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Measuring the Infrastructural Adequacy for Agriculture: A Comparative Analysis of Indian States

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SUMMARY

Agricultural infrastructure influences the yield as well as facilitates procurement, processing, preservation, and trade. This study developed a methodology for quantifying the status of both physical and institutional infrastructures for agriculture in India. Further, the study identified the relative state-level agricultural infrastructural adequacy status in the country based on secondary datasets. Spatial variation was observed in irrigation, markets, road, extension, credit, and storage infrastructure. Composite infrastructural classes highlighted that all the states in the country have infrastructural inadequacy in one or more parameters. Thus, improvement in agricultural infrastructure in the country calls for huge investments to enhance the income of the farmers.

Keywords: Infrastructure adequacy, Agricultural sustainability, Enhancing farm income, Socio-economic suitability.

1. INTRODUCTION

Adequate agricultural infrastructure is a sine qua non for significantly improving agricultural productivity, transforming existing subsistence farming into a modern commercial farming system, and lowering the costs. Patel (2010) highlighted the importance of agricultural infrastructure by estimating that a one percent increase in the stock of infrastructure is associated with a one percent increase in GDP across all countries. Inadequate physical or institutional infrastructure leads to lower productivity of the sector (Llanto 2012). Improved roads and well-functioned domestic markets affect agricultural productivity (Andersen and Shimokowa 2007). Better roads reduce transaction costs associated with agricultural activities increase output prices and permit entry into new and more profitable activities. On the other hand, deficit transportation may lead to narrowing cropping choices, lower agricultural productivity, and lower technological adoption in developing countries (Lokesha and Mahesha 2017; Chamberlin *et al.* 2014). Therefore, the development of road infrastructure is imperative for agriculture and overall economic growth. A perusal of Table 1 shows that market and road infrastructure correlates positively to the agricultural productivity in the country.

Besides, the role of irrigation infrastructure, financial institutions, and extension services are also irrefutable. Irrigation improves agricultural development, agricultural productivity, land productivity, cropping intensity, and crop yield (Narayanamoorthy 2001; Hussain 2004; Lipton 2003). Bhattarai and Narayanamoorthy (2004) stated that with a one percent increase in irrigated areas, input productivity increased by 0.32 percent during 1970-94. Likewise, low-cost credit from financial institutions helps in increasing production investment, which in turn enhances farmers' returns (Petrick 2004). Along with these, many researchers highlighted that lack of an adequate number of experts in KVKs and access to communication facilities are the major bottlenecks to spread the latest technological and institutional updates to the farmers (Casella 2017; Sajesh *et al.* 2016). Poor coverage of government extension programs (NSSO 2005) leaves us with only 40 percent of the farmers having access to information sources. Lack

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Table 1. The linkage of agricultural productivity with market and road infrastructures

S.No.	States/Union Territories	VOA[#] (000 Rs/ha)	Market Density[##] (per 000 ha)	Total Road Density[##] (Km per 000ha)
1.	Andhra Pradesh	97.79	0.06	28.56
2.	Arunachal Pradesh	135.00	0.07	108.75
3.	Assam	86.41	0.01	110.94
4.	Bihar	66.79	0.01	39.74
5.	Chhattisgarh	43.71	0.04	20.21
6.	Gujarat	81.74	0.03	17.38
7.	Haryana	103.57	0.04	12.12
8.	Himachal Pradesh	143.64	0.07	98.89
9.	J&K[####]	76.52	0.05	51.59
10.	Jharkhand	108.84	0.02	29.79
11.	Karnataka	56.27	0.02	31.18
12.	Kerala	121.12	0.06	94.69
13.	Madhya Pradesh	60.79	0.02	18.24
14.	Maharashtra	56.98	0.02	35.09
15.	Odisha	70.50	0.02	63.29
16.	Punjab	117.13	0.06	25.29
17.	Rajasthan	44.68	0.01	13.77
18.	Tamil Nadu	108.92	0.04	52.75
19.	Uttar Pradesh	72.63	0.02	23.93
20.	Uttarakhand	102.15	0.04	86.32
21.	West Bengal	151.10	0.01	59.90
Pearson's correlation coefficient with VOA			0.529*	0.554**

Source: '#' SGDP- agriculture, 2014-15 at a constant price for the base year 2011-12, Central Statistics Office, Ministry of Statistics and Programme Implementation, Government of India.
'##' estimated by authors based on the number of markets from the official website of AGMARKNET
'###' Estimated by authors based on data for 2014 from the Ministry of road, transport and highways, GOI
'####' includes J&K + Laddakh
Note: ** and * indicate correlation is significant at the 0.01 and 0.05 level respectively after excluding outliers

of storage infrastructure leads to (i) compromise on safe handling of perishables, (ii) huge losses, and (iii) demand-supply mismatch of the perishables. As a result, we observe high price fluctuations and illegal hoarding of some essential commodities like onion and potato. Therefore, considering the importance of the market, road, irrigation, extension, communication, and credit availability, we developed a methodology for quantifying and the relative state-level agricultural infrastructural adequacy status in the country and identified the regions of infrastructural inadequacy.

