Impact of reduced fallow availability on regional crop yields in low input cropping systems in West Africa

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Background and objectives

Cropping systems in West Africa are predominantly low-input systems based on invading virgin land and/or soil fertility restoration through fallowing under the natural regrowth of vegetation after the cropping period. On the other hand, increasing population pressure leads to reduction in fallow availability and compromises soil fertility restoration. The objective of this paper was, therefore, to quantify the regional effect of future population growth on crop yields in West Africa.

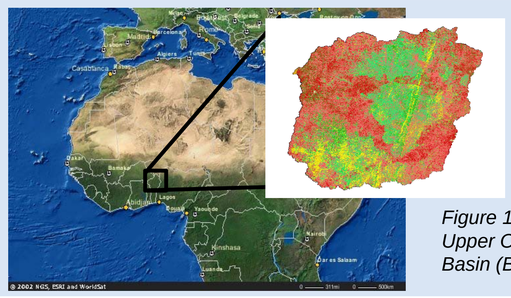


Figure 1: Upper Oueme Basin (Benin)

Methods

- Definition of land use scenarios (L1, L2 and L3) for the Upper Ouémé catchment (15,000 km^2, Fig. 1) based on demographic projections (Figure 2), assumptions regarding future road networks and legal frameworks for forest protection (CLUE-S model)
- Subdivision of the basin into 1492 agronmomic response units based on climate, soil and fallow-crop-rotations
- Determination of the mean fallow-cropland ratio in each subbasin as ratio between the area of fallow and cropland
- Calculation of the frequency distribution of fallow-cropland ratios within the basin according to Gaiser et al. (2010)
- Coupling of the spatial database and the Environmental Policy Integrated Climate model (EPIC) (Enders et al. 2010)
- Simulation of maize yields at the level of agronomic response units and aggregation to the basin level (Gaiser et al. 2011)

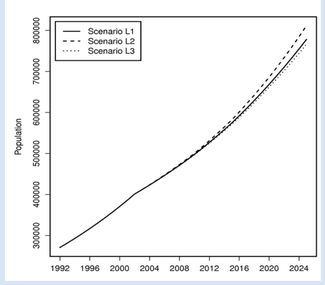
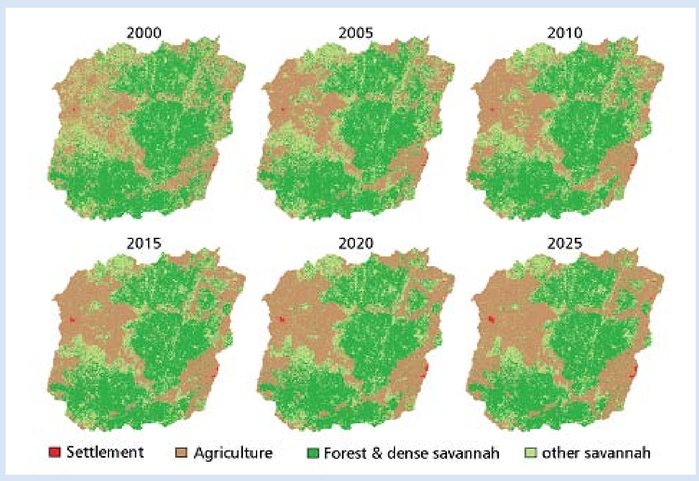


Figure 2: Assumed demographic growth in land use scenariosl1, L2 and L3

Results

- In all land use scenarios the proportion of cropland increases; the magnitude of the increase depends on proximity to roads and settlements (Figure 3)
- The fallow-cropland ratio decreased in the three scenarios from 0.87 in the year 2000 to 0.66, 0.48 and 0.60 for L1, L2 and L3 respectively in 2050 (Figure 4)

Figure 3: Changes in cropland area from 2000 to 2025 in the land use scenario L2 (Menz et al. 2010)



