Croplands

Beyond Bread and Butter

Chapter 2
Croplands – Beyond Bread and Butter

Introduction

1. Agricultural land/ Cropland is the land area under temporary crops such as cereals, temporary meadows for mowing, under market or kitchen gardens, and land temporarily fallow and also land under permanent crops that is land under crops that occupy them for long periods and need not be replanted after each harvest. In other words, it is a main food production area. Croplands are important ecosystems as they contribute to several ecosystem services like food production, air regulation, soil and water conservation, environmental decontamination, etc.

2. In terms of the SDGs, reaching the SDG targets simply will not be possible without a strong and sustainable agricultural sector. Along with its direct impact on hunger and malnutrition, management of our food system is also linked to other development challenges being addressed in the SDGs. Given the fact that rural people represent the largest segment of the world's extreme poor by far – more than 70% of the total, agriculture is an engine of pro-poor economic growth in rural areas. Studies have shown that efficient management of croplands is critical for ensuring growth in agriculture, which would be at least twice as effective in reducing poverty and hunger than from any other sector[1]. Similarly, with agriculture alone requiring more water than what can be sustained to feed the world even before domestic and industrial needs are met[2], Goal 6 of ensuring water availability for all requires making the right choices in view of the status of croplands. Croplands are also critical for helping the world tackle climate change, since agriculture's carbon mitigation potential could reach as much as 7.5% of total global emissions, depending on the adoption of agricultural productivity measures.

3. Croplands are a critical, terrestrial man-made ecosystem and it is vital that while taking measures to improve the efficiency of farmland so as to meet the growing consumption demand, adequate care is taken to ensure that the croplands are in good condition in that they support biodiversity and the abiotic resources (soil-air-water) are not depleted and are capable of providing a balanced supply of ecosystem services.

4. Given the linkages of the croplands with the local and global environment, climate regulation, food, energy and others, it is important to monitor the status of croplands. In

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[1] FAO 2009, "How to Feed the World in 2050", Food and Agriculture Organization of the UN, Rome.
[2] https://farmingfirst.org/sdg-toolkit#section_2

this background, extent and condition accounts have been compiled, drawing from the SEEA framework, for the States of India, along with the physical flows of soil regulation services provided by the croplands. The format of the accounts is given in **Table 1** below.

Table 1: Format for Cropland Ecosystem Accounts

Extent Accounts for Croplands
1. Net area Sown
2. Total Cropped Area
3. Area sown more than once
4. Cultivable land
5. Cultivated land
6. Un-cultivable land
7. Un-cultivated land
Condition Accounts for Croplands
1. Depicting intensification and irrigation
2. Depicting fragmentation: Gini Coefficient of Land Concentration
3. Depicting crop diversification: Effective Number of Crop Species
Flows of Ecosystem services: Soil Regulation Services provided by croplands

Data Sources and Methods

Extent Account

5. India's cropland spans an area of about 156 million hectares. Land Use Statistics (LUS) is a comprehensive and systematic account of land use in India based on the nine-fold land use classification on land utilization.

Land Use Statistics in India

6. The land use statistics in India were developed as a source of information for planning of agricultural production. Out of a geographical area of 328.73 million hectares, statistics are available for 305 million hectares, with coverage of more than 93%. The reporting area is classified into the following nine categories:

i. Forests
ii. Net area sown
iii. Area under non-agricultural uses
iv. Barren and unculturable land
v. Permanent pastures and other grazing lands
vi. Land under miscellaneous tree crops, etc.
vii. Culturable waste land
viii. Current fallow

ix. Fallow Land other than Current Fallow

7. Land Use Statistics, besides giving the cropped area under both food and non-food crops, also gives the following statistics.

i. Total Cropped Area: The total area sown once and/or more than once in a particular year - the area is counted as many times as there are sowings in a year.
ii. Area sown more than once: Areas on which crops are cultivated more than once during the agricultural year
iii. Irrigated Area: Areas irrigated for cultivation through such sources as canals (Government and Private), tanks, tube-wells, other wells and other sources. It is divided into two categories:
    a. Net Irrigated Area: This is the area irrigated through any source once in a year for a particular crop.
    b. Total Net Un-Irrigated Area: This is the area arrived at by deducting the net irrigated area from the net sown area.
iv. Total Irrigated Area: This is the total area under crops, irrigated once and/or more than once in a year. It is counted as many times as the number of times the areas are cropped and irrigated in a year
v. Total Un-Irrigated Area: This is the area arrived at by deducting the total irrigated area from the total cropped area.
vi. Cropping Intensity: This is the ratio of Total Cropped Area to Net Area Sown.
vii. Total cultivable land: This consists of net area sown, current fallows, fallow lands other than current fallows, culturable waste land and land under miscellaneous tree crops.
viii. Total Un-Cultivable Land: This is the area arrived at by deducting the total cultivable area from the total reported area.
ix. Total Cultivated Land: This consists of net area sown and current fallows.
x. Total Un-Cultivated Land: This is the area arrived at by deducting the total cultivated area from the total reported area

Crop Diversification

8. Crop diversification is referred to as cultivating more than one variety of crop, either of the same species or different species in a given area. It is one of the cost-effective ways to provide an insurance or a buffer against environmental fluctuations as each species respond differently to changes. Several studies have shown that crop diversification not just increases resilience, which is the ability of an ecosystem to return to its original productive state after being disturbed, but also increases the level of yield.