2. MATERIALS AND METHODS

2.1 Data

The data on five parameters namely road density, market concentration, extension system score, credit institutions availability, and cold storage density was used from online government sources i.e. market data from AGMARKNET; irrigated area, roads, communication, and credit access from Census India, 2011 (http://www.censusindia.gov.in/ 2011census); and KVK data from KVK portal (https://kvk.icar.gov.in/).

2.2 Methodology

In this study, the FAO land suitability evaluation methodology (FAO 2017) which classifies the crop suitability classes into five major (S1, S2, S3, N1, N2) classes was adapted for measuring the socio-economic adequacy. However, we have combined the two not suitable classes i.e. N1 and N2 into N.

There are two basic differences between land evaluation methodology and the one required for adequacy level estimation of infrastructure. Firstly, infrastructure is mostly common for all crops; hence, there is no need for estimation at the crop level. Secondly, for the land evaluation framework, the standard requirement of a crop is known based on agronomic practices and field-level research done for the crops. On the other hand, to the best of our knowledge, there is no standard available in the known literature for the infrastructural requirement. Therefore, we developed a methodology to quantify the existing status of the agricultural infrastructure. Four infrastructural classes were also identified along with the respective ranges. The identified ranges are based on village-level data from 21 major states in the country with outliers removed. Also, the ranges are relative to the current infrastructure status in the country. With more development in the country and changing patterns of crops, the ranges need to be updated subsequently using the suggested methodology.

The rest of this section presents the quantification models and the criteria identified for adequacy classes of each infrastructural parameter. For estimating the market adequacy, data related to the number of markets were transformed into a variable called radial distance. To estimate road, communication, extension, and credit adequacy a corresponding score was estimated as explained in the following sub-headings. During the estimation of the ranges of adequacy classes,

the outliers were removed from the data. Outliers were calculated using mean +/- 3 times the standard deviation. However, the scores were obtained for all the major states to highlight the relative infrastructural adequacy in the states.

Estimation of market concentration: The market concentration is expressed by radial distance in kilometers. Market concentration (no. of markets per 1000 hectares of NSA) was modified to radial distance (R) using equation (1). R is inversely related to market availability as lower radial distance means ease of market availability.

Radial distance catered by one market in kilometers is as follows:

$$R = \sqrt{\frac{Net\ sown\ area\left(in'000ha\right)}{100 * \Pi * no.of\ markets}} \quad (1)$$

Further, the radial distance of each state was estimated to ascertain the range values for each market infrastructure adequacy class (Table 4).

Estimation of irrigation infrastructure score: Area under irrigation per ha of net sown area (I) was used as a proxy for the availability of irrigation infrastructure in the state (Table 4). The identified criteria depict that the states having irrigation availability to more than 82 percent of net sown area are under the S1 category while the ones, which are less than 17 percent, are under the N category.

Estimation of road density score: Criteria for road suitability class was developed using the village-level data in the country (Table 5). Qualitative data on seven types of roads namely national highways (NH), state highways (SH), district roads (DR), other district roads (ODR), pukka road (PR), kuccha road (KR), and water-bound macadam (WBM) from village amenities dataset was converted to quantitative values using scores in the range 0-10 (Table 2). Table 3 estimates the weights for each type of road using pairwise comparison method (Saaty 2001).

Table 2. Scoring criteria based on availability distance of road/ communication/ credit

Distance	Score
Available	10
Available within 5 km range	5
Available within 5 to 10 km range	3
Available at more than 10 km	0

Table 3. Weights of different category of roads using a pair-wise comparison matrix

Road	NH	SH	DR	ODR	PR	KR	WBM	Weights (w)
NH	1	1	3	4	5	8	9	0.3
SH	1	1	2	3	4	8	9	0.3
DR	1/3	1/2	1	2	3	6	7	0.2
ODR	1/4	1/3	1/2	1	2	5	7	0.1
PR	1/5	1/4	1/3	1/2	1	5	7	0.1
KR	1/8	1/8	1/6	1/5	1/5	1	3	0.0
WBM	1/9	1/9	1/7	1/7	1/7	1/3	1	0.0

Source: Estimated by the authors

Note: National Highways (NH), State Highways (SH), District Roads (DR), Other District Roads (ODR), Pukka Road (PR), Kuccha Road (KR), and Water Bound Macadam (WBM).

Now, using obtained quantitative individual scores as well as weights associated with each road, road scores of villages (S_{v_i}) were estimated and aggregated using area-based weightage in the state (equation 2).

$$S_V = \sum_{j=1}^{7} W_j R_j$$

where,

S_V: road suitability score of a village

R_j: score for j^{th} type of road in the village as per Table 2,

W_j: the weight assigned to the j^{th} type of road as per Table 3.

$$\text{Road Density Score}\left(S_s\right) = \sum_{i=1}^{n} \frac{a_i}{A} * S_{v_i} \quad (2)$$

where,

a_i: area of i^{th} village

A: $\sum a_i$ "i.e. the sum of areas of all villages in the state"

Estimation of Extension suitability score: It is an aggregate of KVK and communication score.

