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Yale-UNAM Project
Geospatial Analysis and Modeling of Non-Renewable Biomass: WISDOM and beyond
Research grant provided by the Global Alliance for Clean Cookstoves

Tier II :

WISDOM Honduras

Analysis of woodfuel supply, demand and sustainability in Honduras

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Abstract

The spatial analysis of Honduras' consumption and supply potential of fuelwood and charcoal, carried out as part of a pan-tropical study of woodfuel sustainability, reveals that 46-47% of the annual consumption is unsustainable, corresponding to 1.7-1.8 Mt tons DM of woody biomass, if the biomass released as by-product of deforestation is actually used as fuel. However, when we calculate the fraction of non-renewable biomass that could be affected by improved stoves or fuel switching, which excludes these by-products, we find the unsustainable share of fuelwood harvested independently of LCC is quite small. Indeed, there is a relative abundance of woody biomass available throughout the country. In addition, in coffee-growing regions, a substantial amount is produced sustainably via regular pruning of shade trees.

Thus, while there is a strong argument to promote cleaner more efficient cookstoves throughout the country to reduce health risks linked to fuelwood use, it is unlikely that reducing fuelwood demand would significantly reduce CO_2 emissions on a national scale unless these steps were simultaneously taken in conjunction with other measures to reduce deforestation.

This study integrates most relevant and recent information available from forestry and energy sectors and from socioeconomic surveys. The Honduras analysis followed the Woodfuel Integrated Supply Demand Overview Mapping (WISDOM) model, and is used to validate the pan-tropical analysis of woodfuel sustainability recently completed by the Yale-UNAM research project. Results indicate that the pan-tropical model over-estimated the non-renewable harvesting fraction (64% vs 47%) due to higher demand estimates and to different reference data on deforestation.

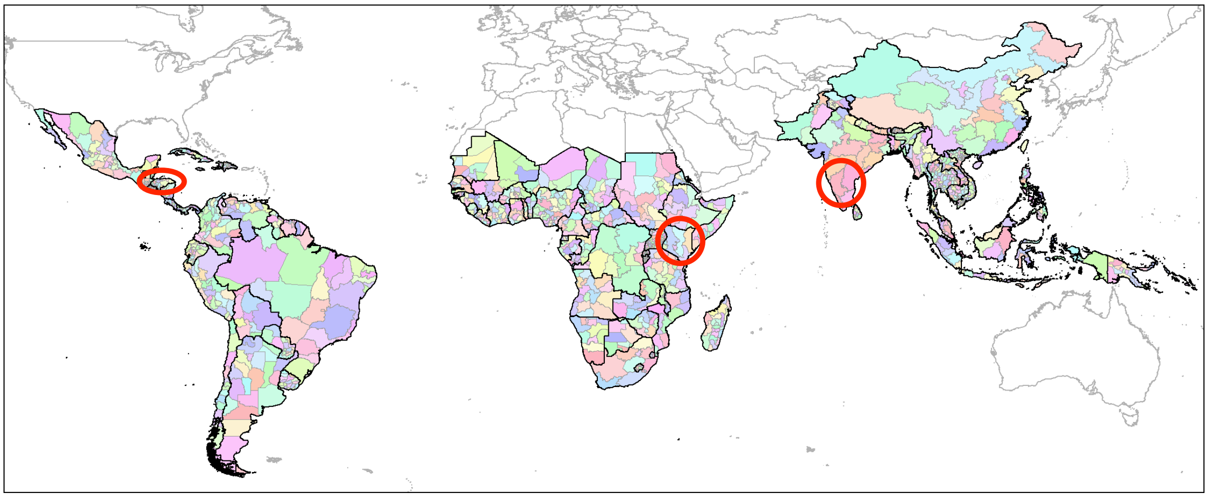
This study provides the first country-wide spatial-explicit estimation of woodfuel supply, demand and sustainability, which has considerable national-level policy relevance. The results of this study can contribute to the definition of national strategy objectives and, given its spatial character, can support the tailoring of sub-national policy options and interventions.

INTRODUCTION

The Project

The "Geospatial Analysis and Modeling of Non-Renewable Biomass: Wisdom and Beyond" study, commissioned by the Global Alliance for Clean Cookstoves (GACC) and supported by the UN Foundation, is implemented by the Yale School of Forestry and Environmental Studies (FES) in partnership with the Centro de Investigaciones en Geografía Ambiental (CIGA) and the Centro de Investigaciones en Ecosistemas (CIEco) of the National Autonomous University of Mexico (UNAM).

Figure 1: Global map showing countries included in Tier I analysis (90 countries divided into 1480 sub-national units) and selection of Tier II and Tier III analyses locations.



The project follows a three-tier approach to draw comparisons between three different geographic scales of analysis: Tier 1 – Pan-tropical (1, 2)); Tier 2 – National/state level (3, 4); and Tier 3 – Local level (Figure 1).

Honduras is selected for Tier 2 and Tier 3 analyses. Tier 2 analysis, the focus of the present report, analyzes woodfuel supply and demand over the whole Country through the application of the WISDOM model. This summary report provides an overview of the main features and findings of the Honduras study.

