EnviStats India
Explainer Series

THEME: CROPLANDS

Measuring Crop Diversification through Effective Number of Crop Species

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Access

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Revision Summary of this Document

Version Number	Date of Issue	Brief Description of Change
Ver1.0	April 8 , 2021	First Version

Contents

Introduction to SEEA Ecosystem Condition Accounts

1. 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 the croplands and strive towards improvement of its condition. The System of Environmental-Economic Accounting - Ecosystem Accounting (SEEA EA) is an integrated statistical framework for organizing biophysical information about ecosystems, measuring ecosystem services, tracking changes in ecosystem extent & condition and linking this information to measures of economic and human activity. Ecosystem accounting incorporates a wider range of interactions between Environment and Human Activities than captured in standard economic accounts. It provides a structured approach to assessing the dependence and impacts of economic and human activity on the environment.

2. SEEA EA framework suggests compilation of the condition accounts to gauge the health of the croplands. Ecosystem condition is the quality of the ecosystem measured in terms of biotic and abiotic characteristics. The framework organises the relevant data on selected ecosystem characteristics and the distance to a reference condition provides insight into the ecological integrity of the ecosystems.

3. Condition is assessed with respect to ecosystem structure, function and composition which, in turn, underpin the ecological integrity of the ecosystem, and support its capacity to supply ecosystem services. Measures of ecosystem condition may reflect multiple values and may be undertaken across a range of temporal and spatial scales. Ecosystem condition can be described by combinations of physical, chemical and biological indicators.

4. In ecology, the description of ecosystem condition is strongly rooted in the concept of ecosystem integrity, which implies an unimpaired condition of being complete or undivided. Ecosystem integrity is defined as the ecosystem's capacity to maintain it characteristic composition, structure, functioning and self-organisation over time within a natural range of variability. Ecosystems with high integrity or condition are typically more resilient – able to recover from disturbances or to adapt to environmental changes.

5. The SEEA ecosystem condition typology (SECT) is a hierarchical typology for organizing data on ecosystem condition characteristics. By describing a meaningful ordering and coverage of characteristics, it can be used as a template for variable and indicator selection and provide a structure for aggregation. The SECT also establishes a common language to support increased comparability among different ecosystem condition studies. A brief description of the SEEA-EA ecosystem condition typology is presented in Table 1 below.

Table 1: SEEA EA ecosystem condition typology (SECT)

	SECT Superclass	SECT class
Ecosystem condition	Abiotic ecosystem characteristics	1. Physical state characteristics (including soil structure, water availability)
		2. Chemical state characteristics (including soil nutrient levels, water quality, air pollutant concentrations)
	Biotic ecosystem characteristics	3. Compositional state characteristics (including species-based indicators)
		4. Structural state characteristics (including vegetation, biomass, food chains)
		5. Functional state characteristics (including ecosystem processes, disturbance regimes)
	Landscape level characteristics	6. Landscape and seascape characteristics (including landscape diversity, connectivity, fragmentation, embedded semi-natural elements in farmland)

6. One such indicator for the cropland condition accounts i.e. Crop Diversification which comes under the category of the Biotic Ecosystem Characteristics has been discussed in the subsequent paras.

Crop Diversification

7. Crop diversification is used to refer to the practice of 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 reduce ambiguities in agriculture and provides 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 security. There is a revived concern related to crop diversity, mostly due to the rising concerns related to biodiversity loss, environment and human health.

8. Crop diversification[1] is vital for economic growth and is an inevitable step to safeguard productivity, profitability and sustainability. Biodiversity (the diversity within and between species and of ecosystems) is integral in measuring ecosystem condition as it contributes to the composition, structure and function of ecosystems. The commonly used biodiversity metrics such as species abundance, species richness or species-based indices are often used measure different aspects of ecosystem condition, in particular composition. Functional diversity of species supports ecosystem function, while fine scale diversity of ecological communities contributes to biodiversity within an ecosystem.