KVK Score: The sufficiency is estimated using the number of subject matter specialists including heads and other staff working in the KVK of the state. KVK score (K_s) is estimated using the ratio of filled posts to the total number of posts in a KVK (equation 3).

$$\text{KVK Score}\left(Ks\right) = \frac{\text{Number of Posts Filled}}{\text{Total Approved Posts}} \quad (3)$$

Communication score: The score is estimated using data on village amenities (Census of India, 2011). Availability of landline, PCO, mobile, and internet were taken as the main communication infrastructure. Similar to road infrastructure, the qualitative data on communication was converted to quantitative data (Table 2). Then, an aggregate score was estimated by giving weights to each communication mode as per importance by expert's opinion (equation 4).

$$C_V = \sum_{j=1}^{4} W_j M_j \quad (4)$$

where,

C_v: communication score of village 'v' out of 10,

W_j: the weight assigned to the j^{th} mode of communication (0.35 for landline and mobile each, 0.1 for PCO and 0.2 for internet),

M_j: mode of communication i.e. Landline (j=1), PCO (j=2), Mobile (j=3) and Internet (j=4)

An aggregate communication score of a state (C_s) is then obtained by combining the weighted village communication score (C_V) of all the villages in the state (equation 5).

$$C_s = \sum_{i=1}^{n} \frac{a_i}{A} * C_{v_i} \quad (5)$$

where,

C_s: state communication score

C_{v_i} : communication score of i^{th} village

n: number of villages in the state

(Notations 'a_i' and 'A' in equation 5 are similar to equation 2)

The extension suitability score (E_s) of a state is finally estimated using equation 6, allotting 0.6 weight to communication and 0.4 weight to KVK as per expert opinion.

$$E_s = 0.6* C_s + 0.4* K_s \quad (6)$$

Credit suitability score: For assigning a score to credit facilities, equal weightage was given to four institutional setups commercial bank, cooperative bank, agricultural credit societies, and self-help groups. In the first stage, the credit suitability of a village was estimated using equation 7.

$$L_v = \sum_{j=1}^{4} 0.25 L_j \quad (7)$$

where,

L_v: credit suitability score of the village

L_j: score of j^{th} institutional setup for availing credit (Table 3)

The credit score (L_s) was estimated by using the area weightage of each village (equation 8).

$$L_s = \sum_{i=1}^{n} \frac{a_i}{A} * L_{v_i} \quad (8)$$

where,

L_s : state credit suitability score

L_{v_i} : credit suitability score of i^{th} village

(Notations 'a_i' and 'A' are similar to equation 2)

Table 4. Criteria used for assigning classes to road, extension and credit adequacy*

Category→	>mean + SD (S1)	Mean to mean + SD (S2)	Mean - SD to mean (S3)	< Mean - SD (N)
Irrigation score (I)	8.2	8.2 - 4.9	4.9 - 1.7	1.7
Road score (S)	5.48	4.53-5.48	3.58-4.53	3.58
Extension score (E)	8.3	8.30 - 6.51	6.51 - 4.72	4.72
Credit score (L)	5.73	5.73 - 4.00	4.00 - 2.28	2.28
Radial distance (R)	6.45	6.45-10.88	10.88-15.10	15.10

Source: Estimated by the authors

*Note: During the estimation of the range of adequacy class, the outliers' values were removed from the data. Outliers were calculated using mean +/- 3 times the standard deviation (SD).

Estimation of storage suitability score: Data on state-wise requirement and availability of cold-storage structures were collected from NCCD 2015. The gap was assessed solely on current consumption patterns of the urban population in the country. Surplus and deficit states based on the percent gap between requirement and availability of the storage capacity concerning availability were identified. Surplus indicates higher availability and deficit represents higher requirement. Further, the distribution of deficit states for the severity of the gap was obtained. Gaps up to 25 percent were categorized as marginally deficit, 25 to 50 as moderately deficit, 50 to 75 as deficit, and more than 75 percent gap were considered as highly deficit states.

Estimation of composite infrastructural suitability: Composite infrastructural suitability of i^{th} state (O) was estimated using the worst criteria principle (Rezaei, 2015) as presented using equation 9.

$$O_i = \min (R_i, I_i, S_i, E_i, L_i, W_i) \quad (9)$$

where, R_i, I_i, S_i, E_i, L_i, and W_i refer to the estimated suitability classes for the market, irrigation, road, extension, credit, and storage for i^{th} state.

3. RESULTS AND DISCUSSION

Spatial variation in selected agricultural infrastructure-based suitability classes amongst various states is illustrated through Tables 6-8 and Figs. 1-6.

Markets: The suitability status of the states based on radial distance catered by the markets is presented in Table 5. A perusal of the table indicates that Uttarakhand, Assam, Rajasthan, and Bihar are not suitable as per agricultural marketing infrastructure status. Uttarakhand has the highest radial distance of about 46 km, indicating a lack of agricultural markets in the state. Agarwal and Singh (2017) confirm these findings as they reported that the state is deprived of agricultural markets and out of 13 districts only 7 districts have markets. Assam, Rajasthan, and Bihar also lack an agricultural market infrastructure (radial distance 17-19 km). Uttar Pradesh and Himachal Pradesh are under highly suitable category radial distance of about 3 km and 6.5 km respectively. Madhya Pradesh, Odisha, Jharkhand, West Bengal, Maharashtra, and Karnataka are marginally suitable while the remaining states are moderately suitable. Although the radial distance catered by markets in agriculturally developed states like Punjab and Haryana is relatively higher (7.3-9.1 km respectively), the presence of adequate road infrastructure compensates them.