Crop diversification also reduces the risk associated with food insecurity. There is revived concern in the present times related to crop diversity, mostly due to the rising concerns related to biodiversity loss, environment and human health.

9. Crop diversification is vital for economic growth and is an inevitable step to safeguard productivity, profitability and sustainability. One of the indices to depict crop-diversification is that of 'Effective Number of Crop Species' (ENCS) which can be computed as:

ENCS= $\mathbf{e^{-H'}}$

where H' is the Shannon Diversity Index and is computed as follows:

H'= $\mathbf{\Sigma\, p_i \ln p_i}$

with p_i representing the proportion of the harvested area for i^{th} crop (or crop group).

The value of ENCS signifies the estimate of the number of crops dominating production in a particular region. Thus, low value of ENCS means low crop diversity and high value corresponds to high crop diversity.

ENCS for the States/Districts of India have been compiled using the crop area statistics as available in the Land Use Statistics.

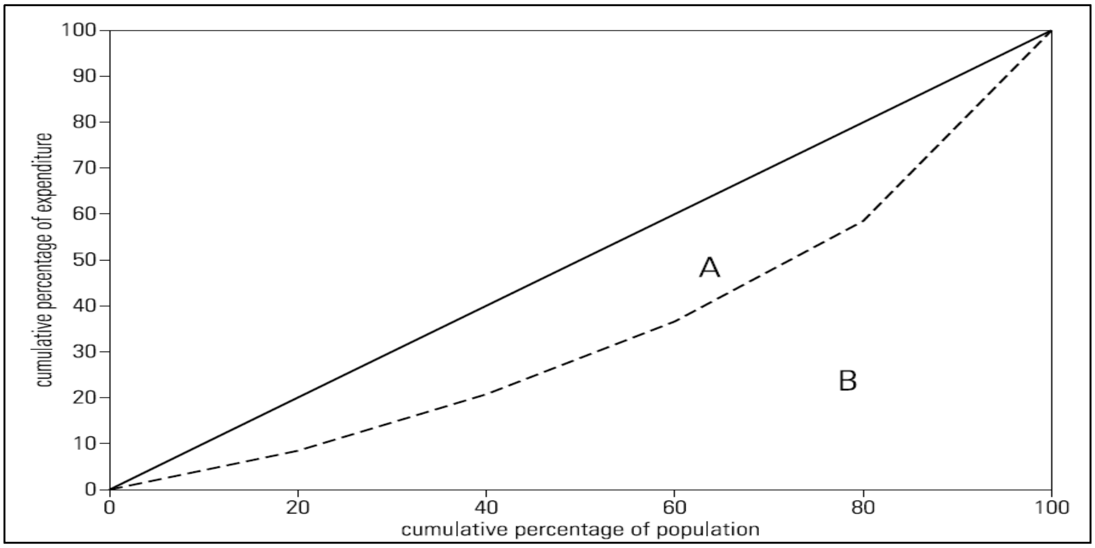
Fragmentation of Cropland

10. The Gini Index, a common indicator of inequality, is based on the Lorenz curve which is a cumulative frequency curve that compares the present distribution with the uniform distribution that represents equality. **Figure 1** gives the Lorenz curve for expenditure and here, Gini coefficient is A/(A+B) where the diagonal represents perfect equality. Formally, let x_i be a point on the x-axis, and y_i a point on the y-axis. Then,

$$Gini = 1 - \sum_{i=1}^{N} (x_i - x_{i-1}) * (y_i + y_{i-1})$$

The Gini coefficient when equal to zero means perfect equality and when equalling one means complete inequality.

Figure 1: Lorenz Curve



11. FAO collates and releases estimates of the Gini Index of Land Concentration using information from the Agriculture Censuses conducted by different countries. The Gini Index of Land concentration can be compiled by taking the cumulative percentage of holdings (from small to large) on the horizontal axis and the cumulative percentage of area of holdings on the vertical axis. Using the same method[3], these indices have been compiled for the States of India by using the reports of Agriculture Census conducted during 2005-06, 2010-11 and 2015-16.