The Honduras context

The demand for woodfuel in Honduras is high, especially in rural areas, and it is clear that in the short and medium term fuelwood will remain the main affordable fuel for a large fraction of rural population, and a significant one for urban dwellers as well (5).

Table 1: Distribution of primary fuel for cooking in 2011/12 (6)

Fuel	Urban	Rural	Total
Electricity	30.7	6.2	18.9
LPG or other gaseous fuel	38.8	10.2	25.1
Kerosene	5.1	0.4	2.8
Charcoal	0.0	0.2	0.1
Fuelwood	22.3	81.0	50.4
Do not cook in the home	3.1	2.0	2.6

Wood resources are relatively abundant and evenly distributed, in particular when we account for the important woody by-products associated with shade-coffee production. At the same time, however, Honduras experiences intense processes of deforestation (7). We hypothesize that this land-use change generates considerable amounts of woody biomass that are in part used as fuelwood.

Beyond the contribution to the pan-tropical study, the Tier 2 analysis of Honduras provides a national diagnostic of woodfuel demand, supply and harvesting sustainability that can contribute to forestry and energy planning in a locally tailored manner and that can support Honduras REDD+ Readiness process.

MAPPING OF WOODFUEL DEMAND

The estimation and spatial distribution of fuelwood consumption in the residential sector was based on the integration of several statistical and cartographic layers. The digital map of villages (almost 28,000) reporting demographic and socioeconomic data from Census 2001 (8), including household's preferred cooking fuel, being the most relevant one. We derived updated estimates 2012 fuelwood saturation and stove characteristics with data from the latest Demographic and Health Survey (6). Average annual fuelwood consumption per household was estimated to be 4.1 tons DM for Traditional Cookstoves (TCS) and 2.1 t DM for Improved Cookstoves (ICS) based on field measurements (9). The consumption of fuelwood in coffee processing was estimated using a previous estimates for 2008 (10), updated to 2012 based on FAO Coffee production statistics (11) and mapped using the coffee cultivation area reported in the recent map of Honduras Forest Types (12). Woodfuel consumption in other sectors was estimated; however, lacking Honduras-specific data, we relied on commercial and industrial woodfuel data from El Salvador (10). The national woodfuel consumption in 2012 is estimated to 3.8 Mt DM of woody biomass, 89% of which in the residential sector, 9% in the commercial and industrial sector and 2.4% in coffee processing, as shown in Table 1. The geographic distribution of woodfuel demand is shown in Figure 2a while statistics by Departament are reported in Table 1.