Roads: Roads are part of infrastructural facilities that complement the access to the markets. Table 5 depicts the relative assessment of road infrastructure in various states using four categories. It will help the policymakers in prioritizing the needs and the states. The score is lowest i.e. about 2.8 for Arunachal Pradesh and Himachal Pradesh, followed by West Bengal, Chhattisgarh, Jharkhand, and Odisha, indicating a lack of road infrastructure in these states. On the other hand, Kerala, with a cent percent of the villages having kaccha and pucca road and 15 percent of the villages having national highways, is highly suitable. Haryana, with 94 percent of villages having pucca road and 76 percent of the villages having kaccha road, is also highly suitable (Table 7). UP and Assam are highly suitable because of pucca roads villages (60% and 18%) and kaccha road villages (67% and 91%) respectively. Gujarat, Maharashtra, Andhra Pradesh, Bihar, and Punjab are found moderately suitable.

Irrigation: Irrigation score shows that even though water is a major constraint, the states like Punjab, Haryana, Uttar Pradesh, and Maharashtra have more than 80 percent of the net sown area under irrigation. Punjab (98%) has the highest net sown area under irrigation. Out of 99 percent of the irrigated villages of Punjab, 94 percent of the villages have more than 80 percent of the Net sown area under irrigation (Table 6). In Haryana, all the villages are under irrigation, with 83 percent of the village having more than 80 percent irrigated area. While in Uttar Pradesh, 77 percent of the villages have irrigated areas more than 80 percent.

*North-Eastern states***:** Irrigation infrastructure helps in assured irrigation to farmers thus improves crop productivity by reducing risk. However, the irrigation practice in the North East Region (NER) is to some extent different from that of the other parts of the country. Hence, while understanding the adequacy status of irrigation in NER states, the demand of the specific area and its rainfall pattern needs to be taken into consideration. Our estimates suggest that most of the NER states like Arunachal Pradesh and Assam have less than 10 percent area under irrigation, which can be due to either lack of irrigation facility or no requirement of irrigation in these states. It has been found that only 11 percent of the total villages in Arunachal Pradesh have irrigated areas, which is even less than 20 percent. In Assam, 74 percent of the villages have less than 20 percent of NSA under irrigation and only two percent of the villages have more than 80 percent of NSA under irrigation (Table 6).

NER has undulating topography, hilly terrain, and climatic variation. Agriculture, in this region depends upon rainwater, minor irrigation, and gravitational irrigation. It has been evidenced that the creation of irrigational facilities in this region was not up to the mark and was not equally endowed with different irrigation facilities. There is a potential for improved irrigational facilities in this region by adopting water harvesting and river-based irrigation system (Sarkar and Goswami 2019; Singha *et al.* 2015) as the NER is endowed with 33 percent of the country's total water resources. There is an inherent advantage of harvesting rainwater for irrigational purposes, as the region is blessed with high rainfall (Patel 2010).

Extension: Poor agricultural extension system leads to yield gaps due to the knowledge gaps (Morris *et al.* 1999; Singh *et al.* 2001). Besides, the availability of communication facilities increases access to the latest knowledge. The extension score based on the number of subject matter specialists and availability of communication infrastructure in the state is presented in Table 5. We observed that the major source of communication is mobile in all the states as indicated by the number of villages (Table 7). Kerala and Gujarat have the highest extension suitability score of 9.48 and 8.42 respectively (Table 5). On the other hand, Jharkhand, Mizoram, and Meghalaya are agriculturally not suitable as per extension suitability score. The major states like Punjab, Maharashtra, Haryana, and West Bengal with an extension score in the range of 8.30 - 6.51 are moderately suitable. Uttar Pradesh and Madhya Pradesh are found marginally suitable with an extension score in the range of 4.00-2.28, emphasizing a need for strengthening extension services in the states.

Credit: Expansion of rural banks is associated with rural poverty reduction (Burgess *et al.* 2005). It also increases access to insurance instruments against production and marketing risk. Kerala with a credit suitability score of 8.93 is the most suitable state with villages having access to SHG (100%), commercial banks (78%), cooperative banks (92%), and agricultural credit societies (63%) (Table 7). Himachal Pradesh and Arunachal Pradesh are found not suitable, indicating a dearth of banking infrastructures in these states. Bihar, Chhattisgarh, Rajasthan, Madhya Pradesh, Odisha, Uttarakhand, and Jharkhand are marginally suitable states with credit suitability scores in the range 1.29-3.87 indicating the need for the development of credit infrastructure in these states. Further, it is observed that the number of villages having access to SHG is much more than the number of villages having access to commercial banks, cooperative banks, and agricultural credit society.

