



Aspects of Estimating Emissions from Land:

Issues of Data Availability for Independent Assessments

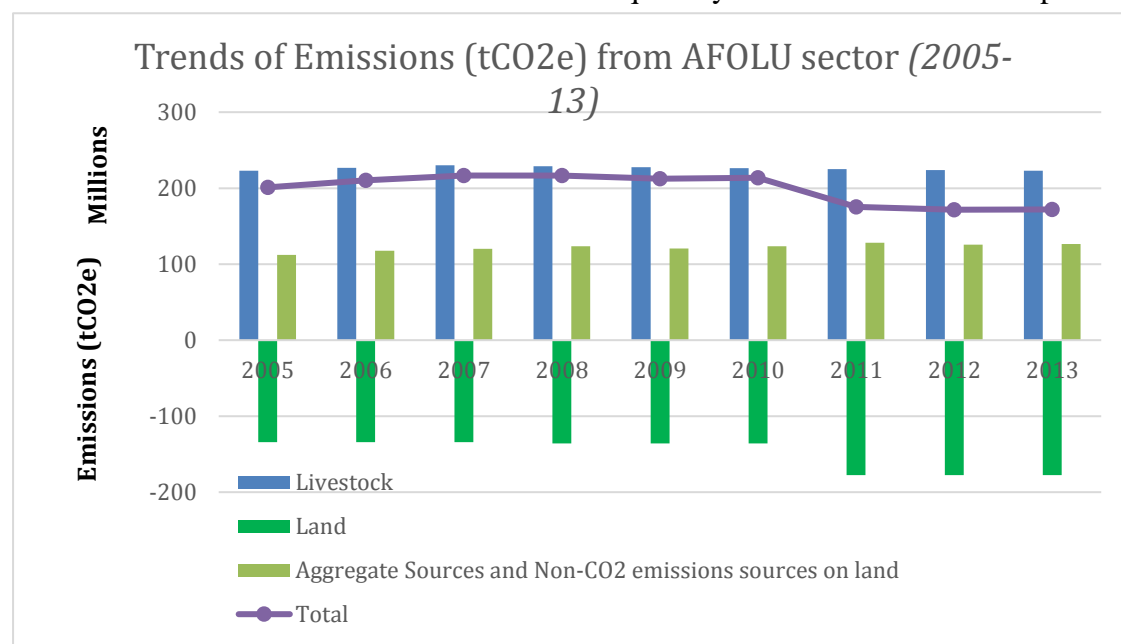


Introduction

According to estimates of the GHG emissions from Agriculture, Forestry and Other Land Use (AFOLU) calculated by the GHG Platform – India from 2005 to 2013, the three major subsectors viz. Livestock, Aggregate Sources and Non-CO2 Emissions from Land, and Land had the following profile:

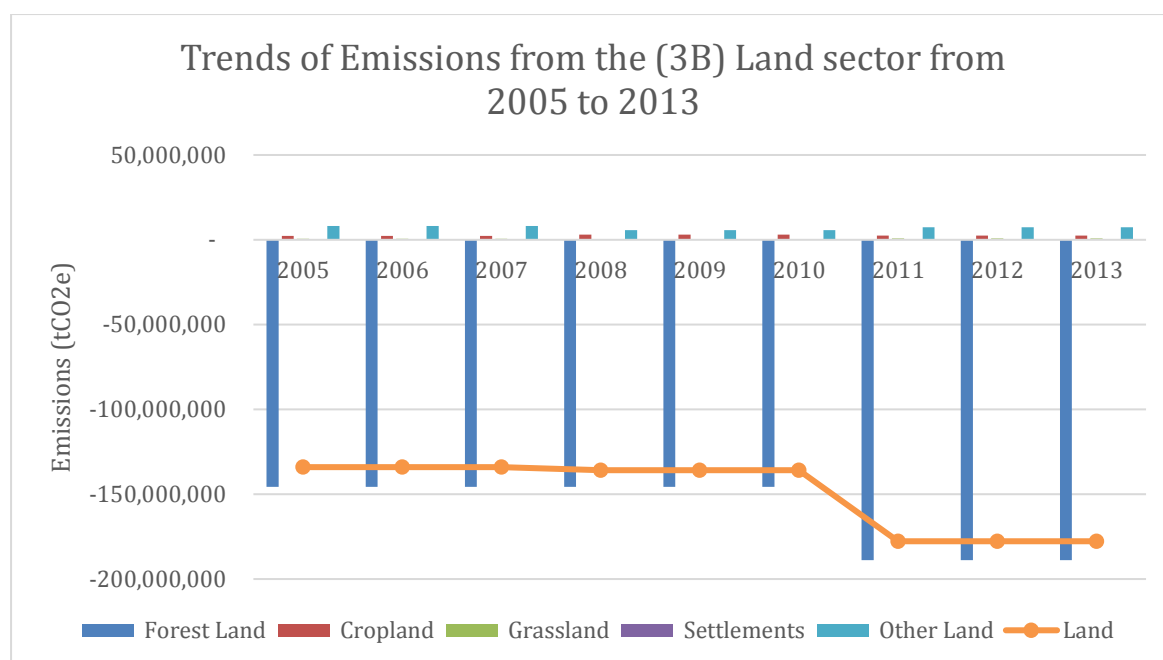
	2005 (GHG Emissions in CO ₂ equivalent GWP calculated as per AR2 in million tonnes)	2013 (GHG Emissions in CO ₂ equivalent GWP calculated as per AR2 in million tonnes)
Livestock	222.87	223.12
Aggregate Sources and Non-CO ₂ Emissions from Land	112.40	126.55
Land	-134.03	-177.73

As can be seen, from the table and the accompanying graph, emissions from the livestock sub-sector contribute the maximum quantity of GHGs to the atmosphere.