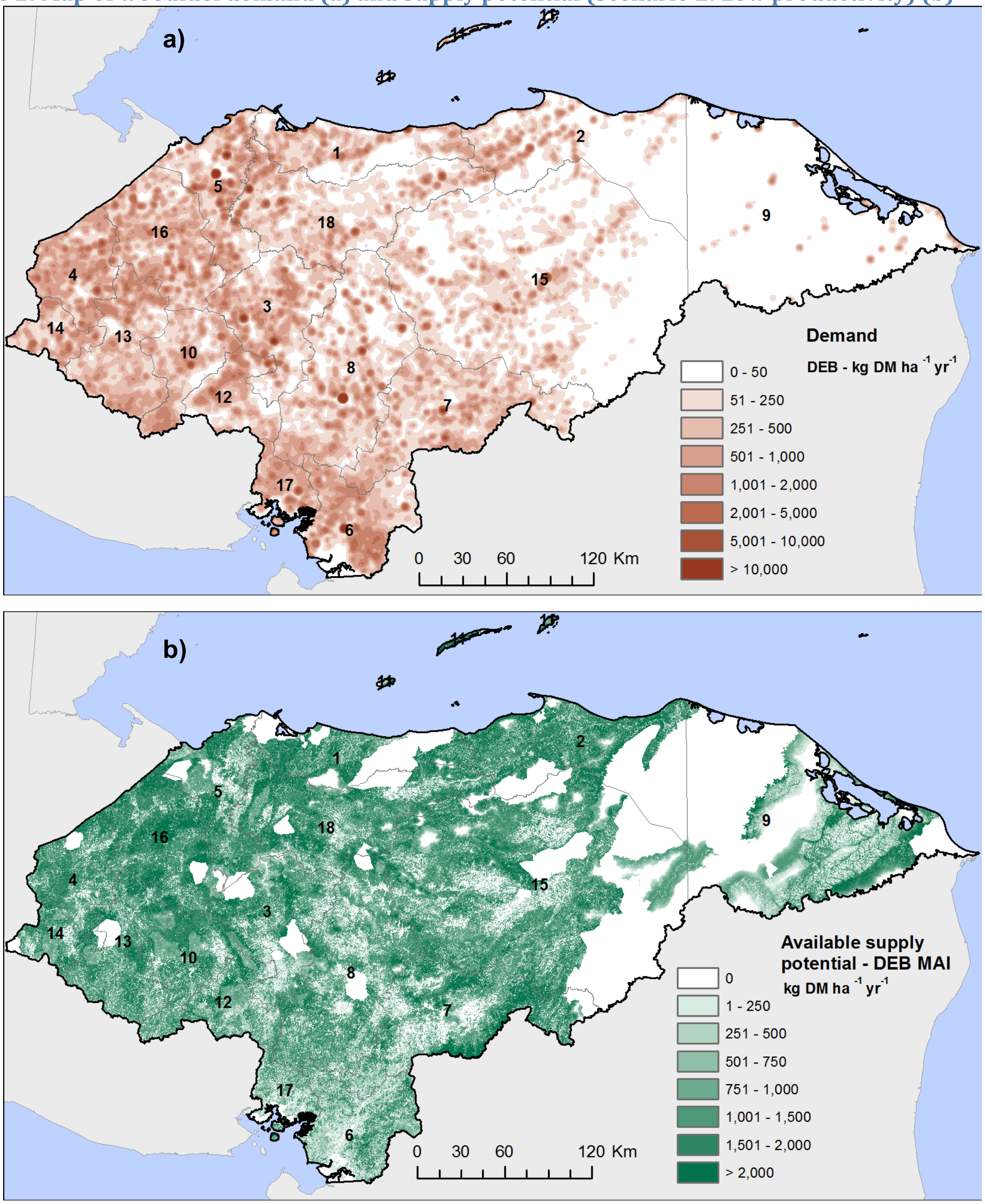
MAPPING OF SUPPLY POTENTIAL

The sustainable supply was estimated and mapped integrating several cartographic and statistical layers, including land use and land cover data (12), biomass stock map (13) and productivity estimates based on stock/MAI relation (1) based on data from numerous other reports and surveys from similar ecological conditions. In order to account for uncertainty on the sustainable productivity, two scenarios were considered: a Scenario 1 of "medium productivity", using two equations based on observations referring to tropical coniferous an tropical broadleaves, respectively, and Scenario 2 of "low productivity", more conservative, using a single equation based on the same set of observations used for the pan-tropical tier 1 study (1). The estimated stock of DendroEnergy Biomass (DEB) [1] and of the Mean Annual Increment (MAI) according to the two scenarios are shown in Table 2.

In addition, protected areas, road network, slope and land cover data was used to estimate the fraction of the resource that can be considered legally and physically accessible. The estimated annual sustainable DEB productivity that is accessible and potentially available for energy use is 14.2 Mt DM for scenario 1 (medium productivity) and 9.4 Mt DM for scenario 2 (low productivity), as detailed in Table 2. The geographic distribution of the sustainable and potentially available supply potential is shown in Figure 2b (showing scenario 2).

[1] DEB includes the whole whole aboveground woody biomass of living plants less leaves, twigs and stumps.

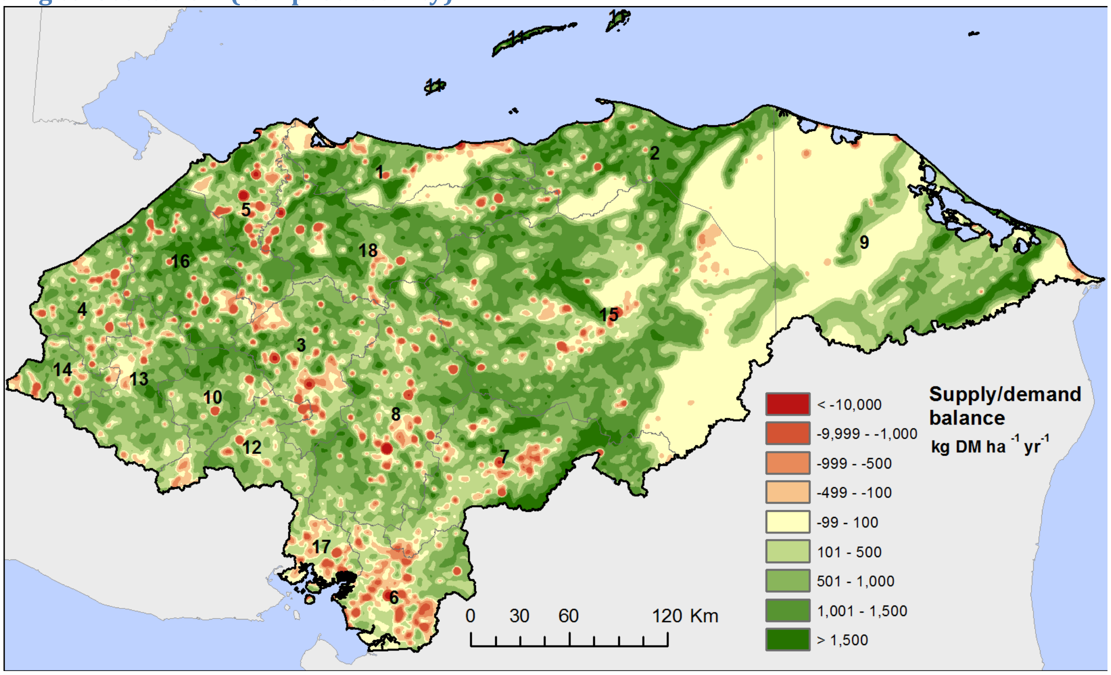
Figure 2: Map of woodfuel demand (a) and supply potential (Scenario 2: Low productivity) (b)



DEMAND-SUPPLY INTEGRATION

The local supply/demand balance map identifies areas of deficit and surplus related to subsistence harvesting or informal local markets. Figure 3 shows the local balance for Honduras, with deficit areas in red, and surplus areas in green, according to scenario 2 (low productivity). The commercial balance is subsequently calculated by excluding from the local surplus the woody biomass that is considered uneconomic for commercial fuelwood production (see local/commercial balance values in Table 3).

