Identifying changes in agricultural practices and policy interventions for sustainable intensification of farm systems in southern Mali

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1 – Introduction

Achieving sustainable development goals for smallholder rural populations within the next eleven years is challenging: besides environmental and climate pressures, rising rural population and unfavorable institutional arrangements diminish the room to manoeuvre within the current system's settings. New farming practices and progressive policies to trigger and support drastic changes are needed. A large array of innovative farming practices have been developed across sub-Saharan Africa (*e.g.* Snapp et al., 2010). Our objective was to grasp the scale of the challenge: what is the potential of changes in farm practices to improve farming sustainability in southern Mali, a region that is representative for land-scarce sub-Saharan Africa? Which policies are needed to support sustainable development?

2 – Materials and methods

Two typical villages (411 households) of the cotton basin of southern Mali were surveyed in 2013. Farms were classified into four farm types according to resource endowment. Participatory trials showed that maize/cowpea intercropping combined with stall-feeding of cows was profitable for farmers (Falconnier et al., 2017). Major factors responsible for the yield gap of cotton and cereals were identified (Falconnier et al., 2018). Starting in 2013, we designed four contrasting scenarios towards 2030. In the "Business as usual" scenario, farmer practices and current policies are maintained. In the "Crop-livestock integration" scenario, all farmers owning cattle intercrop maize with cowpea, and feed cows with on-farm produced cowpea. Subsidies for livestock concentrates (cotton seed cake) and farm-gate milk prices are considered. "Socio-economic development" builds on the previous scenario, with (i) family planning to reduce human net fertility and ii) job creation outside agriculture to increased rural-to-urban migration. In the “Yield gap closure” scenario, additional interventions lead to an increased use of mineral fertilizer on cereals and improved pest and weed management in cotton. Additional subsidies for fertilizer on sorghum and millet and development of small-scale mechanization services are considered. A simple farm model was developed to assess farm calorie self-sufficiency and income (Falconnier et al., 2018). The framework was updated to compute indicators in various sustainability domains, such as human well-being (calorie, protein, iron and zinc self-sufficiency), economic (farm income, labour productivity and intensity), and environmental (partial N balance and nitrogen use efficiency) (Figure 1).

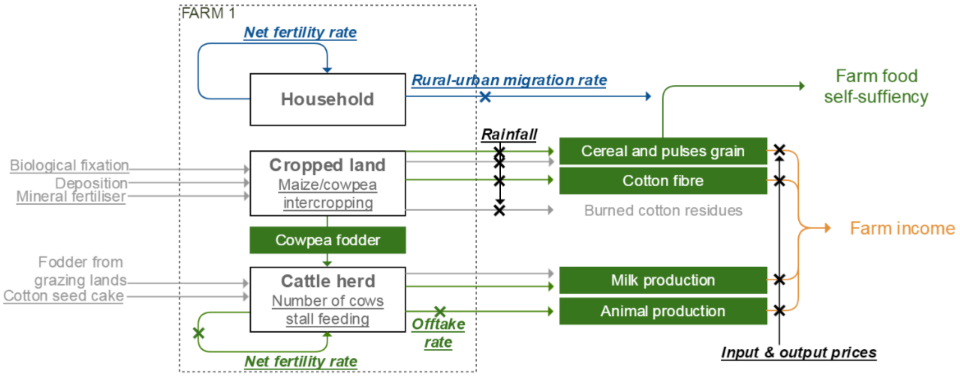

Figure 1: Farm model components (household, cropped land and cattle herd) with flows of animal/crop product (green), people (blue), cash (orange) and Nitrogen (grey) used to compute well-being, economic and environmental indicators. Key parameters influenced by scenarios are underlined.

3 – **Results – Discussion**

The scenario analysis highlighted the need for combining incremental change in agricultural practices with supporting policies to achieve sustainability (Figure 2). Large variations occured between farms, stressing the need to consider an entire farm population rather than representative case studies (Ritzema et al., 2017). In the current situation, only 36% of farms were non-poor and partial N balances were positive for only 18% of farms (Figure 2). With the ‘Business as usual’ scenario, average household size would increase from 19 to 26 persons in 2030 and all sustainability indicators would decrease, except N balance. Enhanced crop-livestock integration barely compensated household size increase: the percentage of non-poor farms remained comparable to the baseline. Partial N balances would however become positive for 56% of farms thanks to biological nitrogen fixation with intercropped cowpea (+25kg N/ha) and imported livestock feed (+29 kg N/ha). “Socio-economic development” lifted 62% of farms out of poverty, and “Yield gap closure” improved this further to 84%. N balances were positive for all farms in this last scenario. Farms were calorie self-sufficient in all scenarios, confirming the breadbasket status of the cotton basin. In the best-case scenario however, only 18% of farms were zinc self-sufficient, highlighting the need for additional changes to solve this widespread health issue (Wessells and Brown, 2012).

