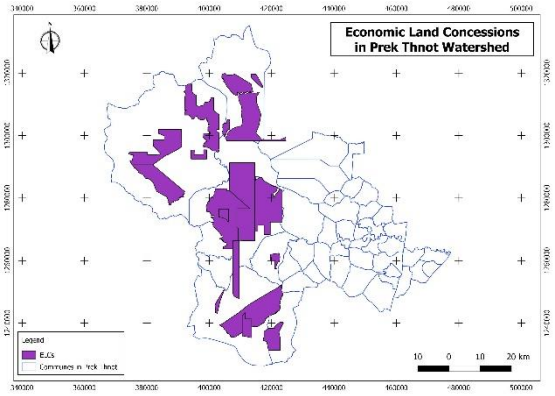

Fig. 4 Land Used by Concessioners

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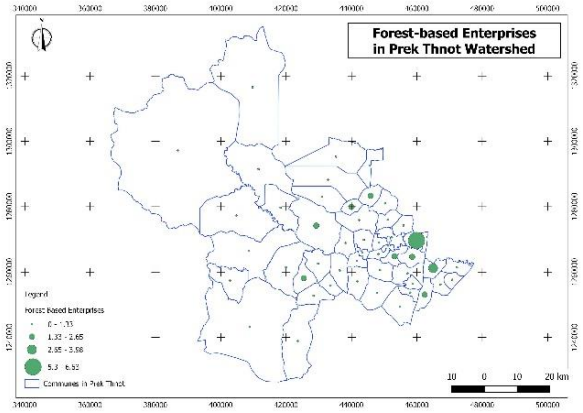

Fig. 5 Forest-Based Enterprises

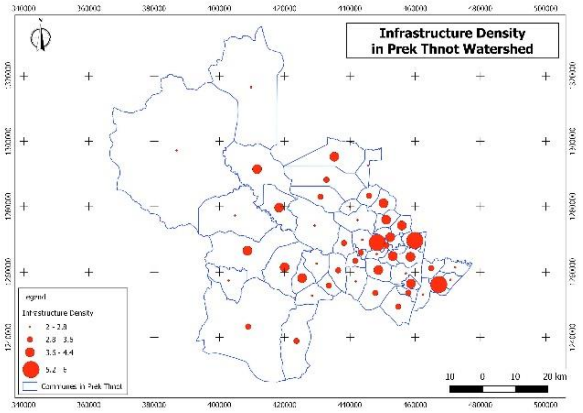

Fig. 6 Infrastructure Density

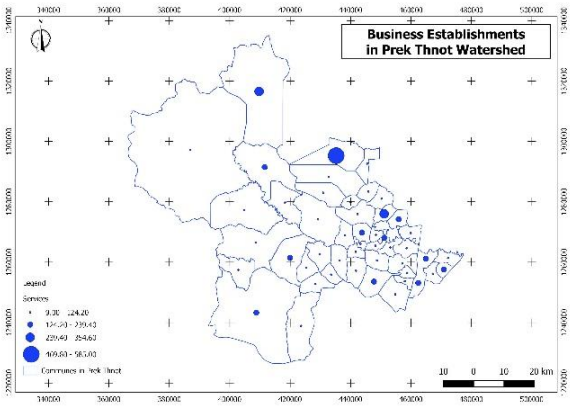

Fig. 7 Business Establishments

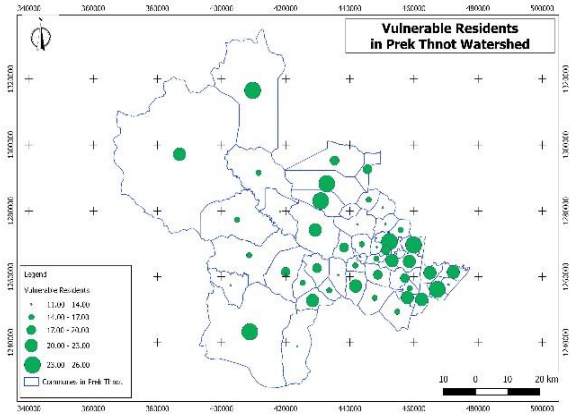

Fig. 8 Vulnerable Residents

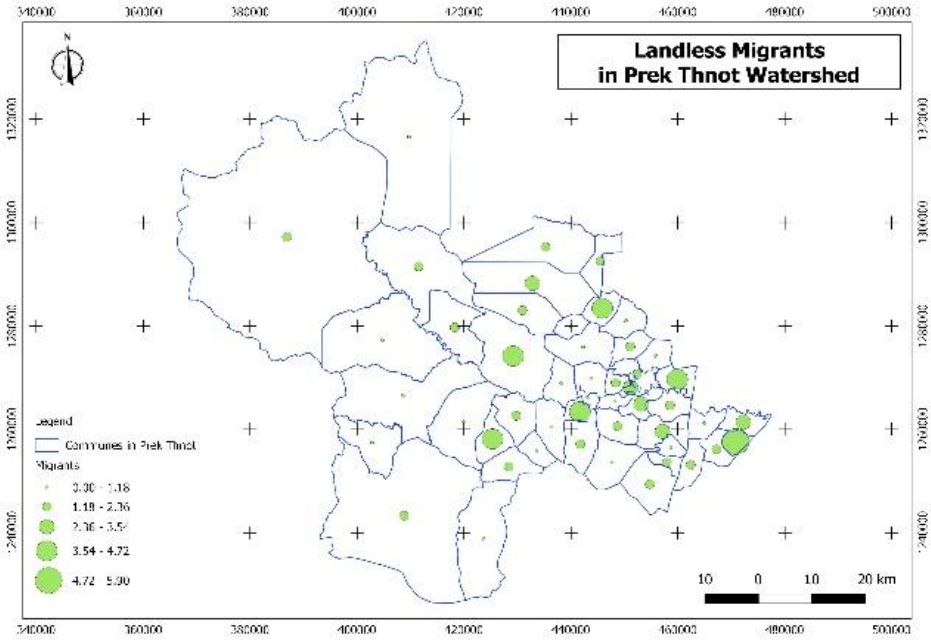

Fig. 9 Landless Migrants