Figure 3: Map of local supply/demand balance calculated within a harvesting horizon of 4.5km, according to. Scenario 2 (low productivity)



COMMERCIAL SUPPLY AND DEMAND – THE "WOODSHED" ANALYSIS

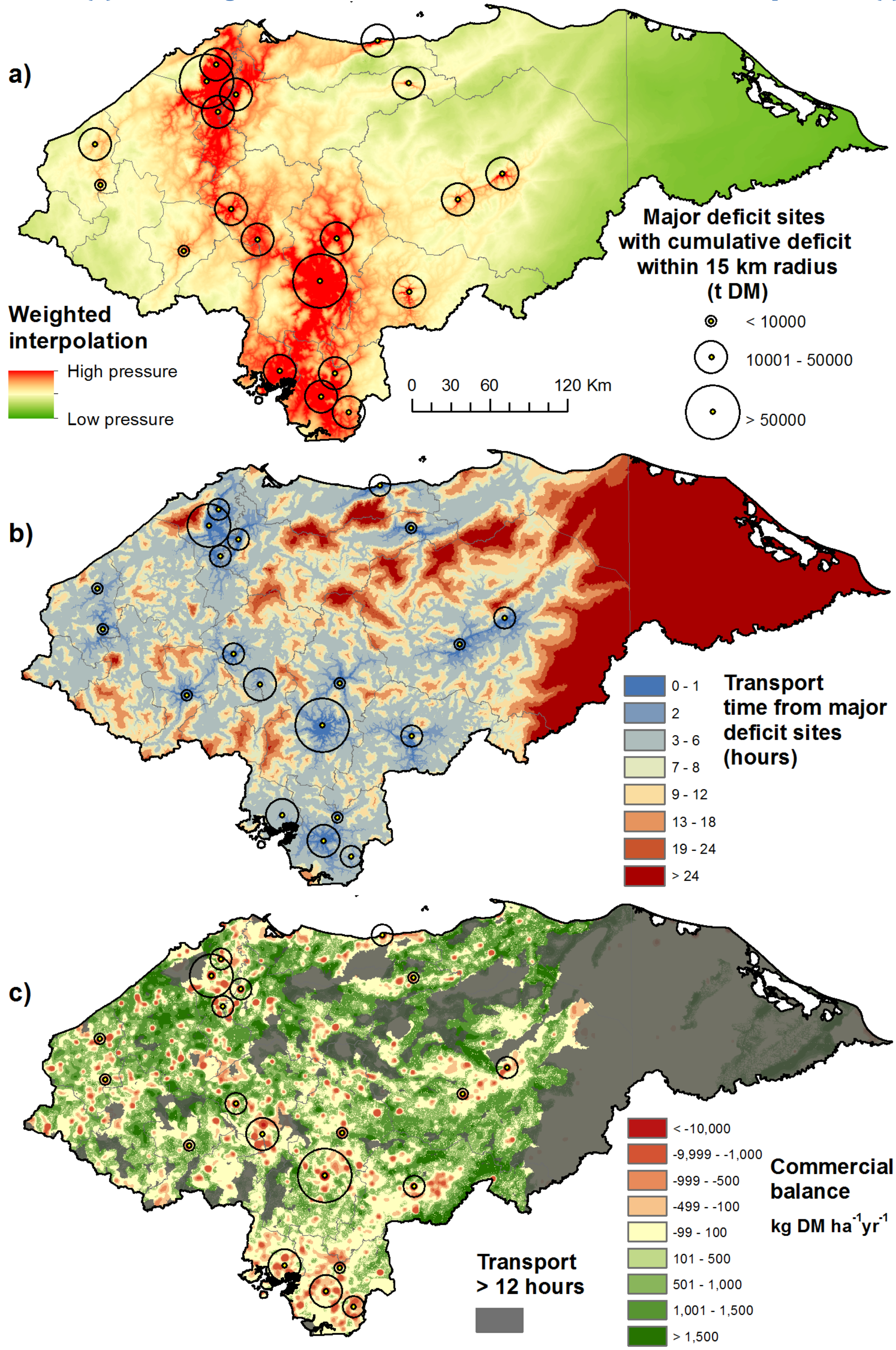
With deficit areas identified, we define a spatial distribution of commercial woodfuel harvesting required to satisfy those deficits by conducting a "woodshed" analysis (analogous to the concept of an ecological watershed). Local deficits for commercial demand are defined within 15 km radii[2]. For the whole of Honduras, 20 points are identified. Figure 4a shows the distribution of the major deficit sites as well as the pressure exerted by commercial demand, which is calculated through weighted interpolation, combining commercial demand and resource accessibility. Figure 4b shows the transport time from these same sites and Figure 4c shows the probable commercial harvesting area applying a threshold of 12 hours transport time (dark grey areas are > 12 hours from the nearest site).