The contribution of this sub-sector was 223.12 million tonnes of CO₂ equivalent in 2013. The other emitting sub-sector viz. Aggregate Sources and Non-CO₂ Emissions from Land contributed around 50% of the emissions from the livestock sector i.e. 126.55 million tonnes of CO₂ equivalent in 2013. The third sub-sector i.e. Land, is a net sink rather than a source of emissions, and was removing 177.73 million tonnes of CO₂ from the atmosphere, amounting to around 51% of the positive emissions emanating from this sub-sector. In this discussion, we focus on estimation of emissions from Land and several issues that arise from attempting to make these estimates

Positive emissions from land are almost negligible. Negative emissions from this sector, primarily from forests, overwhelm the positive emissions from croplands, grasslands, settlements and other lands, and thus result in this category being an overall sink rather than a source. The graph placed below illustrates this.



Between 2005 and 2013, the overall trend of emissions is negative, primarily due to greater CO₂ removals by forestlands after 2011.

The breakdown of overall emissions from land in 2005 and 2013 are as follows:

Category of Land	Emissions in Million tonnes of CO ₂ equivalent in 2005	Emissions in Million tonnes of CO ₂ equivalent in 2013
Cropland	2.30	2.47
Grassland	0.63	0.71
Other land (includes land under permanent snow cover and wasteland)	8.21	7.43
Settlements	0.45	0.49
Forest land	-145.62	-188.83

Uncertainties of Underlying Activity Data for Estimating Emissions from Land

The first obvious limitation of the estimates done by the GHG Platform India is that one of the categories of land identified by the IPCC i.e. Wetlands¹ is missing from the lands whose emissions we estimated. This is because the National Remote Sensing Centre (NRSC) that provides the activity data for making it possible to estimate such

¹ 2006 IPCC Guidelines for National Greenhouse Gas Inventories (http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_01_Ch1_Introduction.pdf)

emissions does not provide data regarding wetlands. The NRSC provides data for a category titled “water bodies” that includes land covered by rivers as well as wetlands. In addition, there is a lack of clarity in capturing changes from forestland to other sorts of land use, as well as land other than forests being converted into forestland.

In addition, to the above, Vasudha Foundation also carried out an assessment of the spatio-temporal changes in the land use, land use cover and forestry using geospatial technology in order to compare the change detected by our analysis with the official change matrices for five states of India. The states that were analyzed were Chhattisgarh, Goa, Kerala, Punjab and Tripura.

We provide below an analysis of the variance between land use assessments done by Vasudha Foundation and compare them with official data on the same land categories:

1. Chhattisgarh

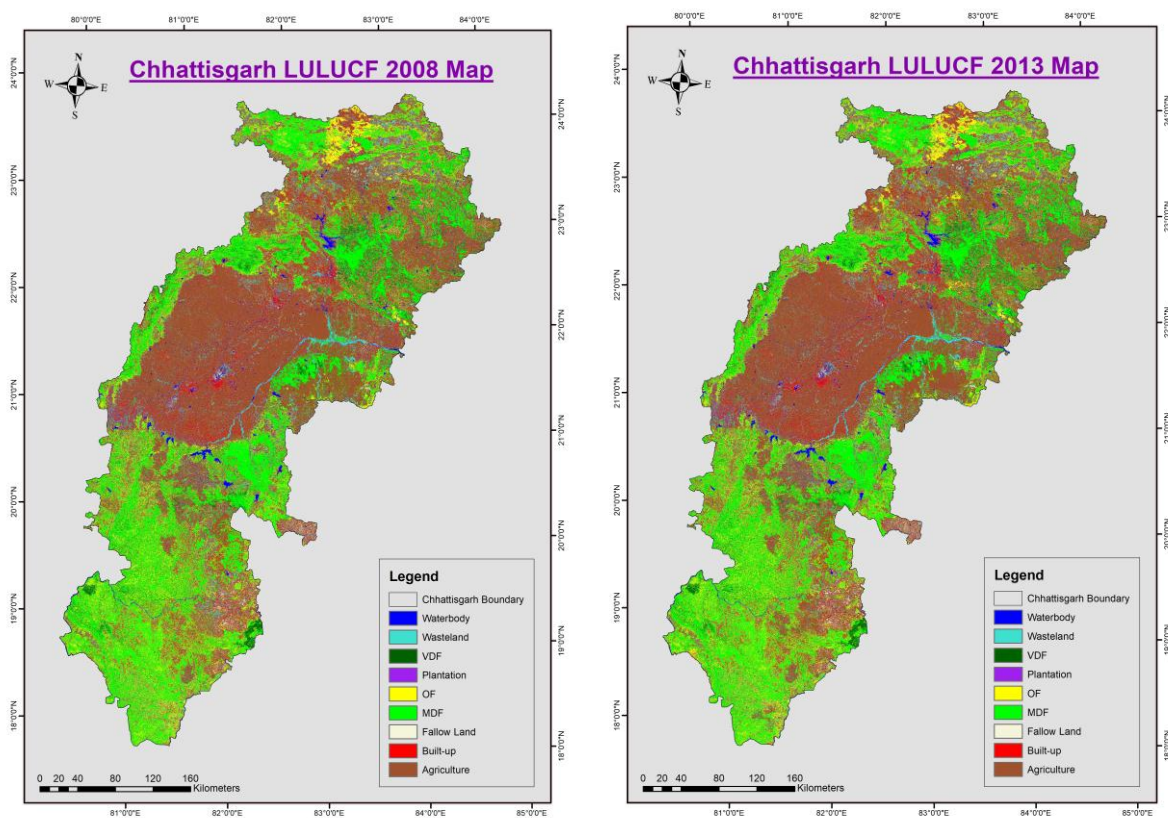


Figure 1: LULUCF comparison of Chhattisgarh

	NRSC 2008	Vasudha Foundation 2008	Variation	NRSC 2013	Vasudha Foundation 2013	Variation
Built-up	4143.2	4482.0	8%	4189.8	4535.0	8%
Forest ²	55678.0	55483.1	0%	55621.0	55270.8	-1%
Cropland	62843.5	64401.2	2%	63606.9	64628.2	2%
Plantations	239.1	608.6	155%	239.1	608.6	154%
Other land	3818.8	7248.2	90%	2849.4	7134.2	150%
Water body	2878.6	3043.4	6%	3037.9	3089.6	2%

The change in LULUCF of Chhattisgarh done by Vasudha Foundation in comparison with NRSC shows slight variations of 8% and 2% in built-up and cropland category respectively, in both years 2008 and 2013. The land-use values for forest for comparison were taken from FSI's change matrix as NRSC did not show any change in forest cover. Therefore, on comparing the forest cover with FSI, the forest cover gave 0% variation from FSI's estimates in 2008 and 1% variation in 2013.

Plantations and Other land showed large variations of 155% and 90% in 2008, which further increased to 154% and 150% in 2013. This variation may have come about since plantations on the crop fields are often not considered/identified among the plantations category. During interpretation, plantations are often remain unidentified near roads, canals and thus are mistaken with other classes of land. As NRSC uses AWiFS data that is a coarse resolution data, these details might not have been identifiable as compared to LISS III data, which is of medium resolution used in this study. Apart from that, 239 Sq. Km and 608 Sq. Km are very small areas as compared to the total area 1,35,266.4 Sq. Km of Chhattisgarh. Coming to the Other Land category, the reason for a large variation from could be that wastelands near rivers alter seasonally due to rise and fall in level of rivers during different seasons, thereby reflecting discrepancies in the identification of such lands.

2. Goa

Classes	NRSC 2008	Vasudha Foundation 2008	Variation	NRSC 2013	Vasudha Foundation 2013	Variation
Built-up	194.134	185.786	-4%	195.392	187.582	-4%
Forest	2151.000	2109.002	-2%	2219.000	2104.979	-5%
Cropland	513.658	374.441	-27%	511.783	405.978	-21%
Plantations	286.884	676.788	136%	287.076	520.028	81%
Other Land	166.638	189.422	14%	165.775	316.498	91%
Water body	127.268	149.395	17%	128.557	149.779	17%

² Forest land values are taken from Forest Survey of India data available in the public domain