9. Government of India is promoting crop-diversification under its schemes for 'doubling farmers' income'. For instance, Ministry of Agriculture has launched the Crop Diversification Programme (CDP), a sub scheme of Rashtriya Krishi Vikas Yojana (RKVY)[2] which is being implemented in Original Green Revolution States to divert the area of paddy crop to alternate crops and in tobacco growing states to encourage tobacco farmers to shift to alternate crops/cropping system. Government of India also provides flexibility to the states for state specific needs/priorities under RKVY. Also, under the National Food Security Mission (NFSM), the Department of Agriculture, Cooperation and Farmers' Welfare has initiated the project, "Crop Intensification: Mapping and Monitoring of Post-Kharif Rice Fallow Lands using Satellite Remote Sensing and GIS Technologies for Rabi Crop Area Expansion" for two years 2016-17 and 2017-18[3]. The project is being implemented by Mahalanobis National Forecast Centre (MNCFC) in collaboration with National Remote Sensing Centre, Hyderabad.

10. Highlighting the importance of the judicious use of natural resources, some of the States like Haryana have restricted the cultivation of paddy in the blocks where there is severe water scarcity, in a recent decision. Under its crop diversification program, the government decided to shift one lakh hectare of paddy sowing area for other crops, primarily maize. Thus, there are deliberate and sometimes firmer steps taken to ensure diversification replacing the more popular crops to have enhanced income and sustainability. As these schemes take root, crop diversification may prove to be one of the cost-effective solutions for the downgrading ecological situation, depleting groundwater levels and declining fertility of soil, which in turn, will help reduce ambiguities in agriculture and enable increasing the resilience against environmental fluctuations.

Effective Number of Crop Species

11. One of the indices to depict crop-diversification, is discussed in Aguilar et. al. (2015)[4], as that of 'Effective Number of Crop Species' (ENCS) which can be computed as:

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

where H' is Shannon Diversity Index (or SDI) and is computed as follows:

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

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

12. 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.

13. It is worthwhile to mention here that the ENCS is not the only method to gauge crop diversification. Alternatively, remote sensing can also be used by studying data at a granular level. Using the temporal satellite data, progress of sowing, progress of harvest, crop health, phenology, etc. can be monitored. The satellite data along with other thematic data are being used, through GIS (Geographical Information Systems) tools, for various agricultural developmental activities, such as Crop Intensification, Precision Farming, Irrigation Management, Cropping System Analysis, Infrastructure Developmental Planning, etc. These tools and the resultant information have the capability to improve the reporting on crop diversification for the benefit of policymakers[5].

Compilation Methodology

14. ENCS for the States of India as well as for the country have been compiled using the crop area statistics as available in the Land Use Statistics. Following method has been used to compile the ENCS.

15. Step I: The data can be obtained from

http://eands.dacnet.nic.in/LUS_1999_2004.htm

which gives the State-wise Land Use Statistics at a Glance. The statements named, "All India Summary Tables", give information regarding the state-wise area of the different types of crops for different years. Although data is available for all the years, 3 years- 2005-06, 2010-11 and 2015- 16 have been considered as an illustration here so that the analysis could be compared to the results of the Agriculture Census, which was conducted during these years.