12. The Agriculture Census in India is conducted at five yearly intervals to collect data on structural aspects of operational holdings in the country. The first comprehensive Agriculture Census in the country was conducted with reference year 1970-71. So far, ten Agriculture Censuses have been conducted in the country, with the latest census being for the reference year 2015-16. The Agriculture Census programme is carried out in three phases, with the operational holding as statistical unit at micro-level for data collection. During Phase-I of the Agriculture Census, data on primary characteristics like number and area of operational holdings by different size classes, ownership characteristics like gender, social groups and type of ownership are collected. During Phase-II of the Census, survey is conducted in selected 20 percent villages for collecting detailed data on characteristics of operational holdings such as land use, irrigation status, tenancy particulars, cropping pattern etc. Phase – III of the Census, popularly known as Input

[3] http://www.fao.org/3/a-am352e.pdf%20

Survey, relates to collection of data on the pattern of input use by operational holdings and is conducted in 7 percent of villages in each of the State/UTs[4].

Soil Regulation Services provided by Croplands

13. The loss of soil from land surfaces by erosion is widespread and reduces the productivity of all ecosystem. Soil erosion and associated damage to agricultural land over many years have resulted in losses in cropland due to abandonment and reduced productivity of the remaining land. This loss of cropland often results in the creation of new cropland out of forests and pastureland and the need to enrich these new croplands with inputs of nitrogen and phosphate fertilizers. In addition, soil erosion reduces the valuable diversity of plants, animals and soil microorganisms.

14. Erosion occurs when soil is left exposed to rain drop or wind energy. In the case of water erosion, the impact of soil erosion is intensified on all sloping land, where with each degree of slope, more of the surface soil is carried away as the water moves downhill into valleys and streams.

15. The main factors influencing the amount of loss due to soil erosion are:

i. Soil structure: Soils with a medium to fine texture, a low level of organic matter content, and weak structural development are most easily eroded. Typically, these soils have low water infiltration rates and therefore are subject to high rates of water erosion and are easily displaced by wind energy.

ii. Status of vegetative cover: Land areas covered by plant biomass, living or dead, are more resistant to wind and water soil erosion and experience relatively little erosion because rain drop and wind energy are dissipated by the biomass layer and the topsoil is held together by the biomass.

iii. Land Topography: The topography of a given landscape, its rainfall and/or wind exposure all combine to influence the land's susceptibility to soil erosion.

16. Soil erosion reduces the general productivity of terrestrial ecosystems. It increases water runoff, thereby decreasing water infiltration and the water-storage capacity of the soil. In addition, during the erosion process, organic matter and essential plant nutrients are removed from the soil and soil depth is reduced. These changes not only inhibit vegetative growth but reduce the presence of valuable biota and the overall biodiversity of the soil. These factors interact, making it almost impossible to separate the specific impacts of one factor from another. For example, erosion, by diminishing soil organic

[4] http://agcensus.nic.in/

matter, reduces the overall soil biomass and biological activity. This adversely affects the diversity of plants, animals, and microbes present in the soil ecosystem since vegetation is the main component of ecosystem biomass and provides the vital resources required both by animals and microbes for their survival.

17. An important ecosystem service produced by croplands is the '***soil erosion prevention service***', thereby, mitigating several of the negative impacts of soil erosion.

18. To begin an assessment of the 'soil erosion prevention services' provided by croplands, the first step is to evaluate the erosion that would occur when vegetation is absent and therefore no ecosystem service is provided. The potential soil erosion in a given place and time is related to rainfall erosivity (that is, the erosive potential of rainfall), soil erodibility (as a characteristic of the soil type) and local topography. Although external drivers can have an effect on these variables (for example, climate change), they are less prone to be changed directly by human action. The actual ecosystem service can then be determined by the difference between the potential soil erosion and the impact mitigated by the ecosystem.

Revised Universal Soil Loss Equation (RUSLE)

19. Owing to the impacts of soil erosion on decline in productivity of arable and non-arable lands, estimation of soil erosion is of utmost importance. Using soil erosion models is seen as a useful first step in identifying the critical areas most vulnerable to soil loss, understanding the spatial distribution of soil loss, and studying the drivers and patterns. The empirical soil loss model called Revised Universal Soil Loss Equation (RUSLE)[5,6] designed to predict long-term annual averages of soil loss, has been widely-used and applied around the world due to its relative simplicity and low data requirements compared to more complex soil erosion models[7]. It is a multiplicative model that uses information about rainfall, topography, soil, land use and cover, and support practices to estimate terrestrial rill/inter-rill erosion by the equation below:

$$\boldsymbol{A = R \times K \times LS \times S \times C \times P}$$

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[5] Renard, K. G. (1997). *Predicting soil erosion by water: A guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE)*. United States Government Printing.

[6] Wischmeier, W. H., & Smith, D. D. (1978). *Predicting rainfall erosion losses: a guide to conservation planning* (No. 537). Department of Agriculture, Science and Education Administration.