Cold storage: There is an overall requirement gap of 10101 (‘000 MT) in the country of fruits, vegetables, dairy, and meat products. Bihar and West Bengal (prominent producers of potato), Maharashtra (onion), Gujarat (dairy products) and Madhya Pradesh

Table 5. Market radial distance, road density, communication, KVK, extension, and credit suitability for major states of India

States	Radial Distance (KM)	Irrigation	Road	Communication	KVK	Extension	Credit
Andhra Pradesh	9.89	4.50	4.56	7.60	8.60	8.00	4.98
Arunachal Pradesh	6.77	1.00	2.81	2.30	9.10	5.02	1.29
Assam	18.92	0.60	5.53	5.10	9.80	6.98	3.58
Bihar	17.22	6.40	4.99	4.60	7.60	5.80	3.87
Chhattisgarh	8.87	3.00	3.79	4.20	8.30	5.84	3.75
Gujarat	10.37	4.20	4.94	9.10	7.40	8.42	5.32
Haryana	9.10	8.80	6.17	8.10	7.30	7.78	6.23
Himachal Pradesh	6.50	2.00	2.84	3.40	8.30	5.36	1.77
J&K	8.23	4.00	4.18	5.10	7.70	6.14	2.19
Jharkhand	12.65	3.50	3.80	3.50	6.40	4.66	2.44
Karnataka	12.52	2.70	4.13	7.60	8.60	8.00	5.14
Kerala	7.60	2.90	6.13	9.40	9.60	9.48	8.93
Madhya Pradesh	12.07	4.50	4.04	4.80	6.50	5.48	3.51
Maharashtra	12.92	8.00	4.76	7.70	8.60	8.06	5.51
Odisha	11.48	2.20	3.93	5.70	7.00	6.22	3.19
Punjab	7.30	9.80	5.41	8.00	8.40	8.16	4.84
Rajasthan	18.89	3.10	4.49	8.10	7.40	7.82	3.72
Tamil Nadu	8.49	5.70	5.70	7.00	8.60	7.64	5.04
Uttar Pradesh	2.96	8.40	4.38	5.20	8.30	6.44	4.16
Uttarakhand	45.94	4.00	5.06	5.70	6.20	5.90	2.96
West Bengal	14.77	5.20	3.51	6.30	8.40	7.14	4.17

Source: Estimated by authors

Table 6. Percent of villages having access to irrigation across irrigation categories

State	Irrigation categories				
	< 20%	20-40%	40-60%	60-80%	> 80%
Andhra Pradesh	31	15	12	10	27
Arunachal Pradesh	11	0	0	0	0
Assam	74	2	2	1	2
Bihar	9	11	16	24	39
Chhattisgarh	60	10	6	5	13
Gujarat	31	15	17	16	18
Haryana	4	3	4	6	83
Himachal Pradesh	64	7	5	3	8
Jammu & Kashmir	40	9	10	11	28
Jharkhand	68	11	6	3	7
Karnataka	43	23	12	7	8
Kerala	44	13	12	10	20
Madhya Pradesh	29	21	19	15	14
Maharashtra	6	5	7	13	66
Odisha	60	4	4	5	10
Punjab	1	1	1	2	94
Rajasthan	35	17	16	13	17
Tamil Nadu	12	12	13	15	43
Uttar Pradesh	3	2	5	11	77
Uttarakhand	69	8	4	3	11
West Bengal	23	15	12	15	34

have huge gaps between requirements and availability of cold storage. The requirement-availability gap is highest in Bihar (3876 '000MT) and West Bengal (3586 '000MT) followed by Maharashtra (2527 '000MT), Madhya Pradesh (1905 '000MT), Jammu Kashmir (843 '000MT), Gujarat (520 '000MT) and Karnataka (500 '000MT). Uttar Pradesh shows 2874 '000 MT surplus cold storage capacity. Thus, UP has scope for increasing production of high-value crops like fruits and vegetables besides the development of dairy and livestock thereby enhancing the farmer's income. The states of Punjab and Andhra Pradesh also display sufficient cold storage facilities for the perishables. Madhya Pradesh has huge gaps in the cold storage capacity. Thus, improvement in agricultural produce storage infrastructure should be included in the agricultural development plan of the states.

Composite infrastructural suitability: Composite infrastructural adequacy status of the states was identified using the worst criteria principle (Table 8, Fig. 7). None of the states is observed with adequate infrastructure. Haryana and Punjab are moderately adequate in infrastructure (10%). Andhra Pradesh, Chhattisgarh, Gujarat, Kerala, Orissa, Tamil Nadu, and Uttar Pradesh are marginally adequate in infrastructural adequacy (34%). Nearly 57.14 percent of states are not suitable in infrastructure adequacy indicating the need to improve the status of one or more aspects of agricultural infrastructure (Fig. 7).

Although intensively data-dependent, the methodology is not sensitive to outliers as they were removed at the time of estimation of infrastructural adequacy ranges. For example, in this paper, Uttarakhand has a very high radial distance of 45 km which may have distorted the adequacy ranges of market infrastructure. Therefore, we treated Uttarakhand as an outlier for market infrastructure adequacy ranges. However, the estimated ranges are applicable for the determination of the adequacy of agricultural markets in Uttarakhand.