Figure:1 Snapshot of the LUS website

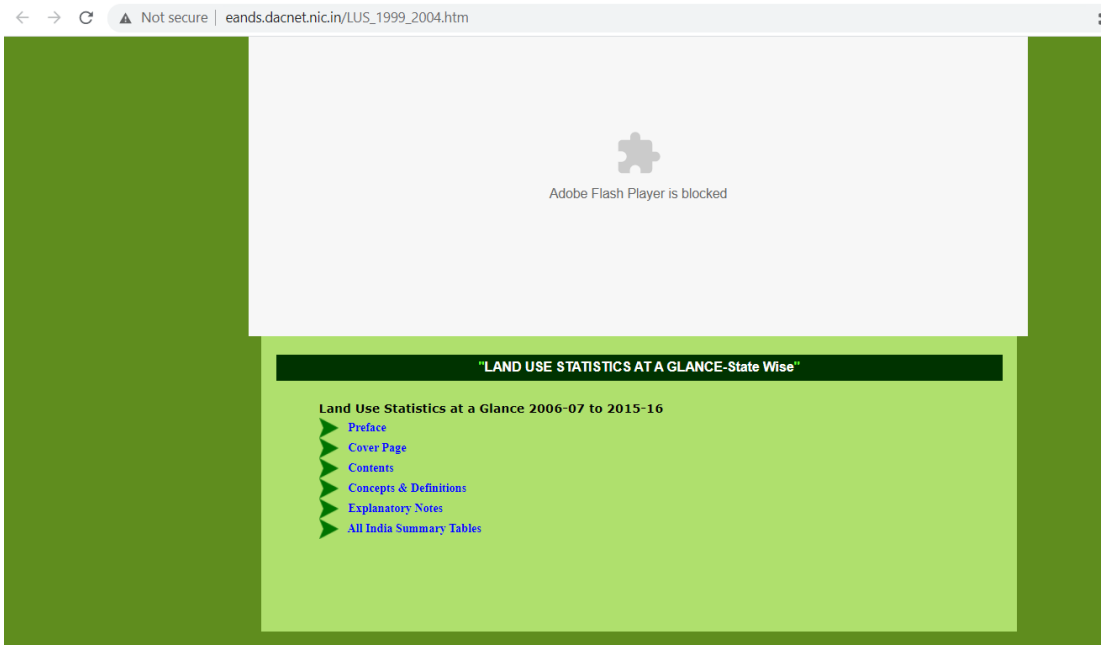
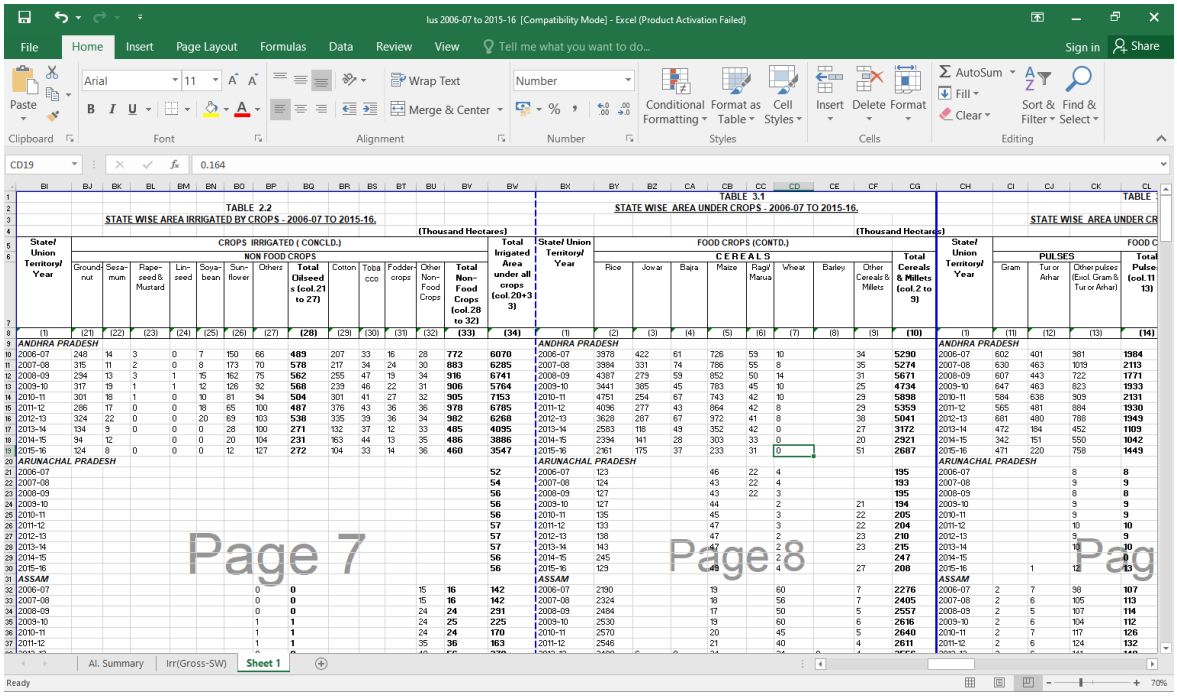


Figure 2: Snapshot of the LUS data



Step II: State-wise Proportion of a particular crop (p_i)=Area of a crop in a State/Area of all the crops in the State.

Step III: Compute - $p_i \ln p_i$

Step IV: Sum ($-p_i \ln p_i$) over all the crops in the state to obtain SDI which is -H'

Step V: ENCS= $e^{-H'}$

Results

16. 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 1** below gives the status of crop-diversification at the State/UT and national level.