[7] Benavidez, R., Jackson, B., Maxwell, D., & Norton, K. (2018). A review of the (Revised) Universal Soil Loss Equation ((R) USLE): with a view to increasing its global applicability and improving soil loss estimates. *Hydrology and Earth System Sciences*, 22(11), 6059-6086.

In the equation given above -

A	Mean annual soil loss (metric tons ha^{-1} $year^{-1}$)
R	Rainfall erosivity factor (megajoules millimetre $hectare^{-1}$ $hour^{-1}$ $year^{-1}$)
K	Soil erodibility factor (metric tons hectare hour $hectare^{-1}$ $megajoules^{-1}$ $millimetre^{-1}$)
LS	Slope-length factor (unit less)
S	Slope-steepness factor (unit less)
C	Cover and management factor (unit less)
P	Support practice factor (unit less)

Data Processing and Factor Generation

20. The methodology used in the present report is the implementation of RUSLE equation in a GIS environment for the estimation of different factors and annual soil loss of the croplands in India. To run RUSLE in GIS software (e.g. ArcGIS, QGIS) the raster layers of land structure, land cover, rainfall and soil data are utilized. In this report, some of the global and local datasets have been used to produce soil loss estimates for croplands.

21. The GeoTIFF rasters of the LS factor and K factor have been prepared with the RUSLE tool in the LUCI for SEEA toolbox[8], which processed these along with the global R factor layer produced by Panagos et al. (2017). LUCI is an ecosystem services modelling tool which illustrates the impacts of land use on various ecosystem services. It runs at fine spatial scales and compares the current services provided by the landscape with estimates of their potential capability. LUCI requires three datasets –Digital Elevation Model (DEM), Land cover data and soil data - to run and it can be enhanced with local data. Ecosystem services like agricultural production, erosion risk and sediment delivery, carbon sequestration, flood mitigation and habitat provision are included in LUCI tool.

22. For C-factor parameterization, NRSC land cover datasets have been utilized. **Experimental estimates** of ***soil erosion prevention services*** have been compiled for the years 2005-06, 2011-12 and 2015-16 for the States of India. The summary of datasets used in estimation of soil erosion is in **Table 2**.

[8] Freely accessible through GitHub

Table 2: Summary of the Data Sources used for RUSLE

Input	Dataset	Source	Resolution
Digital Elevation Model	Shuttle Radar Topography Mission 3 Arc-Seconds Global Dataset[9] (SRTM)	NASA	~ 95 metres
Soil data	Harmonised World Soils Database v1.2[10] (HWSD)	FAO	30 arc-second (~1km at equator)
Rainfall erosivity	Global Rainfall Erosivity Database (GloREDa)[11]	Panagos et al. (2017)	30 arc-second (~1km at equator)
Land cover data	Land Use Land Cover Datasets[12]	NRSC, India	~20-25meters

In order to make uniform spatial analysis environment, the cell size of the generated raster layer is fixed as $\sim 95m \times 95m$.

23. A brief description of each of the factors used in this model for the RUSLE equation is given in the following paragraphs.

Rainfall Erosivity factor (R)

24. The rainfall erosivity factor (R) indicates the effect of rainfall intensity on soil erosion. It accounts for the combined effect of rainfall duration, magnitude and intensity[13]. For a storm, this is defined as a product of the storm's total kinetic energy (E) and its maximum 30-min rainfall intensity (I_{30})[5]. In this report, the R factor was extracted from the global R factor raster layer produced by Panagos et al. (2017)[13] using a relationship between calculated R factor, rainfall and other climate covariates.

Soil Erodibility factor (K)

25. The K factor represents the influence of different soil properties on the slope's susceptibility to erosion[5]. It is defined as the "mean annual soil loss per unit of rainfall erosivity for a standard condition of bare soil, recently tilled up-and-down slope with no conservation practice"[14]. Higher K-factor values indicate the soil's higher susceptibility

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9 https://earthexplorer.usgs.gov/ (Accessed September 23 2019)
10 http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/(Accessed September 23 2019)
11 https://esdac.jrc.ec.europa.eu/content/global-rainfall-erosivity (Accessed May 18 2019)
12 Remote Sensing Applications Area, National Remote Sensing Centre, ISRO
13 Panagos, et.al 2017. Global rainfall erosivity assessment based on high-temporal resolution rainfall records. *Scientific Reports* **7**: 4175. DOI: 10.1038/s41598-017-04282-8.
14 Morgan, R. (2005). Soil erosion and conservation. National Soil Resources Institute. *Cranfield University,125.*

to soil erosion. The soil erodibility factors are estimated using HWSD data and the parameterisation is based on the soil texture class and organic matter content[15].