DISTRIBUTION AND INTENSITY OF WOODFUEL HARVESTING

The spatial distribution of woodfuel harvesting induced by local deficit conditions is critical in the analysis of NRB. In this case we have assumed that demand in rural deficit sites is met by commercial harvesting, just like urban sites, following what we call the "full market" scenario, which is consistent with the one chosen for tier 1 analysis. This assumption shifts pressure toward accessible forest resources and other areas with surplus biomass. Given the relative abundance of woody biomass in Honduras landscapes and the generally positive balance in rural areas, other scenarios assuming use of marginal by-products and overexploitation of local resources were not considered appropriate and would have no significant impact on final results.

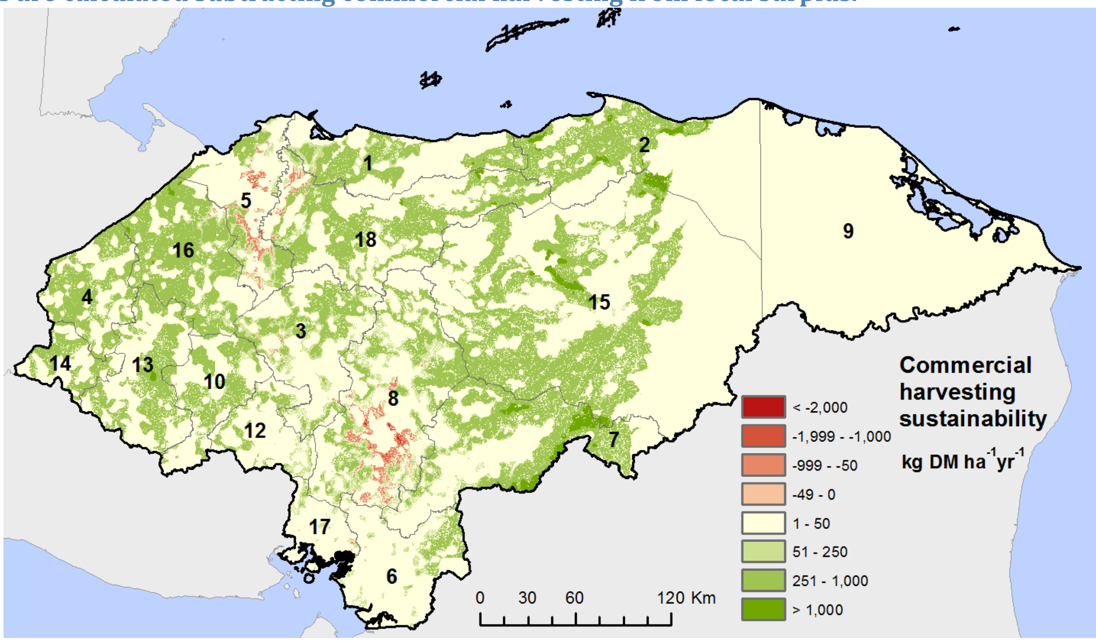
[2] A radius of 15 km is chosen to represent the cumulative commercial demand of all settlements, including the largest urban and peri-urban areas.

Figure 4: Commercial harvesting pressure zone map from major deficit sites (a); transport time from the same sites (b); harvesting area and commercial balance within 12-hours transport time (c)



The spatial distribution and sustainability[3] of commercial harvesting for scenario 2 (low productivity) is shown in Figure 5, which shows that unsustainable harvesting is limited to major urban areas in the Departments of Francisco Morazán (#8), Cortés (#5) and Yoro (#18).

Figure 5: Commercial harvesting sustainability according to scenario 2 (low productivity). Pixel values are calculated subtracting commercial harvesting from local surplus.



Using the assumptions of scenario 1 (medium productivity), sustainability increases (Table 3). Under these conditions, if the supply of fuelwood depended entirely on harvesting accessible resources without relying on deforestation byproducts, national fNRB would be very low, ranging between 0.1 to 0.7 %.

ACCOUNTING FOR LAND COVER CHANGE BY-PRODUCTS

Many parts of Honduras are characterized by high rates of land cover change (LCC), including some 532,000 ha of forest area loss and some 58,000 ha of gain, over the period 2000-2013 (7). We estimate average annual loss and gain of DEB generated in the process by linking area changes with biomass data (13).