4. CONCLUSIONS AND POLICY IMPLICATIONS

We developed the agricultural infrastructural suitability status in the country based on market, irrigation, road, credit, extension, and cold storage infrastructure. Composite infrastructural suitability status indicated a lack of infrastructure in most of the states. Uttarakhand, Assam, Rajasthan, and Bihar have the lowest number of agricultural markets to net sown area highlighting the need for improved access to markets. Although irrigated area and the number of villages having more than 80 percent of the net sown area under irrigation is high for the states like Punjab, Haryana, and Uttar Pradesh, there is a need to address the exigency of depleting groundwater table in these states by increasing water use efficiency and rainwater harvesting.

Most states lack road infrastructure. Four out of 21 states are highly suitable in road infrastructure and 12 are either marginally or not suitable, indicating an overall need for developing and maintaining road infrastructure in the country.

With evolving production and marketing technology, internet access can play a vital role. A marketing structure like e-NAM can be successful only by increasing participants. Lack of internet in most of the villages is evident. Thus, there is a need to provide internet facilities to farmers for increased participation in promising schemes of the Government. Besides, we

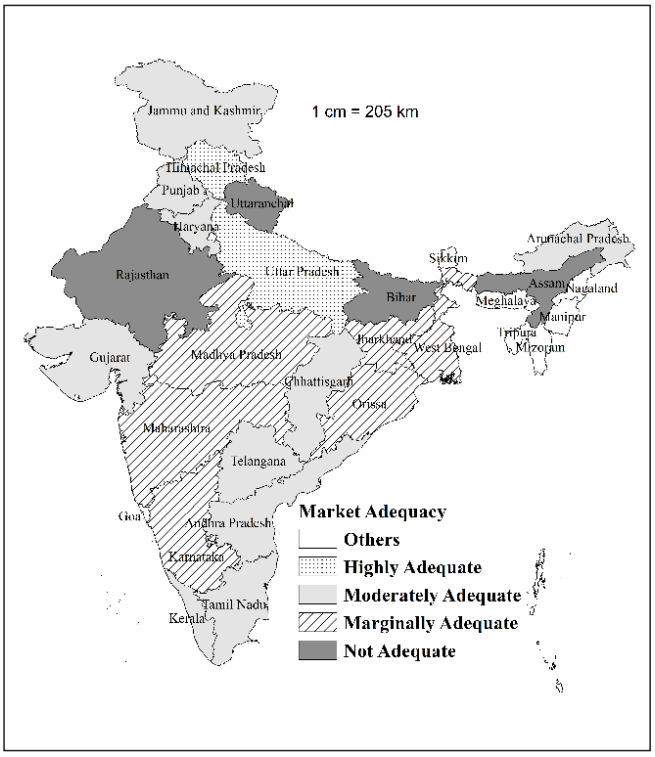

Fig. 1. Agricultural market infrastructure adequacy categorization in major states

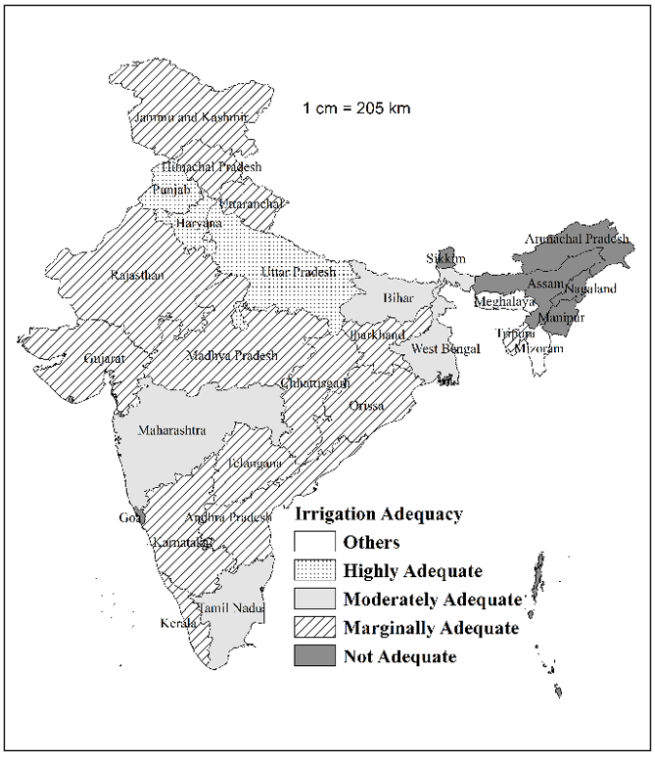

Fig. 2. Agricultural irrigation infrastructure adequacy categorization in major states