Slope-length and Slope-steepness factor (LS)

26. The LS factor, also referred as topographic erosivity factor consists of slope gradient and length of slope which significantly influences the soil erosion. The LS-factor dataset was generated using DEM from NASA following the equation that uses slope length steepness only as shown below[14]

$$\boldsymbol{LS} = \left(\frac{\boldsymbol{l}}{\mathbf{22}}\right)^{\mathbf{0.5}} \times (\mathbf{0.065} + \mathbf{0.045}\boldsymbol{s} + \mathbf{0.0065}\boldsymbol{s}^{\mathbf{2}})$$

where:

- l Slope length or cell size (m)
- **s** Slope steepness (%)

This method is widely used, being relatively simple and not computationally expensive and is therefore suitable for very large study areas (e.g. states or countries).

Cover and management factor (C)

27. The cover and management factor (C) is defined as the ratio of soil loss from a field with a particular cover and management to that of a field under 'clean-tilled continuous fallow'[6]. The C-factors range between 0 and 1, with areas of tree cover and open water receiving values close to 0 while land classified as bare areas receiving values close to 1. The C factor parameterization requires the extensive knowledge of land cover characteristics of the study area. For this particular study, C factor has been fixed as 0.23 drawing from previous studies in India[16,17,18] that have reported C-factor for croplands.

Support practice factor (P)

28. The support practice factor (P-factor) is the soil-loss ratio with a specific support practice to the corresponding soil loss with up and down slope tillage[5]. The values of P-factor range from 0 to 1, areas with no conservation practices receives value 1. In many studies, this factor is ignored due the difficulty of accurately mapping support practice factors. In the present report, P factor for croplands is taken as 1.

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[15] Stewart, B., Woolhiser, D., Wischmeier, W., Caro, J., & Frere M.H. (1975). *Control of water pollution from cropland.*

[16] Mahapatra, S. K., Reddy, G. O., Nagdev, R., Yadav, R. P., Singh, S. K., & Sharda, V. N. (2018). Assessment of soil erosion in the fragile Himalayan ecosystem of Uttarakhand, India using USLE and GIS for sustainable productivity. *Current Science*, *115*(1), 108.

[17] Singh, G., & Panda, R. K. (2017). Grid-cell based assessment of soil erosion potential for identification of critical erosion prone areas using USLE, GIS and remote sensing: A case study in the Kapgari watershed, India. *International Soil and Water Conservation Research*, *5*(3), 202-211.

[18] Patil, R. J., Sharma, S. K., Tignath, S., & Sharma, A. P. M. (2017). Use of remote sensing, GIS and C++ for soil erosion assessment in the Shakkar River basin, India. *Hydrological sciences journal*, *62*(2), 217-231.

Results

29. Accounts using the datasets and methods prescribed in the previous paragraphs have been compiled at state and national level for India for three years – 2005-06, 2010-11 and 2015-16, synchronous with the Agriculture Census. **Table 3** below gives the cropland ecosystem account at the national level.

Table 3: Cropland Ecosystem Account for India

Indicator	Unit	Value		
		2005-06	2010-11	2015-16
Extent				
Net area Sown	'000 Hectares	1,41,162	1,41,563	1,39,506
Total Cropped Area	'000 Hectares	1,92,737	1,97,683	1,97,054
Total Cultivable Land	'000 Hectares	1,82,686	1,82,010	1,81,603
Cultivated land	'000 Hectares	1,55,375	1,55,840	1,54,916
Un-cultivable land	'000 Hectares	1,24,198	1,25,473	1,26,149
Un-cultivated land	'000 Hectares	1,51,510	1,51,643	1,52,835
Intensification				
Area sown more than once	'000 Hectares	51,575	56,120	57,548
Cropping Intensity	%	136.5	139.6	141.3
Fragmentation of Operational holdings				
Gini Index of Land Concentration		0.59	0.58	0.57
Number in '000		1,29,222	1,38,348	1,46,454
Area in '000 Hectares		1,58,323	1,59,592	1,57,817
Percentage distribution of area operated by operational holdings				
Marginal	%	20.2	22.5	24.0
Small	%	20.9	22.1	22.9
Semi-medium	%	23.9	23.6	23.8
Medium	%	23.1	21.2	20.2
Large	%	11.8	10.6	9.1
Status of Irrigation				
Percentage of Gross Irrigated Area to Total Cropped Area	%	43.7	45.0	49.0
Area Irrigated more than once	'000 Hectares	23442	25275	29321
Crop Diversity				
Effective Number of Crop Species	*Number*	18.7	18.6	18.1

30. During the period of 2005-06 to 2015-16, the Gini Index of Land Concentration which is a measure of fragmentation, has decreased marginally from 0.59 to 0.57. As described earlier, Gini coefficient when equal to zero means perfect equality and when equals one means perfect inequality. The level of inequality is also reflected in the fact that small and marginal holdings taken together (0.00-2.00 ha.) constituted 86.08% of the total holdings in 2015-16 against 85.01% in 2010-11[19] while their share in the operated area stood at 46.9% in 2015-16 as against 44.6% in 2010-11. Further, the average size of operational holding has declined to 1.08 ha in 2015-16 as compared to 1.15 in 2010-11. This is likely to reduce further by 2020-21[20]. With higher fragmentation, it becomes difficult to employ effective and efficient irrigation and optimum usage of fertilizers which might be a reason for lower yields and also lead to problems like soil erosion, salinity, etc., and hence, a decline in the overall condition of the croplands. In some states, governments have enacted land consolidation policies to tackle the challenge of the low average size of holdings. These measures need to be expanded further so that farmers can voluntarily come together and pool land to reap the economies of scale.

