Alternative landscapes to face land and energy scarcity

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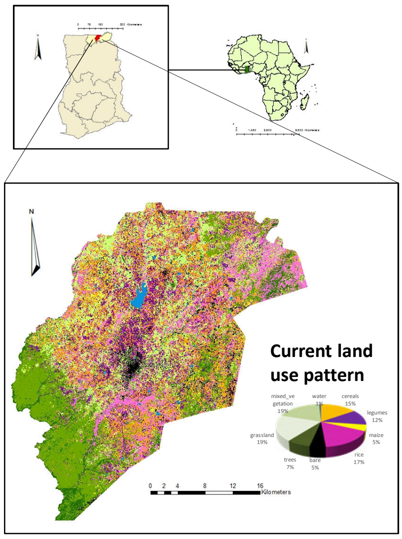
Background

Savannas, due to their suitability for cereal production, are seen as bread baskets for African populations. Nevertheless, deficiencies in key human micro-nutrients intake remain, particularly in such cereal producing regions. On the other hand, the loss of tree cover due to agricultural extensification and fuel demand risks the future potential productivity of savanna soils. In the face of insufficient access to mineral fertilizers, strategies are needed that focus on improving the potential of landscapes to provide biomass and its whole range of benefits to human nutrition and energy security.



Case study region

1,200 km2 of savanna in the White Volta Basin, covering two districts (Bolgatanga and Bongo) in the Upper East Region of Ghana.
Total population: 217,000 inhabitants (72% living in rural areas). One common urban market of 66,000 inhabitants.
High population density 178 p/km^2, population growth rate 2,17%. Guinean climate (1000mm rainfall) but sudanian landscape.

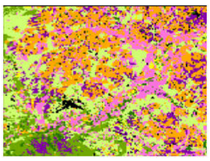
Objective

Estimate the biomass benefits* provided by land at the regional extent under different land use pattern scenarios.

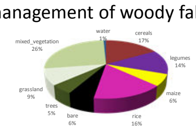
- Nutrients (kilocalories, iron, zinc, vitamin A) and Fuel (megajoules).

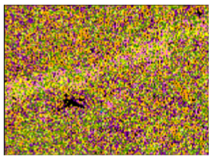
Methodology

1. Land use pattern scenarios are created with the GISCAME□s cellular automata, based on different transition probabilities of land use change.

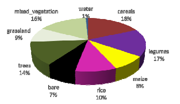


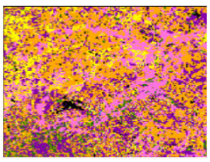
Business as usual: extensification of agriculture over grasslands and management of woody fallows in short rotations.



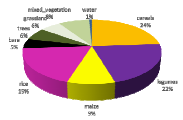


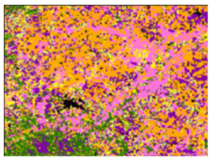
Farmer managed natural regeneration: the amount of scattered trees within farmland is increased.



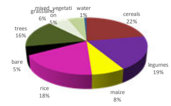


Extensification: biomass demand relies on agricultural land, including substitution of firewood by cereal stems





Protection of forests: some woodlands are spared against conversion, while tree cover within farms diminishes.



2. Biomass provision estimation is estimated at the pixel level (**25 m cellsize**):

- <u>Annual crops</u>: annual average calculated with process-based model (APSIM) run over fifteen years on three different types of soils. The impact of tree cover per hectare on agricultural production is estimated through descriptive statistics of literature data. Vegetable and tubber production, based on official data, is considered constant.

	Millet/Sorghum in-season sequence			Groundnut			Maize			Rice			Maize/Cowpea mix-croppig		
	Shallow soil	Deep crusty soil	Hydric soil	Shallow soil	Deep crusty soil	Hydric soil	Shallow soil	Deep crusty soil	Hydric soil	Shallow soil	Deep crusty soil	Hydric soil	Shallow soil	Deep crusty soil	Hydric soil
	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha
Grain yield	317(181+136)	1449(998+451)	2067(1358+709)	518	1190	999	157	1557	2218	413	1357	3179	672(399+273)	2053(1857-196)	2902(2746-192)
Leaves	263	1203	1716	414	952	799	28	280	399	227	746	1748	168	464	726
Stem	431	1971	2811	104	238	200	154	1526	2174	186	611	1431	504	1393	2177

- Perennial vegetation: average growth every 5-year timestep since year of tree birth, calculated through descriptive statistics of literature review data.

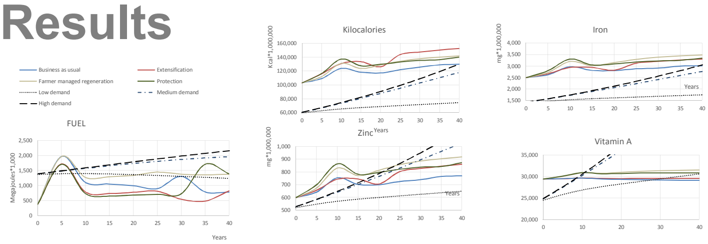
Age t_0	Age t_1	Harvested wood	Fuel value	Annual increment	Fuelwood	Industry	Pole stand	Fruit production
years	*years*	*m³/ha*	*m³/ha*	*m³/ha*	*%*	*%*	*%*	*kg/pixel*
0	5	0	0.00	5.82	100	0	0	0
6	10	0	0.00	3.84	100	0	0	0
11	15	3.96	121.85	1.59	95	5	0	6.25
16	20	3.79	116.62	1.08	90	5	5	6.25
21	25	3.79	116.62	1.08	90	5	5	6.25
26	30	3.77	116.00	1.08	80	10	10	6.25
31	35	3.77	116.00	1.08	80	10	10	6.25
36	40	3.77	116.00	1.08	80	10	10	6.25

3. Conversion of biomass weight (grain, leaves, stem, branches...) into meaningfull food and energy indicators (kcal, iron, zinc, vitamin A, megajoules per ha).

4. Estimation of demand

- under three different trends of population growth rates
- for each nutrient indicator, based on population structure
- assuming a decreasing consumption of firewood per capita

Results



Fuel provision under intensive systems of firewood collection ensures a high provision during first years, due to rapid re-growth of savanna vegetation, but quickly shows a fast depletion of harvesting rates. Shifting towards tree management system that let them grow big and prun them afterwards ensures a more sustained provision of fuel. Caloric and iron supply is sufficient in all scenarios till mid century. Zinc supply might fall short in 15-25 years if population growth rates are kept high. Vitamin A provision is similar under all scenarios and there will be deficits, even under low popualtion growth rates.

Next steps

Inclusion of indicators of soil fertility, such as groundwater recharge and mineralization, for a better understanding of possible long-term effects.
Consider the impact between neighboring land uses will contribute to the integrated assessment of landscape patterns on biomass provision.
An uncertainty analysis, that accounts for a range of possible values under different climate, input use levels and tree population structure scenarios, would improve the robustness of this study.

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