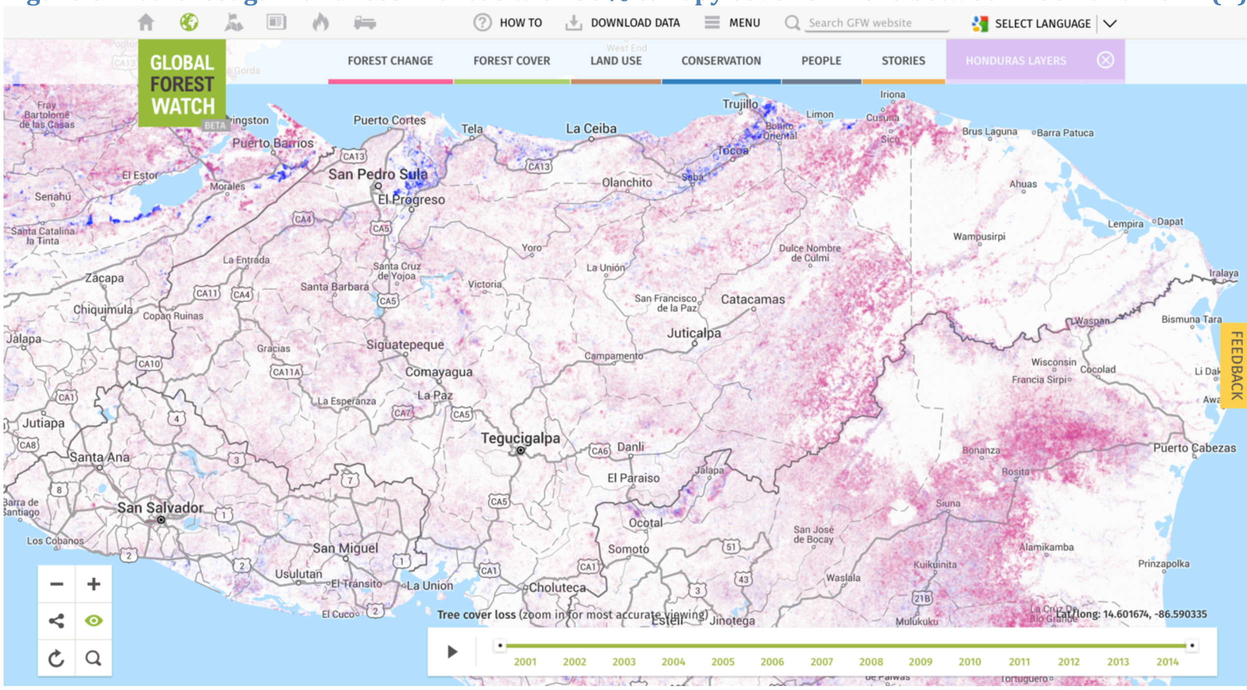
Though not directly linked to woodfuel demand, these LCC processes impact woodfuel supplies. When deforestation occurs in regions accessible to woodfuel users, the cleared woody biomass may be utilized as woodfuel or timber. Similarly, afforestation adds DEB equivalent to the mean annual increment (MAI) of the surrounding land class. In Honduras, processes of deforestation are fairly ubiquitous but they appear particularly intense in the eastern part of the country, often within protected areas (Figure 6). These high deforestation areas are less populated and far from major woodfuel consumption areas, which reduces the likelihood that byproducts of deforestation are utilized for woodfuel due to high transport costs.

However, the degree to which LCC by-products are actually used as woodfuel is unknown. To accommodate this uncertainty, we explore two scenarios. In the first scenario we assume LCC by-products are not used and that all demand originates from woodfuel harvesting, as discussed in the previous section. In the second scenario, we assume that 70% of the DEB by-products originating in accessible harvesting areas are used as woodfuel. Given the large amount of deforestation byproducts

[3] Sustainability is calculated by subtracting the commercial harvesting from local surplus. If the result is negative, then harvesting is unsustainable.

available and their inherently non-renewable character, they have a dramatic impact on the local and national NRB fraction.

Figure 6: Net forest gain and loss in areas with 30% canopy cover or more between 2001 and 2014 (7)



SUMMARY OF RESULTS BY DEPARTMENT

Table 1 summarizes by Department the annual demand for fuelwood in 2012 in the main sectors of consumption and the supply parameters on stock and DEB MAI according to the two productivity scenarios considered. We can observe a fairly regular distribution of demand and supply potential across Departments.

Table 2 summarizes local and commercial balances, the total harvesting taking place in each Department, and the non-renewable harvesting fraction (fNRB). The exclusion or inclusion of LCC byproducts as sources of fuelwood has tremendous impact on NRB results. In the Departments of Colón, Gracias a Dios, and Olancho, the byproducts of deforestation sufficient to accommodate the entire demand for woodfuels, thus bringing the NRB fraction to 100%. At the national level, fNRB increases from 0.1-0.7% when LCC byproducts are not utilized, to 45.6-46.9% when they are utilized.