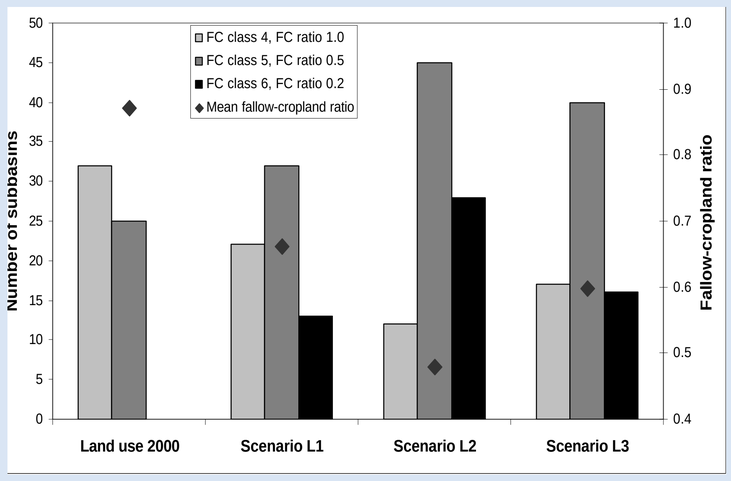
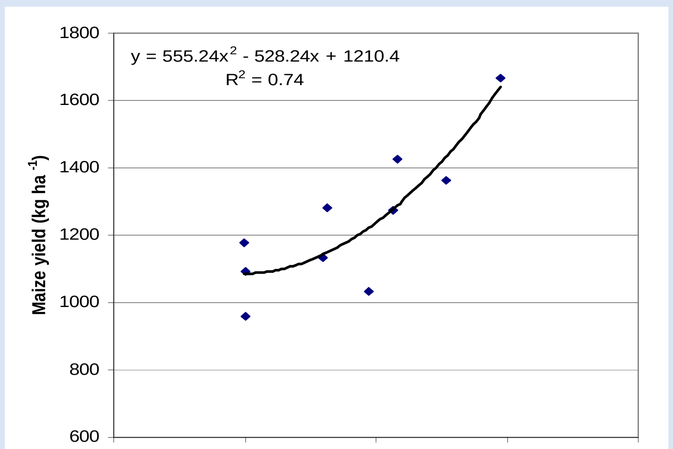


Figure 4: Comparison of the effect of three land use scenarios for the year 2025 on the frequency of sub-basins with mean fallow-cropland ratio of 1.0, 0.5 and 0.2 (bars) and on the area-weighted average fallow-cropland ratio (dots) in the HVO catchment

- Statistical data combined with current fallow-cropland ratios in different districts show, that there is a clear relationship between fallow-cropland ratio in an administrative unit and maize yields (Figure 5)
- Based on the projected ratio of fallow and cropland (Figure 4), trends of maize yield for the three land use scenarios were calculated. Maize yields followed the decreasing trend of the fallow-cropland ratio and estimated yield reductions amounted to up to 24% in the period 2021 to 2050 (Figure 6).

Figure 5: Regression between observed maize yields and the average fallow-cropland ratio in the ten districts of Upper Ouémé basin



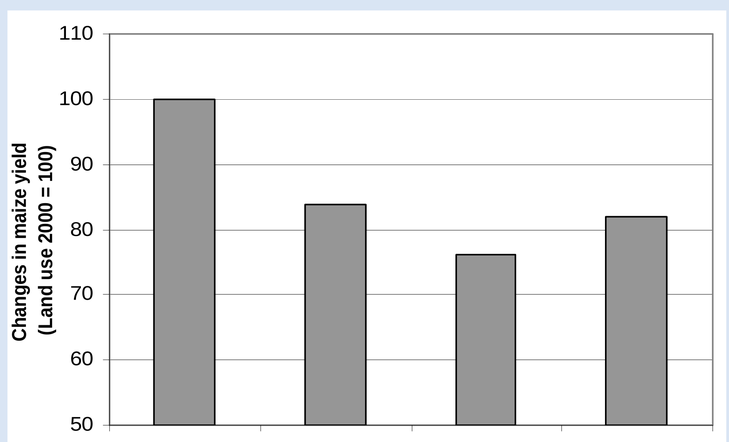


Figure 6: Relative changes in mean maize yields over 30 years as affected by different land use scenarios compared to the land use in 2000

Conclusions

When comparing the yield reductions caused by reduced fallow availability with the impact of climate scenarios in the literature, it can be concluded that, in the near future, land use effects will be at least as important for crop productivity as climatic change provided that soil fertility management does not change drastically.

References

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