Table 1: Cropland Ecosystem Condition Account for India-Crop Diversification

Effective Number of Crop Species	Value		
	2005-06	2010-11	2015-16
All India	**18.7**	**18.6**	**18.1**
Andhra Pradesh	14.2	12.8	14.6
Arunachal Pradesh	5.9	5.0	6.5
Assam	5.8	5.8	5.7
Bihar	5.7	6.1	5.7
Chhattisgarh	4.0	3.8	3.8
Delhi	5.1	5.0	4.8

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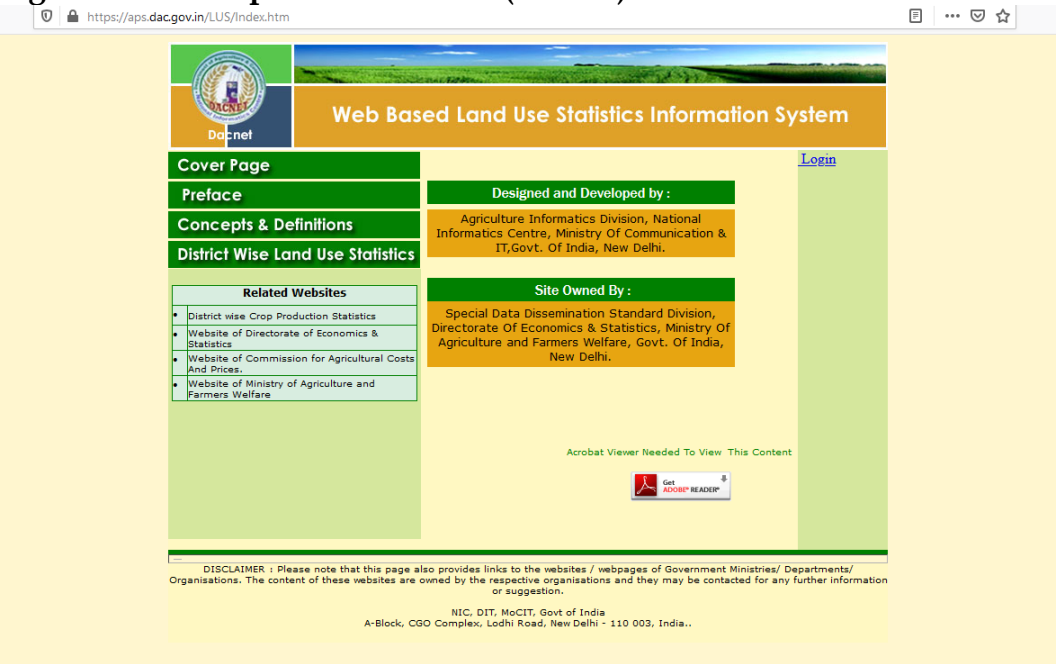
Effective Number of Crop Species	Value		
	2005-06	2010-11	2015-16
Goa	6.1	5.8	6.1
Gujarat	15.5	14.9	16.0
Haryana	7.4	7.1	6.1
Himachal Pradesh	6.3	6.0	6.3
Jammu & Kashmir	6.7	6.9	6.8
Jharkhand	3.7	4.4	4.8
Karnataka	20.1	21.0	21.0
Kerala	11.2	11.0	10.6
Madhya Pradesh	11.5	10.9	9.7
Maharashtra	15.8	14.7	14.7
Manipur	3.2	4.8	5.7
Meghalaya	11.6	10.8	13.3
Mizoram	5.4	10.8	10.6
Nagaland	10.0	10.2	10.5
Odisha	6.8	2.5	2.1
Punjab	4.5	4.2	4.0
Rajasthan	10.9	12.3	11.7
Sikkim	8.2	11.7	10.9
Tamil Nadu	13.6	14.1	13.3
Telangana	1.0	1.0	8.5
Tripura	1.6	6.7	7.7
Uttar Pradesh	8.3	8.1	7.9
Uttarakhand	8.5	8.2	8.4
West Bengal	5.1	5.9	6.0
Andaman and Nicobar Islands	5.1	7.2	6.8
Chandigarh	3.1	2.5	1.5
Dadra and Nagar Haveli	6.4	6.1	5.7
Daman and Diu	1.5	3.8	3.6
Lakshadweep	2.2	2.3	1.0
Puducherry	4.5	4.3	4.4

17. From the table above, it can be seen that the states like Karnataka, Maharashtra and Gujarat have a very high value for the ENCS indicating very high crop diversity; while states like Chhattisgarh, Jharkhand and Punjab show a low value for the ENCS which is indicative of the fact that there is a low crop diversity. The states of Telangana and Tripura have shown an increase in the ENCS in 2015-16 when compared to 2005-06.