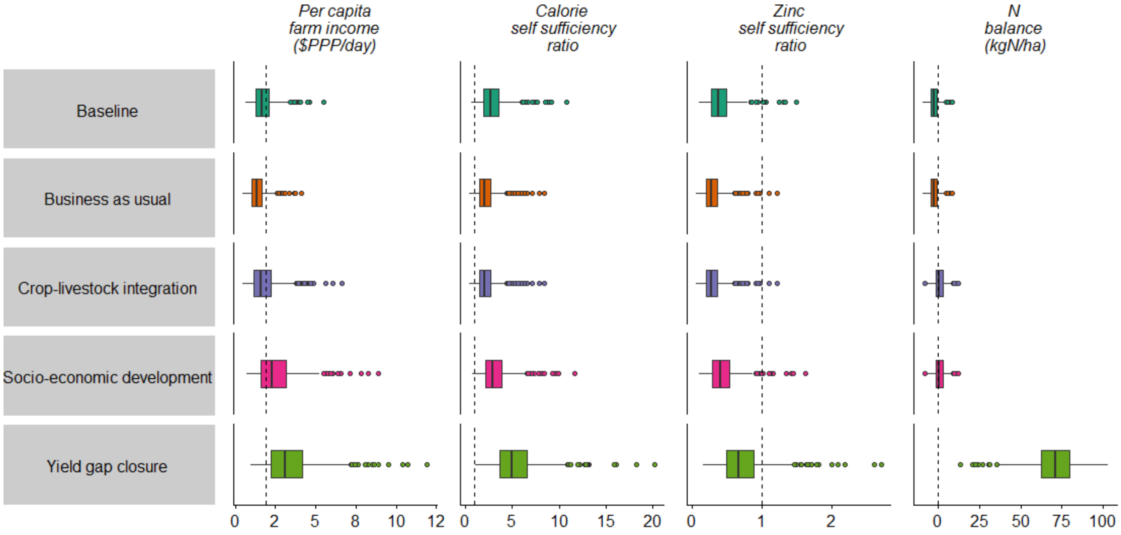

Figure 2: Selected economic, well-being, and environmental sustainability indicators assessed for 411 farms in 2013 and for five scenarios towards 2030. Vertical line represent thresholds for each indicator, *i.e.* 1.9 $PPP/day poverty line (per capita farm income), self-sufficiency ratio of one (calorie and zinc) and neutral N balance.

Though all indicators improve in the "Yield gap closure" scenario, a substantial proportion of farms (16%) remained poor despite the envisioned interventions. Our current work focuses on identifying the farm characteristics responsible for these poverty traps.

4 – **Conclusions**

A series of indicators are needed to fully assess the potential of changes in agricultural practices to contribute to sustainability of farming systems. Tighter crop-livestock integration would only marginally improve farm income, calorie and zinc self-sufficiency and farm N balances, and strategic and multi-sectoral combination of interventions would be needed to achieve sustainability. We estimated that 0.03% of Mali GDP would be sufficient to subsidize fertilizer as hypothesized in the "Yield gap closure" scenario for the whole Koutiala district (*i.e.* 7% of Malian cereal cropland) indicating that such an optimistic scenario would be realistic.

References

Falconnier, G.N., Descheemaeker, K., Traore, B., Bayoko, A., Giller, K.E., 2018. Agricultural intensification and policy interventions: Exploring plausible futures for smallholder farmers in Southern Mali. Land Use Policy 70, 623–634. https://doi.org/10.1016/j.landusepol.2017.10.044

Falconnier, G.N., Descheemaeker, K., Van Mourik, T.A., Adam, M., Sogoba, B., Giller, K.E., 2017. Co-learning cycles to support the design of innovative farm systems in southern Mali. European Journal of Agronomy 89, 61–74. https://doi.org/10.1016/j.eja.2017.06.008

Ritzema, R.S., Frelat, R., Douxchamps, S., Silvestri, S., Rufino, M.C., Herrero, M., Giller, K.E., López-Ridaura, S., Teufel, N., Paul, B.K., Wijk, M.T. van, 2017. Is production intensification likely to make farm households food-adequate? A simple food availability analysis across smallholder farming systems from East and West Africa. Food Sec. 9, 115–131. https://doi.org/10.1007/s12571-016-0638-y

Snapp, S.S., Blackie, M.J., Gilbert, R.A., Bezner-Kerr, R., Kanyama-Phiri, G.Y., 2010. Biodiversity can support a greener revolution in Africa. Proceedings of the National Academy of Sciences USA 107, 20840–20845.

Wessells, K.R., Brown, K.H., 2012. Estimating the Global Prevalence of Zinc Deficiency: Results Based on Zinc Availability in National Food Supplies and the Prevalence of Stunting. PLoS One 7. https://doi.org/10.1371/journal.pone.0050568