31. More than 100 food and non-food crops are grown in India, representing a range of crop groups - cereals, pulses, fruits, vegetables, spices, oil seeds, fibres, drugs and narcotics, to name a few. However, the effective number of crop species (ENCS) in the country is just around 18. At the state level, several variations are observed (**Annexure 2.1**). Among the States having a 'net area sown' of more than 1000 hectares, the States of Assam, Bihar, Chhattisgarh, Haryana, Jharkhand, Odisha, Punjab, West Bengal have an 'effective number of crop species' of about 7, while the States of Andhra Pradesh, Gujarat, Karnataka, Maharashtra and Tamil Nadu have a number of more than 14 species. Crop diversification reduces the need for and associated risk of application of harmful chemicals like pesticides and herbicides, due to the presence of variety of crops that are resistant to pests, weeds and diseases. Government is already promoting crop-diversification under its schemes for 'doubling farmers' income'. As these schemes take root, crop diversification may prove to one of the cost-effective solutions for the downgrading ecological situation, depleting groundwater levels and declining fertility of soil, as also to reduce ambiguities in agriculture and to increase resilience against environmental fluctuations.

Cropland Ecosystem Accounts for the States of India can be seen at Annexure-2.1.

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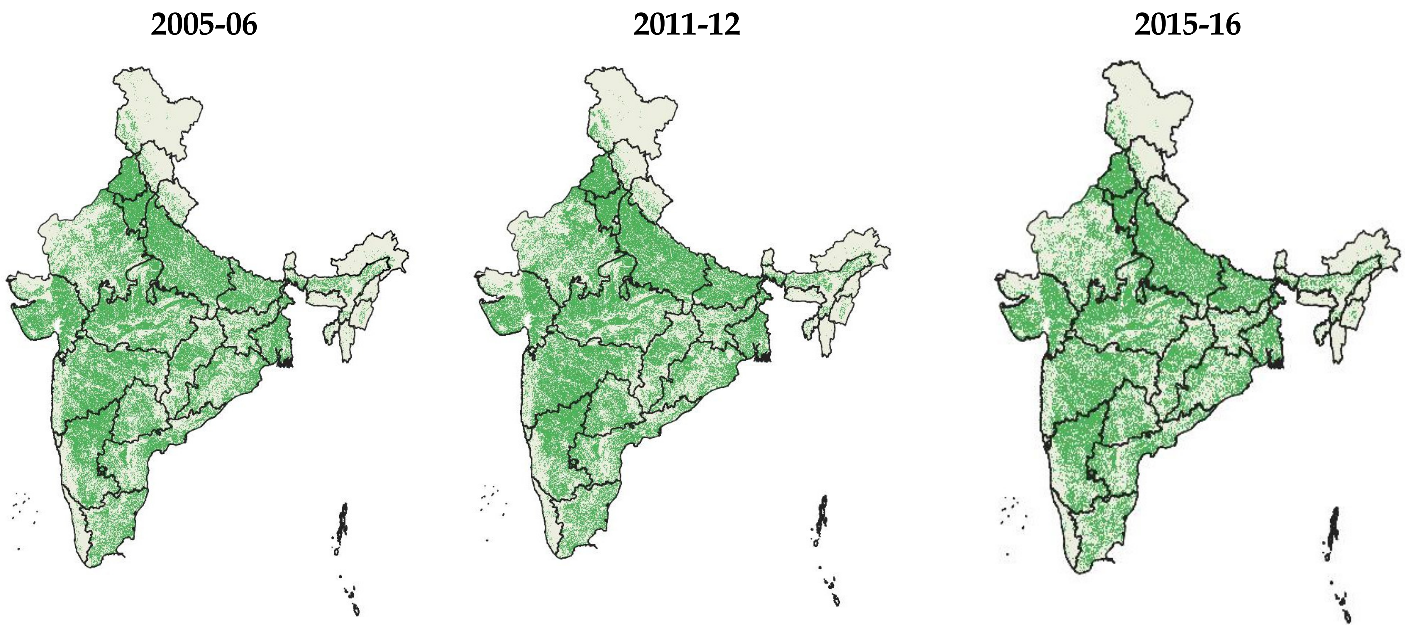
[19] Agriculture Census, 2015-16: All India Report on Number and Area of Operational Holdings, 2019