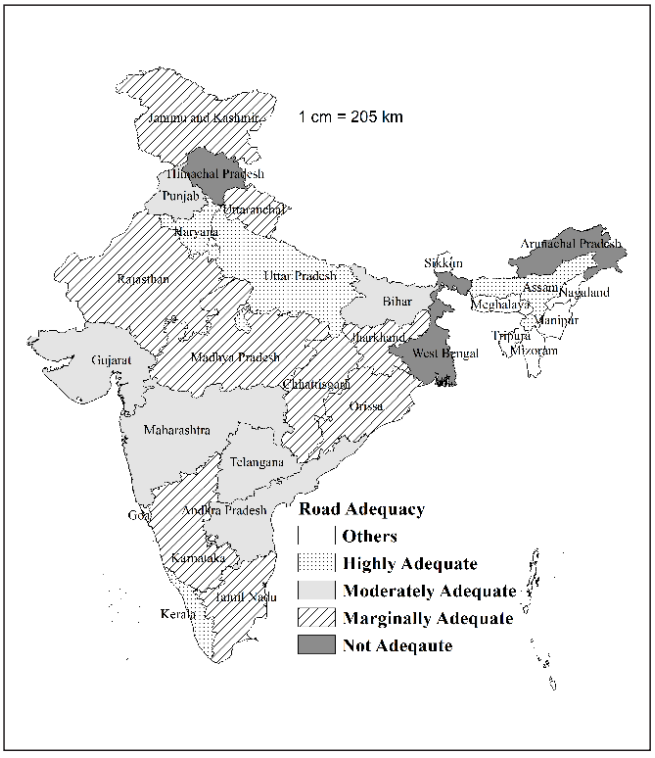

Fig. 3. Agricultural road infrastructure adequacy categorization in major states

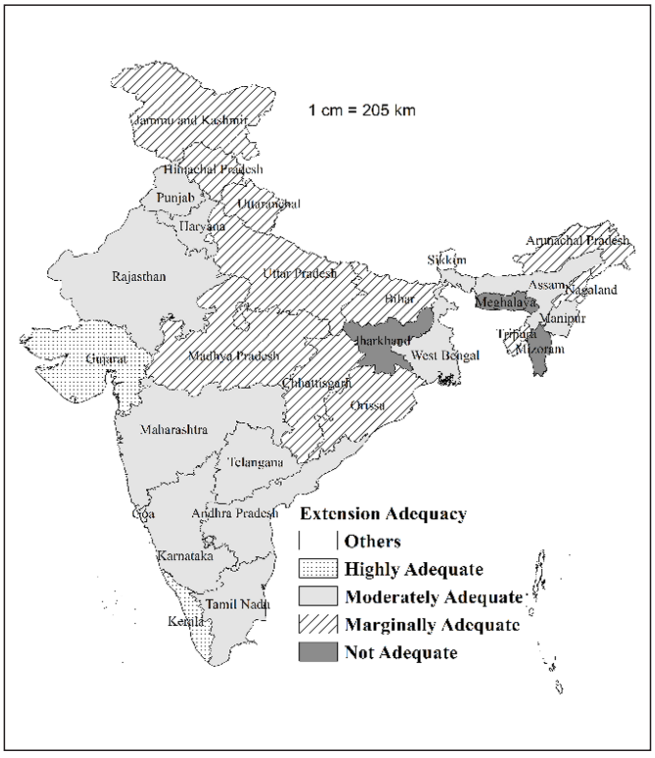

Fig. 4. Agricultural extension adequacy categorization in major states

Source: Estimated by author

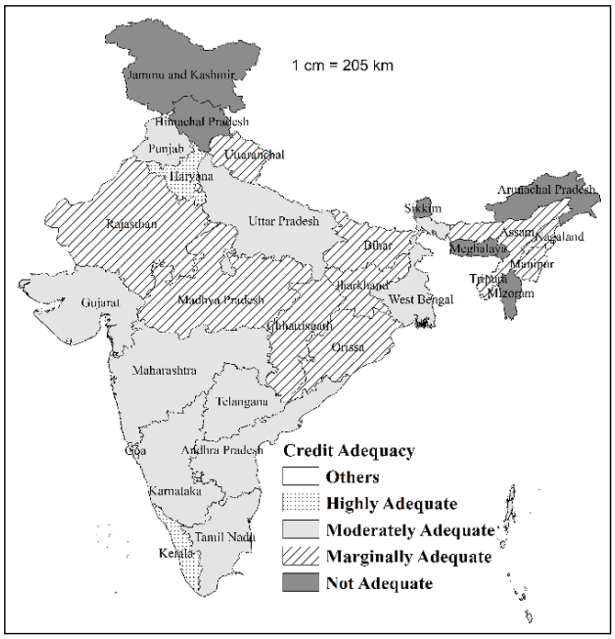

Fig. 5. Agricultural credit adequacy categorization in major states

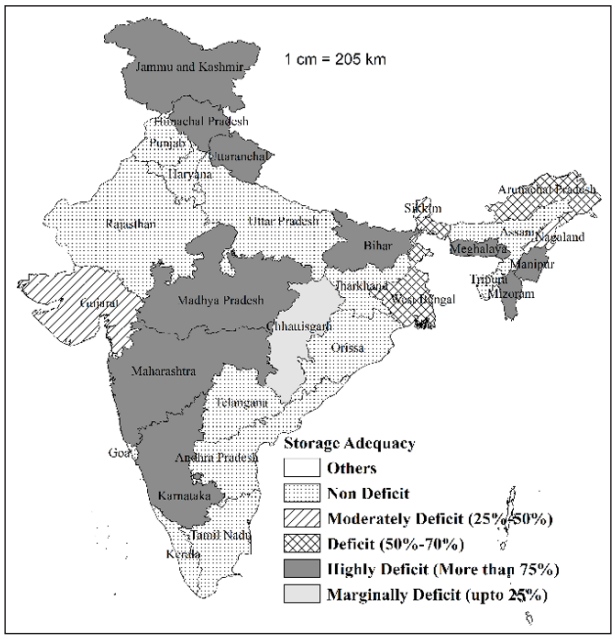

Fig. 6. State-wise gaps in the availability of cold storage regarding corresponding requirements

