**Supplementary Materials**

***Calculation of NPP from literature values***

NPP values for Cassava, Plantain/Banana, Oil Palm and Vegetables were determined using an equation for estimating NPP from Monfreda et al. (2008):

|  |  |
| --- | --- |
| $$NPP\_{i}=\frac{EY\_{i}×DF\_{i}×C}{HI\_{i}×RS\_{i}}$$ | (2) |

where i is the specific crop, NPP is net primary production, EY is the metric tons of economic yield per hectare, DF is the dry proportion of the economic yield, and C is the carbon content (0.45 g C g dry matter-1). HI refers to the harvest index, a standard measure of the proportion of total aboveground biological yield allocated to the economic yield of the plant (Donald and Hamblin, 1976). The root:shoot ratio, RS, indicates the ratio of below to aboveground production. Measures for economic yield for each crop were estimated using literature and policy documents for Ghana or similar tropical environments (Table S1).

Although HANPP values for oil palm were determined using Monfreda et al. (2008) as a guide, it should also be noted that it is not possible to determine whether the palm trees observed are used for palm oil or for palm wine. However given the rapid expansion of the palm oil industry in Ghana in the last ~20 years, with harvested areas now exceeding ~350’000 ha per year (FAO, 2018), it was assumed that palm oil production was the primary purpose for the palm observed in the landscape, though much of the oil palm production in this region is for local consumption. Further, research suggests that palm trees are often eventually used for palm wine when they have become less productive for palm oil (Meikle et al. 1996).

Settlement was assigned a 100% value of HANPP (17 Mg/ha). Fallow was estimated using Haberl et al. 2008 as a guide. No measure could be found to determine the NPP of fallow, as such it was assigned an average of the HANPP percentage values for grazing land (19.4%) and forestry (6.6%). The rationale for using these values is the varied nature of fallow lands, which include multiple vegetation classes from scrubby brush to trees. The resulting HANPP percentage value for fallow of 13% was applied to the forest baseline NPP (17 Mg C/ha), resulting in a HANPP value of 2.21 MgC/ha/yr, and an NPP value of 14.79 Mg C/ha/yr. To account for the uncertainty in this value, the standard error was set to ± 20% of the NPP value (Table 2). Uncertainty was set to 20% as this was considered sufficiently high enough to capture the potential variability of this land use type, as it would assume 68% of values would fall between 11.83 Mg C/ha and 17.75 Mg C/ha, which is a substantial range considering the range for other values derived in this study.

The NPP value for grassy fallow was estimated values from the Oakridge National Laboratory (Olson et al. 2013). The total NPP value averaged over tropical/grassland C4 biome was found to be a maximum of 7.25 MgC/ha/yr and a minimum of 4.97 MgC/ha/yr (μ=6.11). Due to the fallow nature of these grassy areas, it was assumed that they are not being harvested for human consumption or use.

**Figure Captions**

**Figure S1.** The area of each measured land use in the AB, HM and KA regions.

**Figure S2.** Cocoa only HANPP values for estimated cocoa densities of 600 trees/ha (top) and 719 trees/ha (bottom) for AB, HM and KA regions.

**Figure S3** NPP and standard deviation values per hectare of the AB, HM and KA regions assuming a density of 719 trees per hectare.

**Figure S4** Number of grid cells with each value of NPP for all three regions, for cocoa densities of 600 trees per hectare (blue) and 719 trees per hectare (orange).

**Tables**

**Table S1** Yield values for crops used to calculated NPP (see: Equation 1 [from Ramenkutty 2008]).

|  |  |  |
| --- | --- | --- |
| **Crop** | **Yield Value (Mg ha-1)** | **Source** |
| **Cassava** | 11.9 | Breisinger et al. 2008 |
| 10.8 | FAO, 2013 |
| **Plantain/Banana** | 8.1 | Breisinger et al. 2008 |
| 10.5 | FAO, 2012 |
| 8.2 | FAO, 2012 |
| 5.7 | Norgrove & Hauser, 2014 |
| 7.8 | Norgrove & Hauser, 2014 |
| **Oil Palm** | 5.8 | Rhebergen et al. 2016 |
| 5.1 | IPNI, 2015 |
| 6.9 | IPNI, 2015 |
| 4.6 | MASDAR, 2011 |
| **Vegetables** | Yam | 12.4 | Breisinger et al. 2008 |
| Cocoyam | 6.7 | Breisinger et al. 2008 |
| Maize | 1.5 | Breisinger et al. 2008 |
| Tomatoes - Rainfed | 25 | Breisinger et al. 2008 |
| Okra | 10.9 | MOFA,2013 |
| Tomatoes | 6 | FAO, 2013 |
| onions | 16.7 | FAO, 2013 |
| Chillies and green pepper | 6.5 | FAO, 2013 |
| Chillies and green pepper | 8.3 | FAO, 2013 |