Strategies for rural poverty alleviation in India: A perspective based on remote sensing and GIS-based nationwide wasteland mapping

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Incidence of poverty and land degradation is seen to co-exist in several agro-ecological zones in India. The policies and interventions related to poverty alleviation, aimed at breaking this nexus, drive labour and capital flows by creating the alternate livelihood systems beyond the exploitative dependence of stakeholders on marginal natural resources. Examining the penetration of such policies and interventions needs extensive database on the natural resources as well as socio-economic indicators. Nationwide wasteland mapping project, carried out by National Remote Sensing Agency, provides insights into the problems related to natural resources degradation. Using these maps and statistics therein, in conjunction with relevant socio-economic parameters, this article brings out the dynamics of relationship between the incidence of poverty and natural resources degradation in the different States of India, representing the diverse ecosystems as well as different economic and social policy regimes and institutional mechanisms. Looking beyond wasteland mapping, the study examines how macro-economic variables could determine the dynamics of poverty and natural resources degradation relationship in rural India.

THE countries of Asia and the Pacific region account for nearly two-thirds of the chronically poor and undernourished in the world. FAO estimates indicate that by 2010, Asia will still account for about one-half of the world's malnourished population[1]. In Asia, poverty has mainly been a rural phenomenon and nearly three-fourth of the poor live in rural areas, with large majority of them dependent on natural resources for employment and income. South Asia, which had a poverty incidence of 43% (or about 520 million people), contributed about 40% of the world's poor. Development of natural resources thus offers a potentially enormous means of poverty reduction.

In developing countries, poverty and environmental deterioration are often viable in proximity to each other and have led many to infer that a two-way causality exists between human and environmental degradation. Environmental degradation usually occurs when production and consumption activities of growing populations irreversibly weaken the recycling capabilities of nature. These economic activities are also attributed to the development of markets, the advent of modern technology, and the spatial integration of inaccessible areas to market systems. In many developing countries, however, environmental degradation such as soil erosion, deforestation and pollution are most visible around poor settlements, leading some policy makers to highlight the direct links between poverty and the environment.

One has to recognize that both poverty and the environment are descriptions of states of human and natural resource attributes and cannot be reduced to simple one-dimensional cause–effect relationships. Apart from conceptual difficulties in modelling linkages, another handicap has been the absence of adequate or reliable datasets on poverty and environment characteristics. The challenge for operational research is exploring how circumstantial evidence and inductive logic can be used to explain the nature of interactions between the two states. Based on nationwide wasteland statistics *vis-à-vis* State and district-wise poverty estimates available with the concerned agencies, this study is one such attempt, and evaluates the incidence of poverty with the backdrop of natural resources degradation and the role of institutional interventions, with illustrations from India.

Nationwide wasteland mapping

In recent years, there has been growing need among planners to know spatially the regions with co-existence of poverty and environmental degradation, their precise distributions and the impact of various poverty-alleviation measures *vis-à-vis* environmental management. It is in this context that the importance of satellite remote sensing and Geographical Information System (GIS) in providing such information is well documented[2].

In India, for targetting environmentally degraded lands to initiate poverty alleviation programme, at the behest of the Ministry of Rural Development, Government of India,

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the National Remote Sensing Agency (NRSA), Department of Space carried out a nationwide wasteland mapping which contains details on different types of wasteland, down the line up to the village levels. Using GIS technique, village boundaries are integrated with micro-watershed boundaries and wasteland maps. The detailed methodology of nationwide wasteland mapping is discussed[3] in Wasteland Atlas 2002.

Presently, these maps, serving as primary input in planning reclamation measures, micro-level inventory and monitoring of the wasteland reclamation measures, are being used by the Department of Land Resources of the Ministry of Rural Development, State Forest and Agriculture Departments, District Rural Development Agencies NGOs, etc. for various institutional interventions aimed at poverty alleviation. For example, wasteland maps provide valuable inputs to the Integrated Wastelands Development Project, which has been under implementation since 1989–90. The scheme is being implemented on watershed basis, and is focused on employment generation in rural areas besides enhancing participation of people in the wasteland development programme. Similarly, there are other rural development programmes like the: Drought-Prone Areas Programme and Desert Development Programme, besides formulating land reforms policies, which will be supported by village-level wasteland information. With the current emphasis on creating digital environment to enable e-governance, especially in a sector like rural poverty alleviation, digital archives of village-level wastelands are of great significance to harness the benefits of Information and Communication Technologies (ICTs) at grassroots levels.