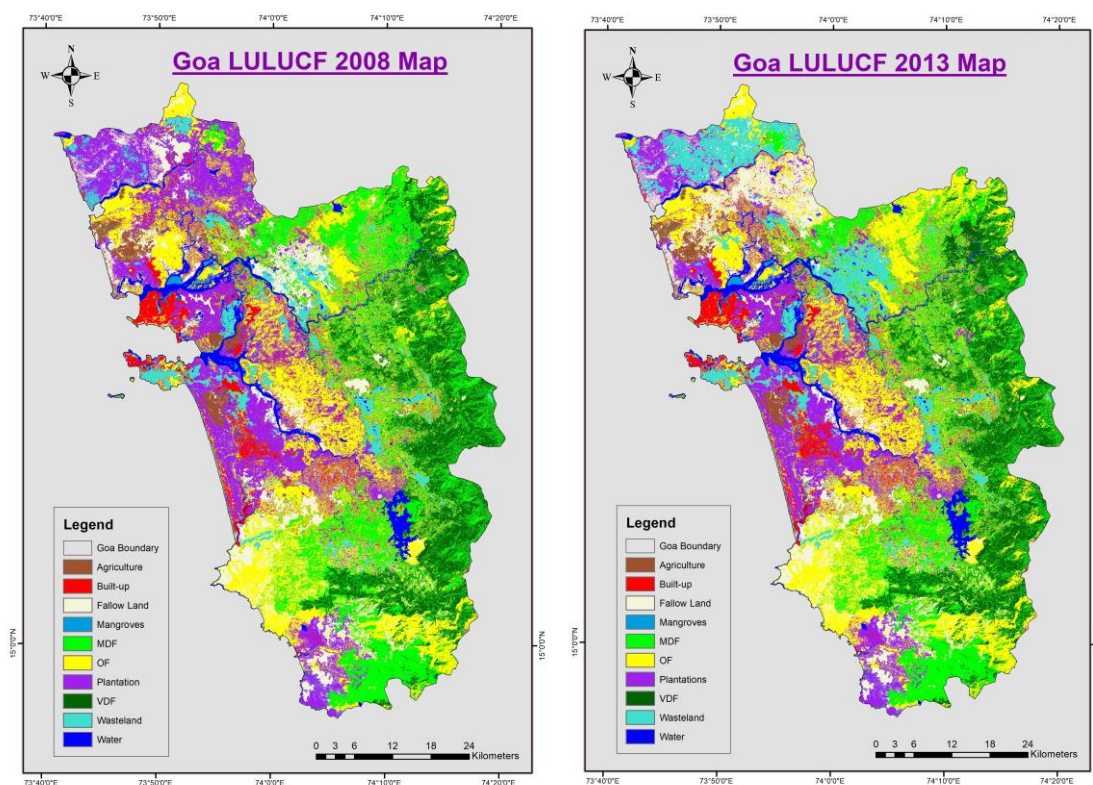


Figure 2: LULUCF comparison of Goa

For most of the land categories, the variation between the assessment done by Vasudha Foundation and the data assessed by NRSC as well as FSI was not beyond a standard variation that may arise in any two assessments conducted on similar geographies.

However, a major difference observed in Goa's assessment by Vasudha Foundation was in the Other land category. Our assessment gives an increase of Other land by 127.1 sq. km in 2013 with the percentage of variation increasing from 14% to 91%. This may well be due to large scale mining of iron ore. Goa is a major iron ore exporting state and over 60% of Country's iron ore export is from Goa. The mining belt of Goa covers approximately 700 sq. km and is mostly concentrated in four talukas namely, Bicholim of North Goa district and Salcete, Sanguem and Quepem of South Goa district³. Mining and associated activities have greatly affected the natural landscape of Goa, which is characterized by the appearance of wasteland in the satellite data that was interpreted by us.

3. Kerala

³<http://www.goaenvi.nic.in/mining.htm>

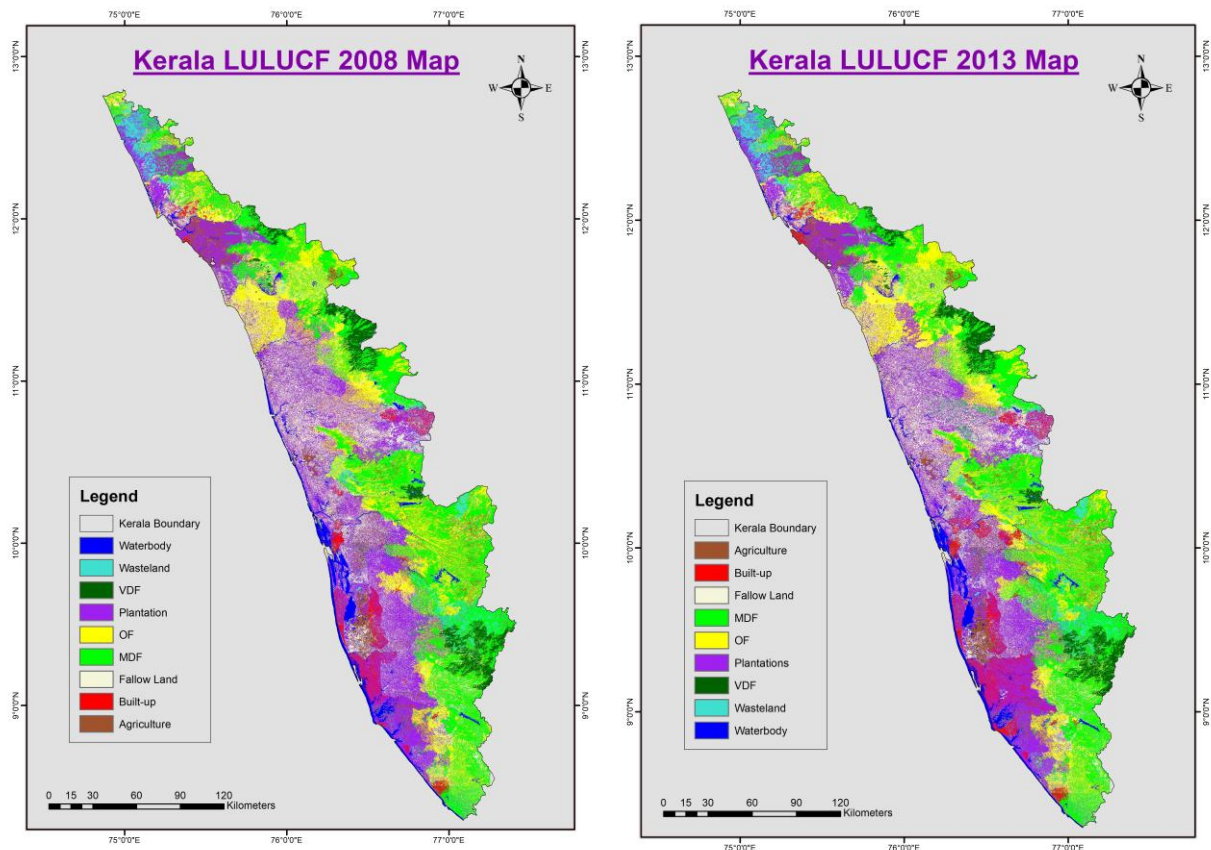


Figure 3: LULUCF comparison of Kerala

Classes	NRSC 2008	Vasudha Foundation 2008	Variation 2008	NRSC 2013	Vasudha Foundation 2013	Variation
Built-up	620.00	937.99	51%	1451.71	1033.82	-29%
Forest	17335.00	17592.83	1%	17922.00	17528.41	-2%
Cropland	3578.38	8013.46	124%	3444.44	7875.48	129%
Plantations	13892.90	9194.23	-34%	13907.47	9086.93	-35%
Wasteland	1725.78	1897.31	10%	826.16	2118.78	156%
Water body	1081.89	1545.38	43%	1269.58	1537.79	21%