18. Similar exercise could also be undertaken at the district level, since the information on Land Use Statistics is also available at the district level on the following site:

https://aps.dac.gov.in/LUS/Index.htm

Figure 3: The snapshot of the LUS (district)



The district wise Land Use Statistics, can be obtained by clicking on the corresponding tab and the "Area Under Crops" Report can be downloaded after selecting the State and the Year. The downloaded report (for the State of Bihar for the year 2016-17) will be similar to the snapshot shown below.

Figure 4: Snapshot of the district wise LUS for the State of Bihar

Area Under Crops in Each District of Bihar State for The Year Ending 2016-17 (Hectare)

District	Food																
	Cereals and Millets																
	Rice				Jowar			Bajra	Maize	Ragi	Wheat	Barley	Other Cereals and Millets			Total Cereals and Millets
	Autumn	Winter	Summer	Total	Kharif	Rabi	Total						Kharif	Rabi	Total	
1.ARARIA	17424	91101	7301	115826	-	-	-	-	42246	145	36223	-	-	-	-	194440
2.ARWAL	-	41710	-	41710	-	-	-	-	516	38	14284	90	-	-	-	56638
3.AURANGABAD	-	175198	-	175198	-	-	-	-	1175	2	71130	704	-	-	-	248209
4.BANKA	679	94858	-	95537	-	-	-	-	10374	-	32959	189	-	-	-	139059
5.BEGUSARAI	46	18103	-	18149	94	-	94	-	56443	45	60600	48	1476	-	1476	136855
6.BHAGALPUR	1235	30769	-	32004	10	-	10	10	40696	-	48349	1249	167	-	167	122485
7.BHOJPUR	8906	89989	7	98902	614	-	614	925	2636	1	50356	2785	92	4	96	156315
8.Bihar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9.BUXAR	-	87780	-	87780	944	-	944	2548	1276	-	82733	1570	-	-	-	176851
10.DARBHANGA	33811	43116	1681	78608	-	-	-	-	14360	589	59875	15	-	-	-	153447
11.GAYA	-	98653	-	98653	-	-	-	-	4388	123	71950	666	-	-	-	175780
12.GOPALGANJ	57636	25384	-	83020	-	-	-	-	11278	40	77637	-	-	-	-	171975
13.JAMUI	-	71386	-	71386	-	-	-	-	4434	-	46108	208	-	-	-	122136

Utilizing the district wise information regarding the different crops, the ENCS for the districts can be computed.

Conclusion

19. Ecosystem condition accounts provide a structured approach to recording and aggregating data describing the characteristics of the ecosystem assets and how they have changed over time.

20. Measurement of ecosystem condition is of significant interest in supporting environmental policy and decision making, which is often focused on protecting, maintaining and restoring ecosystem condition. Comprehensive and comparable measures of ecosystem condition are therefore of direct relevance.

21. A primary benefit of compiling ecosystem condition accounts stems from using an approach to compiling data on different aspects of ecosystem condition that supports alignment with other data on ecosystems, for example concerning ecosystem extent and ecosystem services flows. This structured approach – based on a common understanding of the size, composition, function, location and types of ecosystem assets – offers insight into changes that is more comprehensive than that provided by individual data sets.

22. The estimates of 'Effective Number of Crop Species' are one such indicator of the condition of croplands, and as has been illustrated, can inform on the probable areas of intervention required for improving the croplands. With the croplands intricately linked to several Sustainable Development Goals, like those of hunger, poverty, malnutrition and also water and energy use, these policy measures become critical for India's progress towards Sustainable Development.

References

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[2] Press Release on Crop Diversification by Ministry of Agriculture & Farmers Welfare, Release ID 1605057 dated March 3, 2020

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[4] Aguilar J, Gramig GG, Hendrickson JR, Archer DW, Forcella F, Liebig MA (2015) Crop Species Diversity Changes in the United States: 1978–2012. PLoS ONE 10(8): e0136580. doi:10.1371/journal.pone.0136580ttps://www.researchgate.net/publication/281552541_Crop_Species_Diversity_Changes_in_the_United_States_1978-2012

[5] Smart Agri Post, February 2019, Application of Space Technology in Agriculture; available at https://smartagripost.com/wp-content/uploads/2019/02/SAP-february-spread-page-low-res-1.pdf