Disaggregated poverty mapping: an imperative need

One could argue that poor individuals, in their search for food, would convert forests to farms, grow food on steep slopes and degrade marginal farmlands. The derivative of wasteland map generated by NRSA, areas showing marginal agricultural lands which are comparable to spatially broad level incidence of poverty map at State level, has also captured this (Figure 1).

In poor economies the pressure of population would force agriculture onto more and more marginal lands, permanently impairing regeneration capabilities of nature, leading one to conclude that finite natural resources would thus face increasing problems of negative externalities, and ecological systems would be irreversibly degraded in their physical capabilities. To examine this simplistic assumption, wasteland maps provide valuable insights. In Table 1 wastelands at State levels are listed along with poverty and other socio-economic indicators.

Despite more than 70% population in the rural India being dependent on natural resources, the relationship between wasteland and poverty is seen to be complex (Figure 1). In fact, at State level, the occurrence of wastelands does not seem to be connected with incidence of poverty. Bihar, for example, is characterized by just 6% wastelands with 57% population below poverty line. Jharkhand, with 19% wastelands, has got more than 60% population below poverty line. Uttar Pradesh has 9% wastelands with more than 44% population below poverty line. Similarly, West Bengal with just over 6% wastelands has got more than 40% population below poverty line.

There is another set of states wherein the incidences of poverty as well as wastelands both are equally high. For example, Assam with more than 25% wastelands has got more than 45% population below poverty line. Similarly, Rajasthan is characterized by more than 30% wastelands and 26% incidence of poverty. On the other hand, there are States like Punjab with just 4% wastelands and 11% population below poverty line, followed by Andhra Pradesh, Haryana, Kerala and Gujarat.

At the district level, the relationship between incidence of poverty and wastelands has increased significantly for almost all the States (Figure 2). In case of Andhra Pradesh, for example, this is depicted in Figure 3 and Table 2. It is important to note that regression coefficient (R^2) between incidence of poverty and wastelands increased from 0.0167 at State level to as good as around 0.5 for quite a few States at the district level. It is expected that regression coefficient may increase further if it is derived at the village level. It brings out clearly that a meaningful relationship between incidence of poverty and wastelands exists at much higher level, may be at the village level. The direct links between poverty and resource degradation require further ground-level research and thus calling for disaggregated wasteland mapping to establish closer linkages with incidence of poverty.

Role of public policy and institutional interventions

The linkages between poverty and environmental degradation are, however, not just governed by the physical

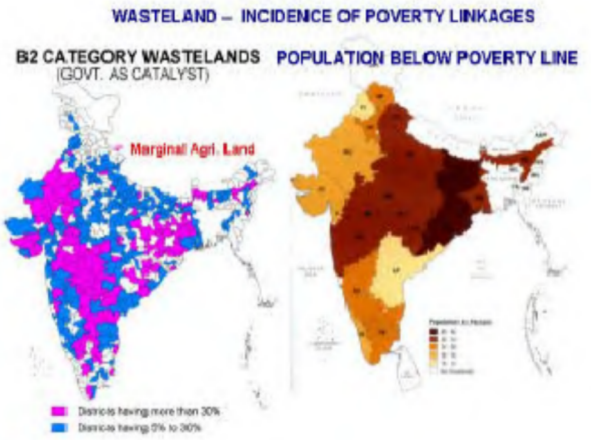

Figure 1. Marginal lands (Source: NRSA) and incidence of poverty (Source: *Food Insecurity Atlas of Rural India*).