Table 2: Woodfuel demand by sector and supply potential according to medium and low productivity scenarios

ktons DM yr-1 (wood eq.)	Demand				Supply potential								
					DEB stock	Annual productivity Scenario 1 (Medium MAI)				Annual productivity Scenario 2 (Low MAI)			
Department	Residential	Commercial & industrial	Coffee processing	**Total demand**		Total MAI	Legally accessible MAI	Accessible Mai (legal & physical)	**Available MAI**	Total MAI	Legally accessible MAI	Accessible Mai (legal & physical)	**Available MAI**
1-ATLANTIDA	139.4	21.2	0.1	**160.7**	50,110	1,062	595	527	**527**	746	412	363	**363**
2-COLON	117.5	10.9	0.1	**128.4**	107,313	2,124	1,076	964	**964**	1,511	746	666	**666**
3-COMAYAGUA	237.5	15.0	15.1	**267.6**	33,367	1,022	785	756	**738**	659	509	488	**470**
4-COPAN	213.1	9.1	11.7	**233.9**	22,367	671	634	622	**617**	413	387	379	**374**
5-CORTES	226.6	95.4	1.3	**323.3**	33,199	815	638	610	**608**	553	430	410	**408**
6-CHOLUTECA	288.8	14.1	0.1	**303.0**	14,636	525	471	459	**457**	334	298	291	**289**
7-EL PARAISO	252.5	9.5	13.4	**275.4**	45,466	1,404	1,321	1,250	**1,234**	874	816	768	**752**
8-FRANCISCO MORAZAN	367.0	96.2	2.3	**465.5**	51,236	1,359	1,229	1,148	**1,111**	952	857	797	**761**
9-GRACIAS A DIOS	40.0	2.3	0.0	**42.3**	172,708	3,519	1,469	868	**858**	2,513	1,032	610	**599**
10-INTUBUCA	150.3	2.6	4.5	**157.5**	24,592	639	580	553	**542**	431	389	370	**359**
11-ISLAS DE LA BAHIA	1.1	2.1	0.0	**3.2**	2,381	53	46	43	**43**	37	32	30	**30**
12-LA PAZ	126.5	3.8	6.8	**137.1**	16,385	489	404	389	**381**	310	254	243	**235**
13-LEMPIRA	216.1	1.8	10.5	**228.3**	30,497	893	804	778	**766**	577	515	497	**485**
14-OCOTEPEQUE	83.2	2.4	7.3	**92.9**	11,279	343	276	270	**267**	213	169	165	**162**
15-OLANCHO	285.3	12.0	3.7	**301.0**	235,751	5,241	3,215	2,614	**2,562**	3,697	2,250	1,819	**1,767**
16-SANTA BARBARA	261.4	10.5	12.5	**284.3**	48,418	1,287	1,206	1,169	**1,158**	826	774	748	**737**
17-VALLE	112.8	5.0	0.0	**117.8**	6,481	211	157	155	**155**	136	99	97	**97**
18-YORO	265.0	24.4	2.5	**291.9**	66,058	1,629	1,422	1,263	**1,244**	1,125	979	867	**848**
HONDURAS	**3,384**	**338**	**91.7**	**3,814**	**972,244**	**23,285**	**16,327**	**14,439**	**14,233**	**15,907**	**10,949**	**9,609**	**9,403**

Table 3: Local and commercial supply/demand balance and NRB estimates with and without the use of land cover change (LCC) byproducts, according to medium and low productivity scenarios.

ktons DM yr-1 (wood eq.)	Scenario 1 (medium productivity)				Scenario 2 (low productivity)					NRB - sc. 1 with LCC byproducts		NRB - sc. 2 with LCC byproducts	
	Local balance	Commercial balance	Total harvesting (local & commercial)	fNRB (no LCC byproducts	Local balance	Commercial balance	Total harvesting (local & commercial)	fNRB (no LCC byproducts	Available LCC byproducts	NRB	fNRB	NRB	fNRB
Department	kt	kt	kt	%	kt	kt	kt	%	kt	%	kt	%	kt
1-ATLANTIDA	369	315	160	0.0	203	160	172	0.0	134	83.6	134	77.7	134
2-COLON	832	753	151	0.0	535	463	161	0.0	689	100.0	151	100.0	161
3-COMAYAGUA	469	359	268	0.0	202	127	265	-0.1	94	35.1	94	35.5	94
4-COPAN	383	347	240	0.0	139	108	225	0.0	60	24.9	60	26.6	60
5-CORTES	281	194	269	-0.2	82	23	267	-2.7	94	34.8	94	35.1	94
6-CHOLUTECA	155	82	246	0.0	-14	-73	195	0.0	33	13.5	33	17.1	33
7-EL PARAISO	957	827	309	0.0	476	374	310	0.0	173	56.1	173	56.0	173
8-FRANCISCO MORAZAN	643	478	371	-0.9	292	153	388	-5.0	84	22.5	84	21.5	84
9-GRACIAS A DIOS	814	497	44	0.0	555	302	44	0.0	100	100.0	44	100.0	44
10-INTUBUCA	386	302	169	0.0	203	144	170	0.0	53	31.2	53	31.0	53
11-ISLAS DE LA BAHIA	39	30	4	0.0	26	19	4	0.0	0	0.0	0	0.0	0
12-LA PAZ	244	155	134	0.0	98	44	122	0.0	27	20.2	27	22.1	27
13-LEMPIRA	538	462	250	0.0	258	193	243	0.0	74	29.6	74	30.4	74
14-OCOTEPEQUE	175	133	90	0.0	70	43	84	0.0	23	25.1	23	26.9	23
15-OLANCHO	2,261	1,844	344	0.0	1,466	1,139	385	0.0	1,382	100.0	344	100.0	385
16-SANTA BARBARA	871	821	364	0.0	449	410	382	0.0	153	42.1	153	40.0	153
17-VALLE	37	18	99	0.0	-21	-37	80	-0.1	12	12.5	12	15.5	12
18-YORO	957	820	307	0.0	561	454	323	-0.3	190	61.8	190	58.7	190
HONDURAS	**10,410**	**8,438**	**3,819**	**-0.1**	**5,581**	**4,046**	**3,819**	**-0.7**	**3,375**	**45.6**	**1,742**	**46.9**	**1,793**