[20] State of Indian Agriculture 2015-16, Department of Agriculture, Cooperation & Farmers Welfare, Directorate of Economics and Statistics, Ministry of Agriculture & Farmers Welfare

32. **Experimental estimates** of ***Soil Erosion Prevention services*** provided by croplands have been compiled for three years-2005-06, 2011-12 and 2015-16. To assess the regulating Ecosystem Services provided by croplands to mitigate the soil loss, first the soil erosion owing to the local climate, topography and soil characteristics with no vegetation present are estimated; i.e. the erosion that would occur in the absence of the associated ecosystem services provided by the cropland vegetation. Thereafter, soil loss is estimated in the presence of the croplands and the difference of these is the estimate of 'Soil Erosion Prevention Services' provided by croplands.

33. **Figure 2** shows the distribution of croplands in India for years 2005-06, 2011-12 and 2015-16, while **Table 4** quantifies the soil erosion prevention service provided by croplands. Estimates for the smaller States and Union Territories have not been compiled since the global datasets may not be able to capture enough details for these areas.

Figure 2: Distribution of Croplands in India



Source: LULC, NRSC, ISRO, India

Table 4: Experimental Estimates of Soil Erosion Prevention Services Provided by Croplands

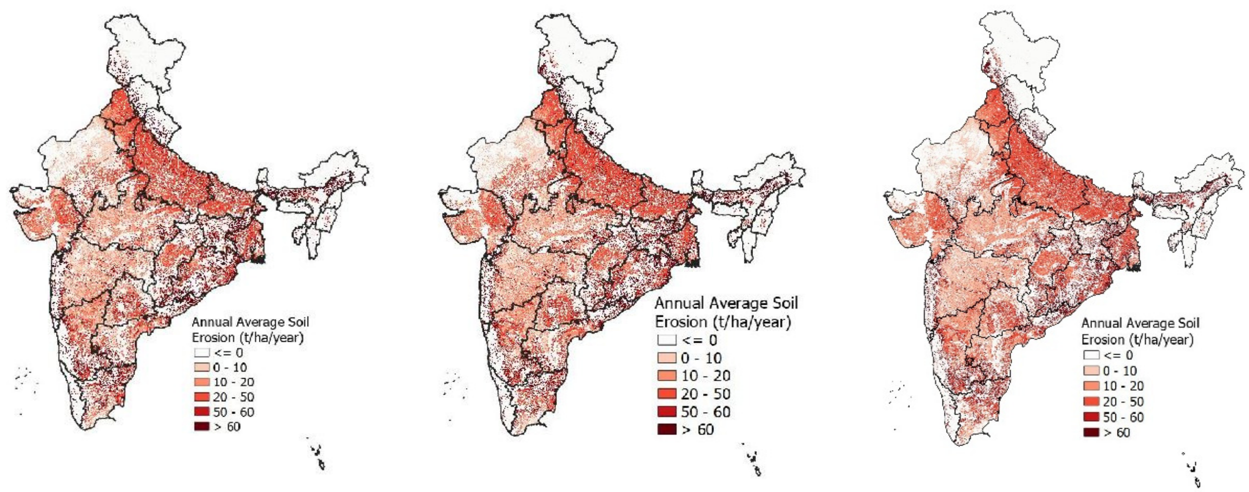
Sl. No.	State	Mean Soil Erosion Prevention (tons/ha/year)		
		2005-06	2011-12	2015-16
1	Andhra Pradesh	27.9	30.1	30.8
2	Arunachal Pradesh	24.0	26.3	29.7
3	Assam	28.8	27.7	27.7
4	Bihar	23.5	25.5	26.5
5	Chhattisgarh	21.3	22.6	23.5
6	Gujarat	15.0	14.5	14.3
7	Haryana	22.5	21.1	21.6
8	Himachal Pradesh	162.5	154.8	152.2
9	Jammu & Kashmir	21.0	23.0	24.4
10	Jharkhand	29.9	31.4	25.2
11	Karnataka	24.2	24.2	24.1
12	Kerala	14.5	17.9	18.5
13	Madhya Pradesh	16.6	16.8	16.8
14	Maharashtra	22.1	22.4	21.8
15	Manipur	100.0	108.6	89.3
16	Meghalaya	31.8	32.0	37.2
17	Mizoram	161.8	149.5	157.7
18	Nagaland	34.3	34.6	34.8
19	Odisha	49.9	48.1	48.6
20	Punjab	25.0	24.5	24.7
21	Rajasthan	7.2	8.3	7.1
22	Tamil Nadu	31.5	33.3	33.5
23	Telangana	18.3	19.1	19.9
24	Tripura	23.0	22.6	22.3
25	Uttar Pradesh	26.1	28.0	27.7
26	Uttarakhand	168.1	163.5	164.9
27	West Bengal	46.8	46.9	47.5

34. **Table 4** presents the assessment of the annual average amount of soil loss prevented by croplands. Croplands help in soil erosion prevention by protecting soil loss from wind and water erosion to a great extent. The results show that the amount of soil loss that could be prevented when land cover is croplands instead of bare soil. The values are observed to be high for hilly states like Uttarakhand, Himachal Pradesh and some of the north eastern states which may be attributed to steep slope.

