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WATER HARVESTING IN MALIAN AGRICULTURE

ASSESSMENT OF ITS EFFECTIVENESS UNDER VARIOUS CLIMATE CHANGE SCENARIOS

CONTEXT

Under the right conditions, the use of traditional water harvesting practices can improve water retention, alleviate poor soil fertility, and improve crop yields. An improved understanding of the effectiveness of these agricultural practices under a changing climate can be gained through the use of parameterized modeling techniques. In this case, the Agricultural Policy/Environmental Extender (APEX) model, developed for use in managing farms and small watersheds, has been used in combination with climate scenario modeling to test the effect of traditional water harvesting practices on yields of several crops in the Mopti region of Mali.

MODEL PARAMETERS

This study used a hypothetical site consisting of four soil types commonly found in the Mopti region: regosols, lithosols, arenosols, and luvisols. Regosols and arenosols are poorly developed soils with low organic content and low water-holding capacity. Lithosols and luvisols have higher organic content and better water holding capacity. The major crops used for modelling were maize, millet, sorghum, and upland rice. Based on farmer surveys in Mali, the four water harvesting practices modelled were soil or stone bunds, vegetated filter strips, contour ridges, and *zai* (planting pits). The performance of each practice was evaluated for each crop and soil type based on the impacts on surface runoff, crop yield, soil organic carbon content, and soil loss. The results were then compared. The effects on these parameters were examined for both current and projected future climates, as well as for scenarios with and without use of a water harvesting practice. While the impacts on all of these parameters are addressed in the full paper, this brief will focus primarily on the impacts on crop yields.

The APEX model was calibrated with measured climate data for the Mopti region from 1991-2000 and crop yield data from the Food and Agriculture Organization of the United Nations (FAO). The calibrated APEX model provided a satisfactory representation of maize, millet, sorghum and upland rice yields, as well as runoff amounts, during the baseline years. Given the wide variability in future precipitation amounts projected in the Sahel, however, four future climatic scenarios were developed, based on predictions from two distinctly different climate models. This resulted in a wide range of contrasting precipitation conditions projected for the years 2025-2035 and 2045-2055. The four climate scenarios chosen for the modelling were as follows: a slight warming in 2030, with a significant increase in precipitation; no significant warming in 2030 with a moderate increase in precipitation; a significant rise in temperature for 2050 with no change in precipitation; and a significant rise in temperature for 2050 with a significant decrease in precipitation.

FINDINGS

The future climate scenario results showed interesting and complex changes relative to pre-2000 climatic conditions regarding runoff, crop yield, soil erosion, and soil organic matter. The changes differed depending on which combination of soil, slope, crop, climate, and water harvesting practices were being considered. Projected yields of maize and millet increased for climatic scenarios with increased annual precipitation and declined for decreased precipitation relative to pre-2000 climatic conditions. The yield increase was greater for the more fertile lithosols and luvisols than for the regosols and arenosols. Sorghum and irrigated upland rice yield increases were minimal with increased precipitation, but sorghum yields decreased sharply with decreased precipitation. Decreases in runoff did not always result in increased crop yields, as much of the infiltrated water was unavailable for crop uptake. Changes in soil loss were proportional to changes in runoff, but they were larger for regosols and other soils in which changes in yield and biomass affected soil cover.

Water harvesting practices generally improved crop yield and soil fertility under the various scenarios of future climate change, but these scenarios also showed that the effectiveness of rainwater harvesting practices was affected by climate, soil type, slope steepness, and crop. Benefits from water harvesting practices tended to be greatest for maize and sorghum on more fertile lithosols and luvisols, especially for climatic scenarios that involve decreased precipitation. Yield increases due to water harvesting practices were generally greater with sorghum than with maize or millet on all soils and under all climatic scenarios considered. Overall, contour ridges and *zai* improved crop yield more than bunds, which, in turn, improved yields better than vegetated filter strips. However, rainwater harvesting practices were generally not effective at improving yield of upland rice on flat luvisols or yields of maize and millet on very sandy arenosols, which have very high inherent infiltration rates. These practices also did not generally improve — and often actually diminished — maize and millet yields under climatic scenarios with high annual precipitation. In general, contour ridges and *zai* were found to be more effective at improving crop yield, reducing runoff and erosion, and preserving soil organic carbon than bunds and vegetative strips.

The modeling was affected by two challenges. First, the selection of parameters for the APEX model and for the water harvesting practices was hampered by limited information on soil, climate, and crop yields in the areas modeled. The APEX model, however, did seem able to adequately represent relative differences and changes that resulted from installing water harvesting practices on different soil, slope, crop, and climatic combinations. Second, projections of changes in precipitation varied widely in different climate models. While this challenge was overcome by using two distinctly different climate models that gave a range of contrasting precipitation conditions, it would be beneficial to evaluate the effectiveness of these practices using a wider range of future climate scenarios, as well as a wider range of study locations.

ADDITIONAL INFORMATION

This brief highlights key conclusions from Folle, S., and Mulla, D. J. (2014). *Climate Change in Mali: Impact Modeling of Selected Agricultural Adaptive Practices*. USAID. Interested readers are invited to review the full paper at http://community.eldis.org/ARCC/.