Table 7. State-wise availability status of agricultural infrastructure (% villages)

		Communication				Roads							Credit			
State	**No. of villages**	**Telephone**	**PCO**	**Mobile**	**Internet**	**NH**	**SH**	**DR**	**ODR**	**PR**	**Kr**	**WBM**	**Com Bank**	**Cooperative Bank**	**ACS**	**SHG**
Andhra Pradesh	27800	69	59	82	3	4	10	26	72	73	95	27	9	4	13	93
Arunachal Pradesh	5589	15	4	33	1	5	6	12	23	20	39	8	1	0	0	35
Assam	26395	19	5	65	2	11	14	35	90	18	91	35	3	1	1	72
Bihar	44874	21	19	42	3	7	16	31	42	56	75	51	6	5	17	39
Chhattisgarh	20126	20	13	60	2	5	11	23	45	60	89	69	2	3	7	82
Gujarat	18225	84	48	94	87	5	28	47	80	94	76	37	8	5	38	93
Haryana	6841	88	62	97	7	9	30	51	74	94	78	60	9	11	24	95
Himachal Pradesh	20690	72	25	77	3	6	18	28	43	48	54	35	4	4	15	21
Jammu & Kashmir	6552	38	30	79	4	10	12	26	78	54	89	3	5	3	3	16
Jharkhand	32394	6	11	42	2	3	9	20	33	86	88	57	4	3	4	30
Karnataka	29340	87	71	78	6	6	20	31	35	83	90	48	6	3	13	79
Kerala	1018	100	95	100	61	15	39	82	95	100	100	43	78	92	63	100
Madhya Pradesh	54903	22	4	70	1	4	9	20	39	50	90	58	2	3	8	58
Maharashtra	43665	69	52	86	4	6	18	33	62	81	65	61	7	10	47	70
Odisha	51313	44	10	81	1	4	6	16	25	58	89	19	0	0	2	79
Punjab	12581	81	57	96	6	7	16	32	47	90	73	9	7	10	25	19
Rajasthan	44672	63	57	96	33	5	14	23	86	22	97	78	10	11	15	6
Tamil Nadu	15979	81	64	89	6	11	27	50	51	91	90	80	7	13	22	91
Uttar Pradesh	106774	25	18	65	5	4	14	24	55	60	67	46	3	2	6	66
Uttarakhand	16792	39	18	87	2	8	23	24	29	30	33	25	2	3	4	27
West Bengal	40218	42	20	80	5	2	5	11	27	34	68	23	5	3	9	88

Table 8. Distribution of the states as per suitability classes as per agricultural infrastructure adequacy (n=21)

Suitability Class	Name of the states falling in this category	Selected states (%)
S1	None	0.00
S2	Haryana and Punjab	9.52
S3	Andhra Pradesh, Chhattisgarh, Gujarat, Kerala, Orissa, Tamil Nadu, and Uttar Pradesh	33.34
N	Arunachal Pradesh, Assam, Bihar, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Uttarakhand, and West Bengal	57.14

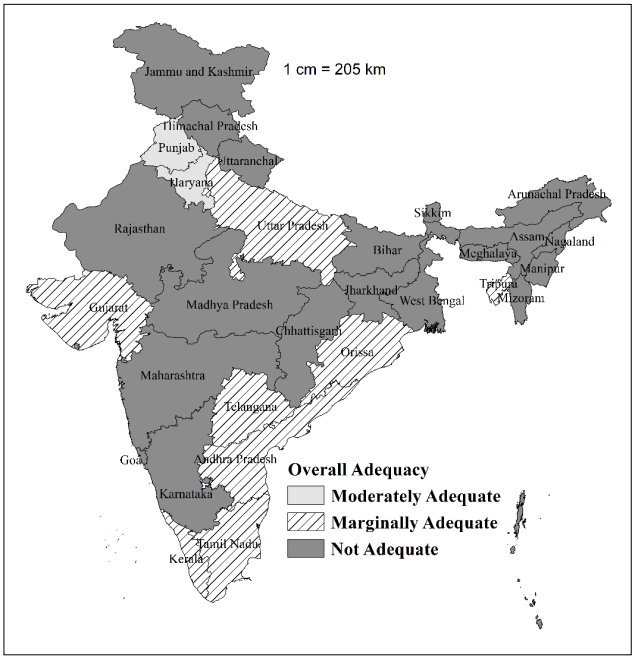

Fig. 7. State-level infrastructural adequacy for agriculture in India

should provide financial institutions with reachable access to the farmers to limit credit disbursement by informal means. The presence of SHG in the villages implies the scope of access to credit if managed properly. Hence, training and awareness programs to the SHG can be successful in improving credit access. Improvement in agricultural infrastructure calls for huge investments. The agricultural infrastructure status presented in this paper will help in identifying the states, which demand more investment to enhance the income of the farmers.

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