35. **Figure 3** below shows the spatial and temporal distribution of soil erosion prevention services provided by croplands in India.

Figure 3: Spatial Distribution of Soil Erosion Impact Mitigated by Croplands

2005-06 2011-12 2015-16



36. The estimates of '***soil erosion prevention services***' given here are preliminary and further improvements in parameterization with expert knowledge and local datasets will enhance these estimates. Also, the future work can involve improving C factor parameterization for the specific crops and vegetation species present on the agricultural land if such detailed data are available. Another limitation is that this report focuses over mainland India, excluding the Islands due to the coarseness of resolution and difference in the extent of global data for such small areas.

Way Forward

37. India has a high dependence on croplands with a majority of its households being dependent on agriculture for their livelihood. In view of the priority attached to the sector, the Ministry of Agriculture has taken several steps to ensure a sustainable development of the sector, while ensuring sustainable use of natural resources. For instance, under the 'Soil Health Card Scheme', the current status of the soil health and the changes due to land management practices are assessed. A printed Soil Health Card is given to the farmer, containing the present levels of macro and micro-nutrients, along with recommendations on fertilizers and soil management practices, so as to enable the farmer to get optimal yields. Similarly, under the 'More Crop Per Drop Scheme', activities focusing on micro level storage structures and precision irrigation systems are taken up

to ensure efficient water conveyance and management, especially in water scarce, water stressed and critical ground water blocks/districts.

38. In addition, there are several organizations looking at different aspects of agriculture in the country. For instance, in the case of soil, the Soil and Land Use Survey of India (SLUSI) and the National Bureau of Soil Survey and Land Use Planning (NBSSLUP) are actively conducting research and building the information base required for policymakers. A few important highlights of these two organisations are given in the following paragraphs.

39. The Soil & Land Use Survey of India (SLUSI) is an apex organization in the country which deals with Soil Survey and Land Resource Mapping. SLUSI is primarily engaged in conducting soil survey of different intensities in order to provide scientific database for developmental programmes encompassing soil and water conservation planning, watershed development, scientific land use planning etc. Detailed Soil Survey of SLUSI deals with systematic detailed study of soils comprising morphological examination of soils in the field, analysis of soil samples in the soil laboratory and preparation of maps in the Remote Sensing & GIS Lab. In general, in the Detailed Soil Survey[21], very high and high priority sub-watersheds area and rainfed are taken up, so as to generate detailed data base on soils which are pre-requisites for formulation of village level plan. The data generated out of soil survey could be interpreted to derive base information on the use potential of land or various utilitarian purposes.

40. The National Bureau of Soil Survey and Land Use Planning (NBSS&LUP)[22], which is one among the chain of Indian Council of Agricultural Research (ICAR) Institutes in India, conducts and promotes research in the National Agriculture Research System in the areas of Soil Survey, Pedology, Geomorphology, Remote Sensing, Geographic Information System, Cartography, Land Evaluation and Land Use Planning.

41. There are several other significant organisations which support the development of agriculture in the country. Together, these organizations produce several insights into the status of croplands in India. However, sustainability in agriculture is a complex idea with many facets, including the economic (a sustainable farm should be a profitable business that contributes to a robust economy), the social (it should deal fairly with its workers and have a mutually beneficial relationship with the surrounding community),

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[21] https://slusi.dacnet.nic.in/dss/aboutdss.html
[22] https://www.nbsslup.in/our-mission.html

and the environmental. Environmental sustainability in agriculture means good stewardship of the natural systems and resources that farms rely on. Among other things, this involves:

- Building and maintaining healthy soil
- Managing water wisely
- Minimizing air, water, and climate pollution
- Promoting biodiversity

42. The cropland ecosystem accounts, as prescribed by the System of Environmental-Economic Accounts (SEEA) is an integrated approach to bringing together a wide range of cropland related statistics across domains – like soil condition, fragmentation, productivity and biodiversity - into one coherent information system that can inform on each of the aspects given above. Improved croplands can also help in an increased supply of ecosystem services like a clean and well-regulated water supply, biodiversity, natural habitats for conservation and recreation, climate stabilization, and aesthetic and cultural amenities. An assessment of these ecosystem services can further highlight the inter-linkages between the condition of croplands and the economy, thereby enabling interventions that can help achieve sustainable agriculture and conserve the resource base for future generation.

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