In the case of Kerala, it was observed that built up area showed substantial increases from 2008 to 2013 as per both NRSC and Vasudha Foundation. The differences between the two assessments however narrowed down in 2013. The two assessments did not vary much in the case of forests. The large variations between the two assessments for croplands, plantations and wastelands are perhaps due to technical reasons of which the primary reason is that these land classifications can be misinterpreted for Kerala because of their similar spectral reflectance. In addition, seasonal data variations in satellite images tend to show up major differences in interpretation of such image.

4. Punjab

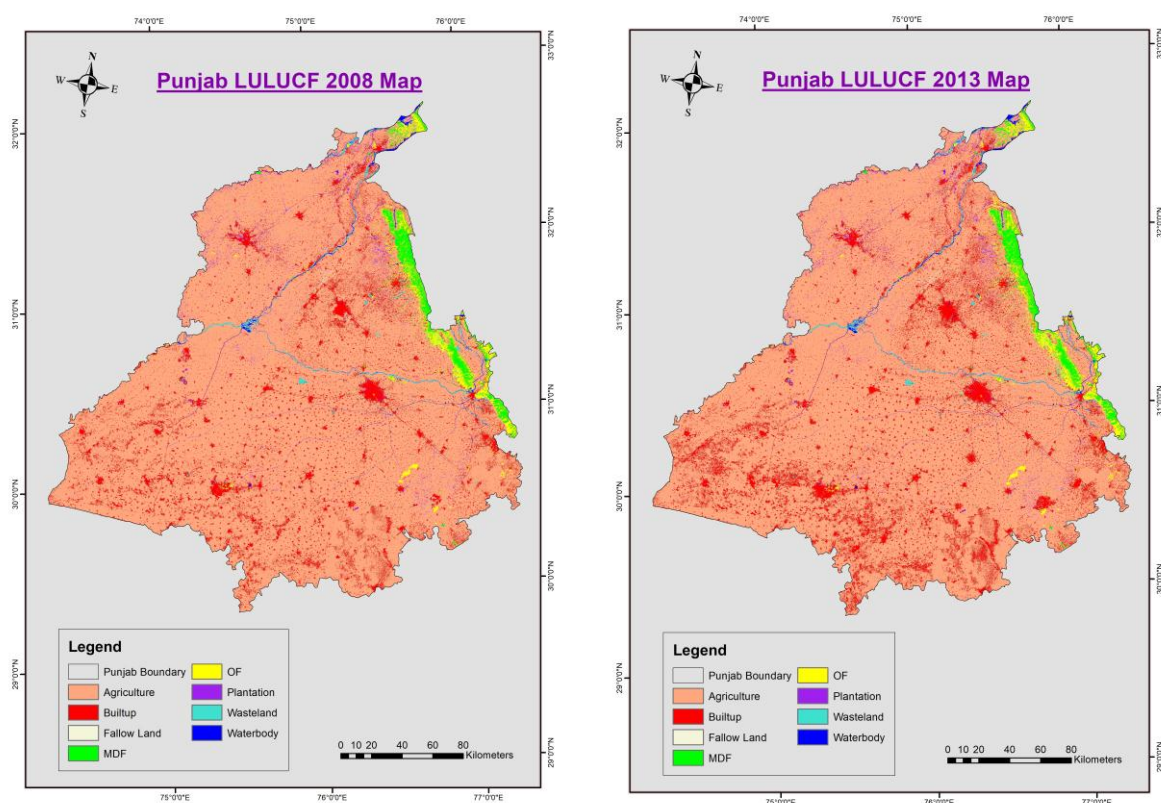


Figure 4: LULUCF comparison of Punjab

	NRSC 2008	Vasudha Foundation 2008	Variation 2008	NRSC 2013	Vasudha Foundation 2013	Variation 2013
Built-up	3594.86	4958.99	38%	4276.40	6098.73	43%
Forest	1664.00	1699.74	2%	1772.00	1756.10	-1%
Cropland	41373.87	42560.80	3%	41373.52	41364.43	0%
Plantations	881.07	489.61	-44%	885.46	497.55	-44%
Other Land	2103.65	435.75	-79%	1407.11	425.04	-70%
Water body	829.60	304.38	-63%	840.57	307.42	-63%

There were large differences between the results of our analysis and the interpretation done by NRSC for Punjab in the case of Built-up areas, Plantations, Other land and Water bodies. Some of these differences could be due to the differences in the resolution of the images used by Vasudha Foundation and NRSC respectively. For example, the expansion of Built up areas has taken place mainly close to the cropped areas, and may have been not detected due to differences in the resolution of the images used. Further, plantations are also often on croplands and may not have been detected or interpreted as distinct from croplands. Also, fallow land may have been interpreted as wasteland or Other Land and therefore cause this variance in estimation. Another challenge in interpreting images specifically for Punjab is

that due to flooded irrigation methods of rice cultivation, many croplands tend to get interpreted as water bodies.