Table 1. Wasteland statistics and indicators of poverty and food insecurity – in India

State	Deficit in food production	Percentage waste land	Percentage below poverty line	Rural infrastructure index (%)	Rural literacy (%) 2001
Andhra Pradesh	1.16	18.81	15.92	42.3	55.33
Assam	1.29	25.52	45.01	74.6	60.92
Bihar	1.55	5.9	56.93	99.2	44.42
Chhattisgarh	0.42	7.53	44.38	60.0	76.23
Gujarat	1.74	21.95	22.18	30.8	58.53
Haryana	0.33	8.45	28.02	34.9	64.0
Himachal Pradesh	0.76	56.87	30.34	11.8	74.38
Karnataka	1.11	10.87	29.88	35.8	60
Kerala	3.99	3.73	25.76	39.7	90.05
Jharkhand	3.7	18.89	62.0	80.0	46.26
Madhya Pradesh	1.12	19.31	42.05	57.4	58.1
Maharashtra	1.27	17.38	37.93	32.4	71
Orissa	1.13	13.71	49.72	64.6	66.44
Punjab	0.16	4.42	11.95	37.7	65.0
Rajasthan	1.25	30.87	26.46	56.9	56.0
Tamil Nadu	1.18	17.7	32.48	31.4	67.0
Uttar Pradesh	0.94	9.4	44.54	84.1	54.0
Uttaranchal	0.85	30.27	24.98	70.0	61.0
West Bengal	1.18	6.44	40.8	89.9	64.0

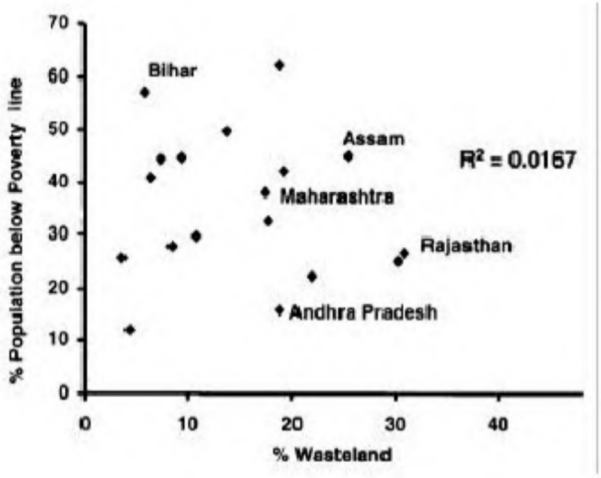

Figure 2. Wastelands and incidence of poverty linkages at State level.

limits of ecosystems, but rather, by the income strategies of the poor. Driven by public policies and institutional interventions, economic and spatial integration of markets occurs and several new marginal income-earning opportunities become available in the informal sector of the economy. Consequently, the dependence of the poor on the natural resource base for livelihood may actually get reduced. It is in this context that the linkage between poverty and renewable natural resource degradation gets altered. In view of this, it is required to evaluate the role of economic and institutional policies in altering labour and capital flows between and within regions (Figure 4).

Yet another aspect to be considered is that production and exchange through impersonal markets is strongly preferred to subsistence activities by poor producers and consumers alike. Although family decisions and mutual responsibilities may continue to define some aspects of household economic behaviour, market exchange irreversibly supplants reciprocity and redistribution as the means of acquiring income and wealth[4]. Under these circumstances, except for a small group of the ultra poor, most individuals and groups could be expected to strive for income security rather than just food security; cash being necessary to purchase non-traditional food and consumption items that reflect changing utility functions. A desire for income security has led to creative income earning efforts through a myriad of highly divisible, labour-intensive, low-skill vocations involving wage labour and self-employment in rural India[5–7]. All these altered the relationship between poverty and natural resources degradation.

The availability of these (often unrecorded) income-earning opportunities reduces the necessity of the poor to mine land and water resources close to their homes for survival. Equally important is whether the poor have the power to gain access or to use available natural resources. Poverty is often visible as unequal access to land and capital because asset ownership is inequitable (Table 1). Moreover, monetization also appreciates land and water values to society, and common property rights begin to get privatized or retain de facto access to productive and water resources because of social and institutional factors, such as changing tenurial relations, laws and regulations, and social and political relations both within and outside villages. Jodha[8], for example, has documented how common values leave the poor de facto access to only marginally productive wastelands.

