Modelling impacts of climate change and alternative management interventions on the multi-functionality of agricultural landscapes in southern Africa

Reimund Roetter\(^1\), William Nelson\(^1\), Johannes Isselstein\(^1\), Simon Scheiter\(^2\), Mirjam Pfeiffer\(^2\), Munir Hoffmann\(^3\), Kingsley Ayisi\(^4\), Anja Linstädter\(^8\), Kai Behn\(^6\), Catrin Westphal\(^1\), Ingo Grass\(^9\), Jan-Henning Feil\(^1\), Jude Odhiambo\(^5\), Peter Taylor\(^5\), Wayne Twine\(^6\), Paolo Merante\(^1\), Gennady Bracho Mujica\(^1\), Thomas Bringhenti\(^1\), Sala Lamega\(^1\), Sara Yazdan Bakhsh\(^1\), Wilhelmine Krieger\(^1\), Valerie Linden\(^5\), Sina Weier\(^5\), and Barend Erasmus\(^7\)

\(^1\)University of Goettingen, Tropical Plant Production and Agricultural Systems Modelling, Faculty of Agricultural Sciences, Germany (reimund-paul.roetter@agr.uni-goettingen.de)
\(^2\)Senckenberg Germany Biodiversity and Climate Research Centre (SBiK-F)
\(^3\)Leibniz Centre for Agricultural Landscape Research, Germany
\(^4\)University of Limpopo, South Africa
\(^5\)University of Venda, South Africa
\(^6\)University of the Witwatersrand, South Africa
\(^7\)University of Pretoria, South Africa
\(^8\)University of Bonn, Germany
\(^9\)University of Hohenheim, Germany

On the background of increasing welfare and continued population growth, there is an ever-increasing pressure on land and other natural resources in many parts of the world. The situation is, however, particularly severe in the drylands of Sub-Saharan Africa. Southern African landscapes, composed of arable lands, tree orchards and rangelands, provide a range of important ecosystem functions. These functions are increasingly threatened by land use changes through competing claims on land by agriculture, tourism, mining and other sectors, and by environmental change, namely climate change and soil degradation. Among others, climate models project that drought risk in the region will increase considerably. Based on comprehensive data sets originating from previous groundwork by several collaborative projects on the functioning of these ecosystems, a number of biophysical and bio-economic models have been developed and evaluated. In the framework of the South African Limpopo Landscapes network (SALLnet) we have now refined and tailored these models for combined use for the assessment of changes in multiple functions of the prevailing agroecosystems when affected by alternative climate and land management scenarios - from field to regional scale. We apply vegetation models (such as aDGVM), crop models (such as APSIM) and integrative farm level models (e.g. agent-based) for different farming systems in conjunction with geo-referenced databases. Model outputs are combined to assess the impact of management x environment interactions on various ecosystem functions. Of special interest in our study are the ecosystem services related to the
provision of food, feed and fuel, soil and water conservation, as well as recycling and restoring carbon and nutrients in soil. To illustrate how the combination of various modelling components can work in assessing management intervention effects under different environmental conditions on landscape level ecosystem services, a case study was defined in Limpopo province, South Africa. We investigated effects of current management practices and an intensification scenario over a longer period of years on soil organic carbon change under rangeland and arable land, potential erosion, productive water use, biomass production, monthly feed gaps, and rangeland habitat quality. Tentative results showed that sustainable intensification closed the livestock feed gap, but further reduced soil organic carbon. More generally, coupling the output of vegetation and crop models regionally calibrated with sound ground/ experimental data appears promising to provide meaningful insights into the highly complex interconnections of different ecosystem services at a landscape level.