5. Tripura

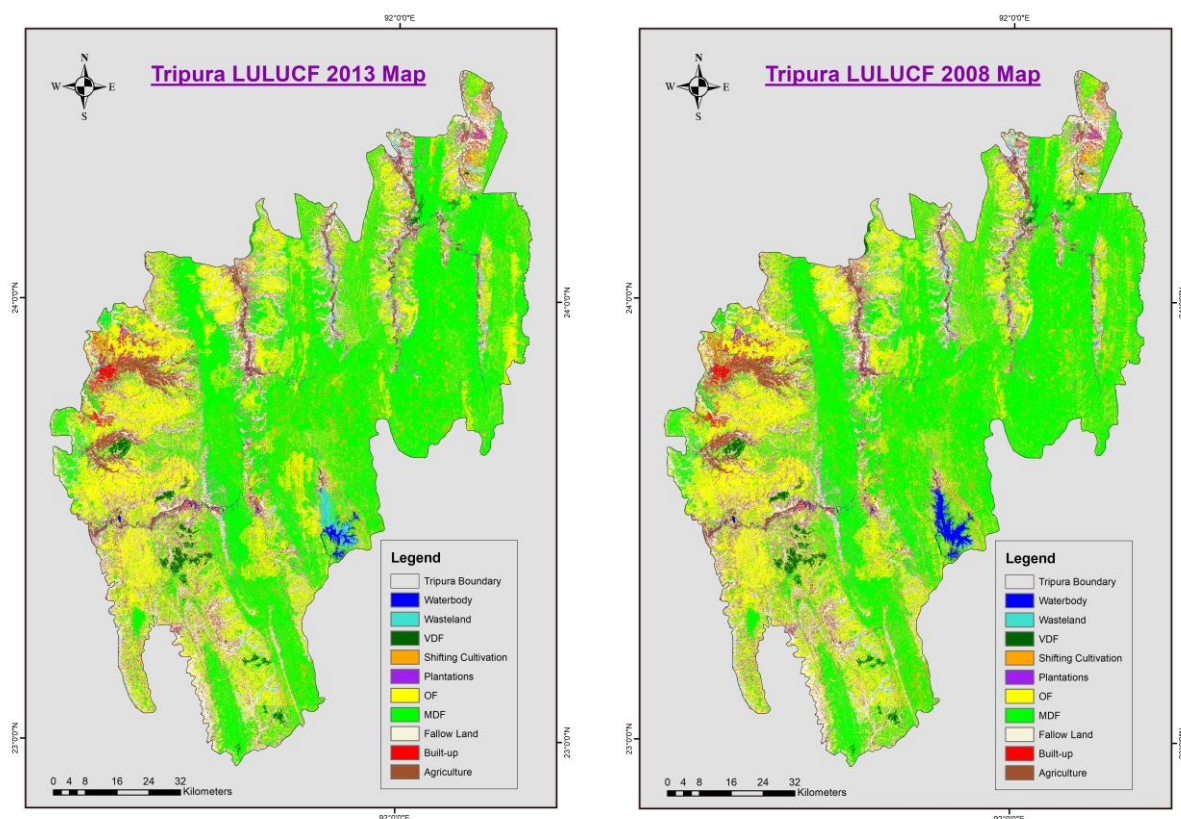


Figure 5: LULUCF comparison of Tripura

	NRSC 2008	Vasudha Foundation 2008	Variation (%)	NRSC 2013	Vasudha Foundation 2013	Variation (%)
Built-up	343.30	224.06	-35%	498.42	206.54	-59%
Forest	6820.59	7762.92	14%	7084.67	7811.36	10%
Cropland	2124.59	1845.14	-13%	1851.45	1751.46	-5%
Plantations	595.99	440.97	-26%	598.83	435.22	-27%
Other land	278.57	102.38	63%	87.07	203.07	133%
Water body	45.44	108.79	139%	88.04	76.60	13%

The variation between the analysis done by Vasudha Foundation and NRSC for built up area is primarily due to the scattered nature of settlements in Tripura, due to which image interpretation assumptions made for each assessment could yield divergent results. Variations between our assessment of Other lands or wastelands and water bodies is primarily due to variations in the water contained in a large lake in Tripura i.e. Dumboor lake. This lake held a much larger volume of water in 2008 when compared with 2013. The shrinking of the lake in 2013 from 2008 and the resultant differences in the interpretation of the images to classify the land situated on the edge

of the lake explains the discrepancy between the assessments made by Vasudha Foundation and NRSC.