Apart from market-incentive structures and institutional constraints, India has attempted to improve the welfare of the rural poor through social and economic policies. Before drawing any policy conclusions on poverty–environment linkages, one has to look beyond just the immediate physical environment, and correlate the largely

Table 2. Wasteland statistics and indicators of poverty and marginalization – in Andhra Pradesh

District	Incidence of poverty (poor %)	Wasteland (%)	Small and marginal holdings (%)
Adilabad	53.1	15.23	54
Ananthpur	50	16.9	63.7
	61.1	38.76	90
Cuddapah	43.1	29.93	84.6
East Godavari	28.6	13.41	55.4
Guntur	33	14.72	87.2
Karimnagar	43.2	12.43	84.2
Kammam	41.7	10.9	68.3
Krishna	29.4	10.56	90.1
Kurnool	41.7	21.97	67
Mahaboobnagar	52.8	13.54	67.2
Medak	48.8	11.73	74.4
Nalgonda	46.6	12.14	74
Nellore	49.7	37.61	97.8
Nizamabad	41.0	18.7	82.4
Prakasham	37.8	21.46	87.8
Ranga Reddy	47.8	19.5	67.9
Srikakulam	53.1	18.89	92.2
Visakhapatnam	45.9	28.24	74.7
Vizianagaram	51.3	20.63	85.8
Warangal	43.2	11.63	80.8
West Godavari	35.7	4.38	71

Data source: *Food Insecurity Atlas of Rural India*, M.S. Swaminathan Research Foundation Centre for Sustainable Agriculture and Rural Development, Chennai; *Wasteland Atlas of India*, Ministry of Rural Development Government of India, and National Remote Sensing Agency, 2000.

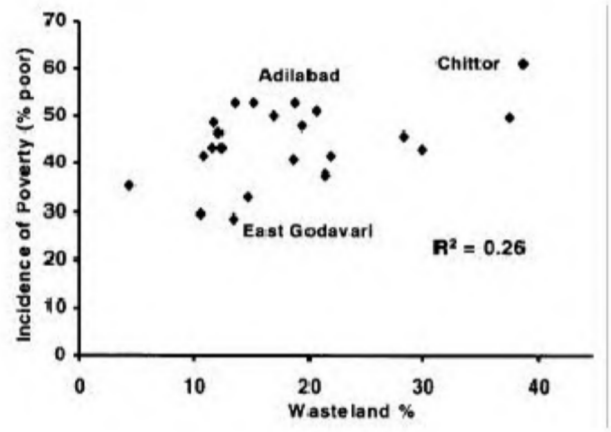

Figure 3. Wastelands and incidence of poverty linkages at district level in Andhra Pradesh.

individualistic survival strategies pursued by the poor to generate income and food security with the following:

(i) Public policies designed to provide basic needs services to poor citizens, because of which economic expectations of the poor begin to improve.
(ii) Natural resource utilization by poor communities, taking into account spatial choices that are available for earning livelihood between farming, off-farm activities and non-farm activities.

The issue for research becomes disentangling complex casual process explaining whether poverty, public policies, institutions or combinations of them cause changes in natural resources use.

Spatial integration of rural poor to market and creation of alternate livelihood systems

Natural resources data on soil, topography, vegetation, water, etc. have been often utilized to assess the economic potential of land areas. It is, however, equally important to understand how macro-economic variables could determine the dynamics of poverty and natural-resources degradation relationship. In this context, it is important to examine the role of certain factors, especially the education and rural infrastructure index (Appendix I), which enables to integrate the poor with market and other off-farm opportunities. Infrastructural investments, notably road construction, have played major roles in changing natural resource use. Roads have increased areas under commercial agriculture, enabled entrepreneurs to invest in natural resources development, and generally increased the mobility of capital and labour.

- In States like Bihar, West Bengal, Uttar Pradesh and Orissa, while rural infrastructure has been very poor (Table 1), the level of education (except for West Bengal) has also been equally poor. Lack of these factors constrains the spatial integration of poor to the market and other opportunities.

- The States like Himanchal Pradesh, Gujarat, Tamil Nadu and Maharashtra, by virtue of having higher rural infrastructure, though the level of education is still not high, have succeeded in integrating the poor to the market and exposed them to non-farm opportunities. The rural hinterland in these States appears to have achieved spatial integration, creating large markets for commodities and labour.
- The integration of the poor to market and non-farm opportunities in Kerala is driven more by literacy followed by rural infrastructure and deficit in food production.