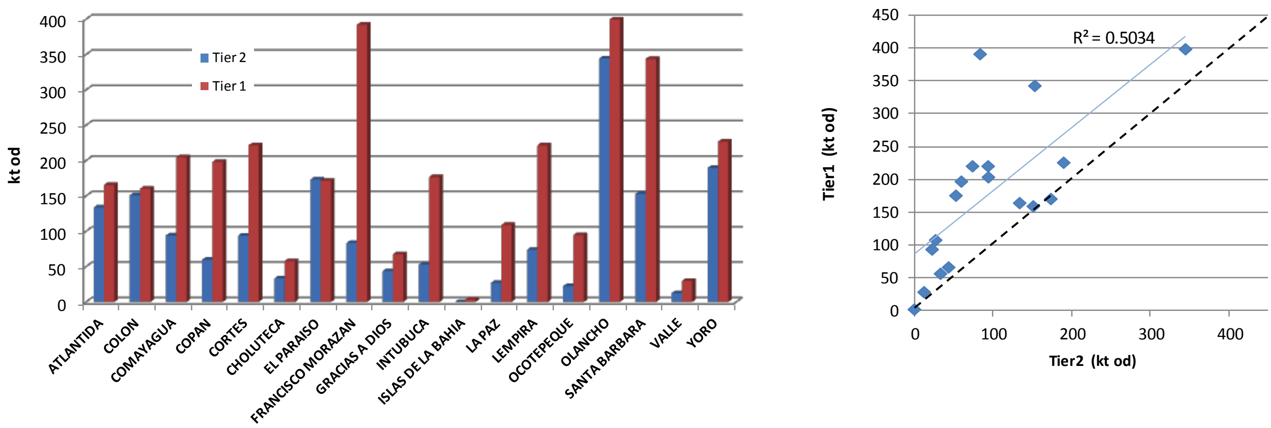
Comparing Tier 1 and Tier 2 results for Honduras

The comparison between results for Honduras from the pan-tropical study (Tier 1) and Tier 2 (this study) shows a relatively good correspondence on the available supply potential. The Tier 1 estimate was 12.5 Mt DEB yr^{-1}, which falls in the middle of the range of 9.4 to 14.2 Mt estimated in the low and medium Tier-2 productivity scenarios. However, the estimate national demand for Tier 1, based on FAO data (14), is 5 Mt, or 32% greater than Tier 2 (3.8 Mt).

As a result of lower woodfuel consumption estimate, national-level fNRB differs significantly, with Tier 1 estimate of 19% from the Tier-1 study compared to 0.1-0.7% ignoring LCC byproducts. When LCC by-products are considered, the Tier-1 estimate was 63.7% compared to a Tier-2 estimate of 46-47%. In absolute values, national NRB estimates from Tier 1 are 1 Mt and 3.2 Mt, excluding and including LCC byproducts, respectively, while from Tier 2 these estimates are much lower: 0.03 and 1.7-1.8 Mt, respectively.

Figure 7 shows NRB values by Department. Tier 1 values are higher than Tier 2 in nearly all administrative units as a result of lower demand value in Tier 2. However, differences between arise as a result of different distribution of LCC by-products between in Tier 1, which was more speculative, and Tier 2, which is based on empirical observations of forest removal (7).

Figure 7: Comparison of Tier-1 and Tier-2 NRB estimates by Department



POLICY RELEVANCE

Besides its contribution to the pan-tropical study, the analysis of Honduras has national-level policy relevance as a tool for strategic planning and policy formulation[4]. In synthesis, the results indicate that the Country has a supply potential that is sufficient for the sustainable production of woodfuels to satisfy its needs. However, the considerable quantity of woody biomass derived from LCC processes such as farming expansion and shifting cultivation is likely to satisfy a large fraction of the country's woodfuel demand. Thus, while the promotion of clean-burning fuel-efficient cookstoves can have a positive impact on heath conditions of rural communities and reduce woodfuel demand, it would probably have a minor impact on LCC and GHG emissions from woodfuel combustion. To that end, policies should focus directly on reducing the farming pressure on forestlands through REDD+ initiatives. Meanwhile, the use of byproducts as fuel should not be considered negatively since it gives value to biomass resources that would otherwise be burned on site.

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[4] See case studies at www.**wisdom**projects.net.

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