In summary, and giving some examples of where the Vasudha Foundation assessment varies greatly from the official data on land use are as follows:

1. For Chhattisgarh, while official data shows 239.1 sq km of land covered under plantations in 2013, our data shows that the land under plantations is much higher at 608.6 sq. km. Further, the other land category in Chhattisgarh, officially covers 2849.4 sq. km., whereas our data shows that other land covers 7134.2 sq. km. in the state.
2. In the case of Goa too, there are large variations in the area estimated for plantations and other land in 2013. While official data show 287.08 sq. km. under plantations, our data shows 520.03 sq. km. falling under this land use in 2013. Similarly, while official data show 165.78 sq. km. under other land, our data shows 316.50 sq. km. under other land in 2013.
3. In the case of Kerala, very large variations were found in the categories of cropland and other land from the official land data for 2013. Thus, while official data for area under cropland in Kerala shows area coverage of 3.444.44 sq. km., our data shows the extent of cropland in Kerala to be 7875.48 sq. km. in 2013. The extent of other land in Kerala was 826.16 sq. km. officially, while our data shows other land coverage as 2118.78 sq. km. in 2013.
4. In the case of Punjab, instead of showing estimates that are higher than the official estimations of area under plantations and other land, our estimates are lower than the official estimates. Thus, while official estimates of area under plantations in Punjab in 2013 are 885.46 sq. km., our estimates show that 497.55 sq. km. were under plantations. Official estimates for other land in 2013 are 1407.11 sq. km. while our estimates for this land category are 425.04 sq. km.
5. In the case of Tripura, 87.07 sq. km. was officially reported to be under other land in 2013, while our data showed that 203.07 sq. km. was under other land.

The data uncertainties highlighted above show that an independent assessment of land use data might throw up numbers that could be vastly different from the official numbers on land use activity data. These uncertainties may also show up in vastly different estimation of emissions underpinned by a totally independent assessment of the activity data underlying the calculations of such emissions.

What add to these uncertainties are also the vastly varying estimations of emissions factors for various categories of land use between default factors assigned by the IPCC and country specific emissions factors.

We illustrate some of these uncertainties below, by calculating emissions from just one category of land, viz. cropland, for comparable time periods based on the change matrix provided by the NRSC and the change matrix that was compiled by the Vasudha Foundation through its own, independent, interpretation of remote sensing data that was available in the public domain.

For Cropland Remaining Cropland, the emissions calculations were the following:

Cropland remaining Cropland	Cumulative Emissions from 2008 to 2013 based on NRSC Change Matrix (Million Tonnes CO2e)	Cumulative Emissions from 2008 to 2013 based on Vasudha Foundation Change Matrix (Million Tonnes CO2e)	Variation in Vasudha Foundation Estimate from NRSC derived estimate (percentage)
Chhattisgarh	3.45	3.35	2.90%
Goa	-0.13	-0.27	-107.69%
Kerala	-7.64	-4.90	35.86%
Punjab	1.88	2.10	-11.70%
Tripura	-0.24	0.05	120.83%

For Forest Land Converted to Cropland, the emissions calculations were the following:

Forest Land Converted to Cropland	Cumulative Emissions from 2008 to 2013 based on NRSC Change Matrix (Million Tonnes CO2e)	Cumulative Emissions from 2008 to 2013 based on Vasudha Foundation Change Matrix (Million Tonnes CO2e)	Variation in Vasudha Foundation Estimate from NRSC derived estimate (percentage)
Chhattisgarh	0.00	0.19	Not applicable
Goa	0.00	0.01	Not applicable
Kerala	0.00	0.04	Not applicable
Punjab	0.00	0.00	Nil
Tripura	0.42	0.24	-42.86%

For grassland converted to cropland, neither NRSC nor Vasudha Foundation's analysis showed any land use change on this nature.

Wetlands converted to cropland was also a category for which neither NRSC nor Vasudha Foundation's analysis showed any land use change

For settlements converted to cropland, while no such category of land use change was detected by the analysis carried out by NRSC, Vasudha Foundation's analysis showed a very marginal change of land use in this category with very small associated emissions. The results are shown below

Settlements Converted to Cropland	Cumulative Emissions from 2008 to 2013 based on NRSC Change Matrix (Million Tonnes CO ₂ e)	Cumulative Emissions from 2008 to 2013 based on Vasudha Foundation Change Matrix (Million Tonnes CO ₂ e)	Variation in Vasudha Foundation Estimate from NRSC derived estimate (percentage)
Chhattisgarh		0.00001	Not applicable
Goa		0.00001	Not applicable
Kerala		0.00018	Not applicable
Punjab		0.00005	Not applicable
Tripura		0.00000	Not applicable

For Other Land Converted to Cropland, the emissions calculations were the following:

Other Land Converted to Cropland	Cumulative Emissions from 2008 to 2013 based on NRSC Change Matrix (Million Tonnes CO ₂ e)	Cumulative Emissions from 2008 to 2013 based on Vasudha Foundation Change Matrix (Million Tonnes CO ₂ e)	Variation in Vasudha Foundation Estimate from NRSC derived estimate (percentage)
Chhattisgarh	-1.78	-0.14	-92.13%
Goa	-0.03	-0.01	-66.67%
Kerala	-0.17	-0.03	-82.35%
Punjab	-0.10	0.00	Not applicable
Tripura	-0.02	0.00	Not applicable

The aggregate emissions estimates across all the cropland categories for which emissions were calculated were as follows:

Aggregated emissions from cropland	Cumulative Emissions from 2008 to 2013 based on NRSC Change Matrix (Million Tonnes CO ₂ e)	Cumulative Emissions from 2008 to 2013 based on Vasudha Foundation Change Matrix (Million Tonnes CO ₂ e)	Variation in Vasudha Foundation Estimate from NRSC derived estimate (percentage)
Chhattisgarh	1.67	3.40	103.59%
Goa	-0.16	-0.27	68.74%
Kerala	-7.81	-4.89	37.39%
Punjab	1.78	2.10	17.98%
Tripura	0.16	0.29	81.25%

Thus, the emissions estimations carried out by Vasudha Foundation, based on their analysis of the land use changes in the five states listed above were significantly

higher than those that were estimated based on the change matrix that was provided by NRSC.