The spatial dynamics of poverty seems to be influenced by the rural infrastructure, availability of transport links, and the growth of production and consumption linkages (Figures 5 and 6). The economic stimuli, however, have also been influenced by several other factors: the structure of product and factory markets, policies that encouraged private investments in natural resources development, and the size and direction of public investments.

Food security, wastelands and scope for interventions

Poverty alleviation and food security are truly inseparable. Food security, providing economic access to the basic nutritional food, is a means of poverty alleviation. In case of total dependence of the rural population on natural resources for food and livelihood, wastelands have direct relevance to food security. Figure 7 does not substantiate that the deficit in food production[9] is directly connected to wastelands (Table 1).

- Jharkhand, Assam and Rajasthan, with very high degree of food insecurity as well as large incidence of wasteland, provide a unique case for institutional interventions, wherein agricultural expansion/intensification could form the basis of poverty alleviation.

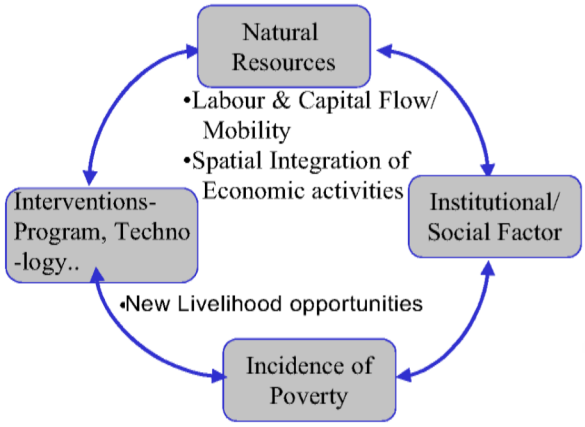

Figure 4. Poverty, natural resources, institutional interventions and societal dynamics – linkages.

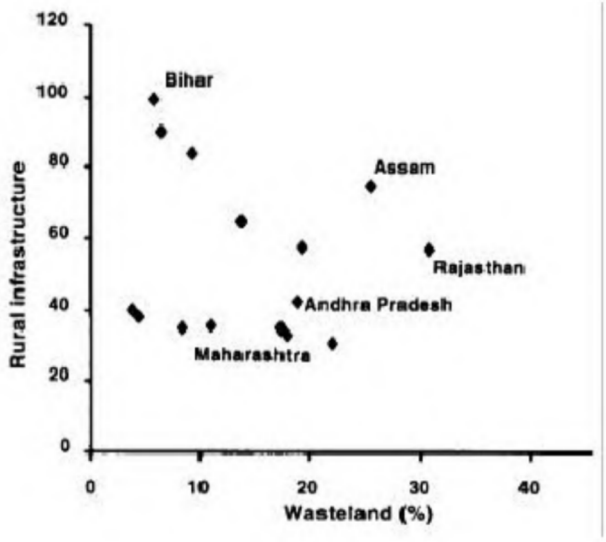

Figure 5. Rural infrastructure index and wastelands.

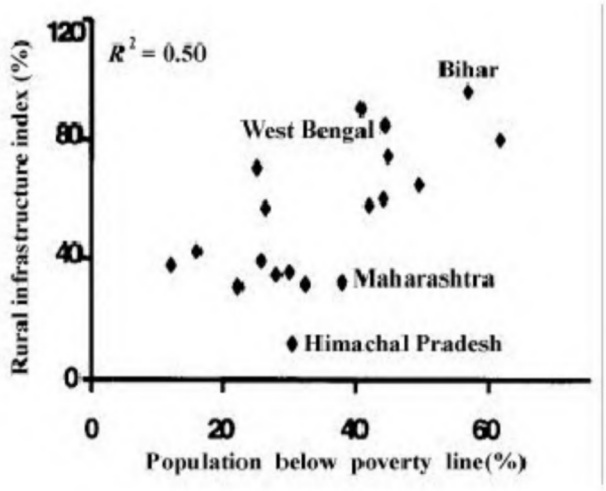

Figure 6. Rural infrastructure index vs incidence of poverty.

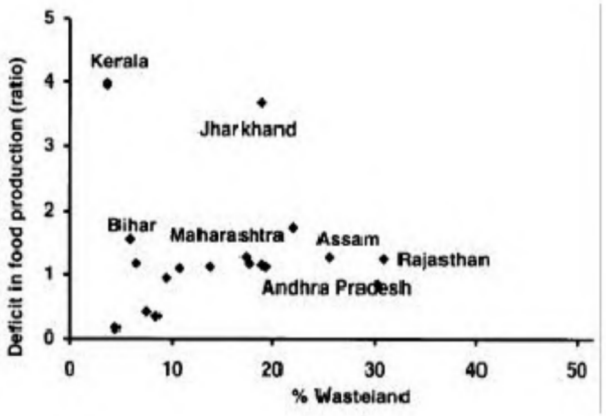

Figure 7. Deficit in food production represented by ratio of consumption to production of cereals (1993–94) vs wastelands.

- On the contrary, Kerala and Bihar, both being also highly food insecure States need to have interventions in other areas for poverty alleviation, as wastelands are quite low in these States.
- The interventions in food-secured States like Punjab, Chhattisgarh, Himachal Pradesh, Haryana, Uttaranchal, Uttar Pradesh and Karnataka need to be focused on off-farm income generation.

It is therefore important to highlight that the economic policies and institutional interventions need to focus on spatial integration of the rural poor to the market forces and creation of alternate livelihood systems. The strategy, however, could be highly disaggregated depending on various *in situ* conditions, including the relationship between poverty and natural resources degradation.

Conclusion

For many developing countries like India, natural resources endowments are the most significant component of national wealth. There is a danger that poorly designed policies, rapidly increasing populations and poverty could irretrievably damage their capital stock. Data on both socio-economic and natural resources variables are usually unavailable at sufficient detailed level (cadastral information or even individual settlements), to examine this. Collecting these datasets is also unaffordable because of competing demands for limited budgetary resources. What this desk study has tried to show is that despite these practical problems, existing sources of wasteland statistics in conjunction with other socio-economic data could lead to a more aggregative, regional-level analysis of natural resources use–poverty–public policy linkages and suggest the appropriate institutional interventions for poverty alleviation.

In conclusion, many macro-economic policy instruments, such as investments in rural infrastructure, education, etc. result in stock changes of physical capital in identifiable areas and thus possibly could alter the relationship between incidence of poverty and natural resources degradation. The economic policy instruments, if translated from conventional monetary aggregates to spatial 'stocks' or areal densities[10,11], make it possible to evolve the appropriate institutional interventions, which could lead to substantial poverty reduction as well as enrichment of natural resources base.

Appendix I. Rural infrastructure index.

Rural infrastructure consists of certain key indicators, which facilitate livelihood access. They reflect certain basic amenities available in rural areas such as:

- Road length per thousand persons;
- Percentage of villages without electricity;
- Percentage of households without electricity, and
- Percentage of households without piped water.

The chosen indicators are first converted into indices and then averaged together to get the composite index. The method of calculating the index is as follows for all the indicators, except 'Road length per thousand persons':

$$I_{ij} = (X_{ij} - X_{imn})/(X_{imx} - X_{imn}),$$

where X_{ij} is the ith rural infrastructure indicator in the jth state, X_{imx} is the ith rural infrastructure indicator with maximum value among all the States, indicating the worst situation (this gets the value of one) and X_{imn} is the ith rural infrastructure indicator with minimum value among all the States, indicating the best situation (this gets the index value of zero).

In respect of 'Road length per thousand population', the following formula was used to get the index of road length.

$$I_{ij} = (X_{imx} - X_{ij})/(X_{imx} - X_{imn}).$$

I_{RI} = Index of rural infrastructure is calculated as follows:

$$I_{RI} = \{\Sigma(I_{ij})/n\} * 100,$$

where $i = 1$ to 4 rural infrastructure indicators and $j = 1$ to 16 States in the country.

The composite index is the average of all the four indices. Each index measures the distance of the State from the worst possible situation, compared to the distance between the best and the worst States. A composite rural infrastructure index of 99% for Bihar means that Bihar has to travel 99% of the distance to reach the level of the state with the best infrastructure.

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