These differences raise certain issues that may be relevant for accurate estimation of emissions from land use, land use change, and forestry as India prepares to move from tier II to tier III methodologies in reporting its emissions to the UNFCCC. Interpretation of remote sensing data lies at the heart of the process of estimating emissions from Lands. In addition, there is still a lack of clarity in official emissions inventories regarding the specific emissions factors that are being used for calculating emissions from land. At present, the process whereby emissions from land are being estimated for official inventories is not fully transparent. There is a need for these estimation processes to become more open and transparent, and draw upon expertise outside the governmental departments and consultants engaged by them. This will allow for a greater understanding of the emission estimation from lands among all stakeholders and greater confidence or quality assurance in the results that are being reported in official inventories.

The Green India Mission and Achievement of Targets: An Attempt at Tracking Progress based on Official Data in the Public Domain⁴

The Green India Mission was formally launched in 2010. Its first goal was stated to be “To increase forest/tree cover to the extent of 5 million hectares (mha) and improve quality of forest/tree cover on another 5 mha of forest/non-forest lands”⁵. This was further broken down into the following targets:

- a) Qualitative improvement of forest cover/ecosystem in
 - i. Moderately dense forests (1.5 m ha)
 - ii. Open degraded forests (3 m ha)
 - iii. Degraded grassland (0.4 m ha)
 - iv. Wetlands (0.1 m ha)
- b) Eco-restoration/afforestation of scrub, shifting cultivation areas, cold deserts, mangroves, ravines and abandoned mining areas (1.8 m ha)
- c) Bringing urban/ peri-urban lands under forest and tree cover (0.20 m ha)
- d) Agro-forestry /social forestry (3 m ha)

These targets, presumably, are to be achieved by 2020, which is when the Green India Mission would have resulted in “enhanced annual CO₂ sequestration by 50 to 60 million tonnes in the year 2020”⁶

Target a(i) aims to improve the quality of 1.5 million hectares of 15,000 sq km of moderately dense forests. Between 2009 and 2015, however, according to the data placed in the public domain by the Forest Survey of India, area under moderately dense forests had shrunk by 5,362 sq km. While at the same time period area under very dense forests had gone up by 2,434 sq km, area under open forest had also increased by 12,574 sq km. Even if one were to assume that all of the increases under very dense forests can be attributed to qualitative improvements in the moderately

⁴ Data for this section has been compiled from Forest Cover Assessments done biannually by the Forest Survey of India, Dehradun

⁵ http://www.moef.gov.in/sites/default/files/GIM_Mission%20Document-1.pdf

⁶ Ibid

dense forests amounting to 2,434 sq km, it is highly likely that the residual reduction in the area under moderately dense forests (2,928 sq km) perhaps degraded into open dense forests. Successful achievement of this part of the target of the Green India Mission thus appears to be off track at this moment.

Target a(ii) aims to improve the quality of open and degraded forests by 3 million hectares of 30,000 sq km. The Forest Survey of India defines open forests as “All lands with tree cover (Including mangrove cover) of canopy density between 10% and 40%”⁷. Assuming, that atleast 50% of the 30,000 sq km would move up the classification and eventually be included in the category of moderately dense forests, the area under moderately dense forests ought to increase by atleast 15,000 sq. km. As already reported above, however, the area under moderately dense forests has reportedly declined by 5,362 sq km between 2009 and 2015. Further, the increase in the area under open forests, i.e. 12,574 sq km between 2009 and 2015 is less than half the target set for itself by the Green India Mission. This part of the Green India Mission too, thus, appears to be off target at the moment.

Targets a(iii) and a(iv) cannot be assessed due to lack of any useful information in the public domain

Target b) seeks to accomplish “eco-restoration/afforestation of scrub, shifting cultivation areas, cold deserts, mangroves, ravines and abandoned mining areas” over 1.8 million hectares or 18,000 sq km. The available data in the public domain suggests that this part of the mission, too, is not on track at present. This is because while area under scrub forests has declined by 814 sq km, area under non-forests lands has declined by 8,832 sq km. Even if one assumes that 50% of this decline could be explained by the increase in the area occupied by open forest (12,574 sq km), it appears that the achievement of this target too, could be off track at the moment

Targets c) and d) is difficult to evaluate with the existing information that is available in the public domain

Conclusions

In our opinion, uncertainties in the land use data arise primarily from lack of transparency on how these data are being generated. We would recommend that there should be a process of greater collaboration and consultation among all stakeholders in the country so that there is a better understanding and appreciation of the data being generated, as well as better use of the said data for the purposes of research and analysis. Within this, there needs to be greater data availability on monitoring progress of the Green India Mission since this is an important part of India’s mitigation efforts reported to the UNFCCC at the ongoing international negotiations.

⁷ Forest Survey of India Scheme of Classification (http://fsi.nic.in/details.php?pgID=sb_8)