Hans H. Ruthenberg-Graduierten-Förderpreis 2018/

Hans H. Ruthenberg Award for Graduates 2018

Lutz-Heiner Otto "Assessing the economic potential and land-use changes of Conservation Agriculture in northern Namibia -A multiperiod modelling approach"

University of Hohenheim, 2017

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Summary

Agriculture in northern Namibia is identified as being severely threatened by climate related changes. Therefore food security in Namibia is also under threat, since most Namibians live in northern communal lands, depending largely on subsistence agriculture. Agricultural activity in this area is mainly rain-fed and a decrease in precipitation may thus increase rural poverty and food insecurity. Applying low-cost climate adapted cultivation methods is a promising strategy to combat adverse climatic impacts. Acknowledging this, the GIZ Namibia started the project *Adaptation of agriculture to climate change in Northern Namibia*, which will focus on training small-holder farmers on climate-adapted cultivation practices especially Conservation Agriculture (CA).

In this framework, the thesis' objective was to conduct a socio-economic assessment of a representative small-holder farm and design a computer model which simulates real-world farming practices. The data was attained through field interviews and secondary sources trom involved stakeholders. The single agent computer simulation model was constructed with the help of the software MPMAS developed at the Hans Ruthenberg-Institute for Tropical Agriculture in Hohenheim. The model was capable of simulating changes in farming practices and income as CA is applied over the years. Further, a global uncertainty analyses was conducted, to analyze how results react to changes in input parameters.

Namibia covers some 824 268 km^2 on the south-western coast of Africa. Ninety two percent of the countries physical environment consists of hyper-arid, arid or semi-arid zones. Most Namibians live in northern communal lands, depending largely on subsistence agriculture. In these areas however, agricultural activity is mainly rain-fed and a decrease in precipitation may thus increase rural poverty and food insecurity. Farmers depend highly on their agricultural output, yet agricultural productivity is low due to poor soil and input management. A high variability in weather patterns and extreme weather events such as droughts has always accompanied agriculture in Namibia. In the latest two Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC) the extent and severity of

expected changes highlights the necessity to understand potential threats and to reflect on means to res pond and adapt. A decrease in rainfall and an increase in mean temperatures, as well as more unpredictable and erratic weather conditions are projected by the IPCC for many parts of southern Africa, especially northern and central Namibia. Applying low-cost climate adapted cultivation methods is a promising strategy to combat adverse climatic impacts.

Acknowledging this, the *Comprehensive Conservation Agriculture Program for Namibia* (CCAPN) was launched in March 2015 by the Ministry of Agriculture, Water and Forestry supported by the FAO. Further, the GIZ Namibia started the project *Adaptation of agriculture to climate change in Northern Namibia*, which will focus on training small-holder farmers on CA. The term CA refers to a set of cultivation principles which have to be adhered: minimum mechanical soil disturbance, permanent organic soil cover and diversification of crop species grown in sequences and/or associations.

The literature research compiled in this thesis concludes that benefits of CA systems are mainly linked to increased soil fertility and increased soil water retention capacity. Further, accumulation of soil organic matter and a decrease of soil erosion are other advantageous observations in CA systems. Results from long-term investigations in southern Africa indicate that crop yield benefits are expected to increase over time when applying all three principles of CA. However, a small yield decrease up to year five after implementation was identified by as a typical feature of CA systems.

It is however hard to quantify possible outcomes of CA practices and what constraints application may face over the period of many years. For the simulation of CA in the economic model designed for this thesis, labor demand and yields of the crops beans and pearl millet were change to reflect the farm-level implementation of CA. Further, the modeled farm had the opportunity to select the CA methods "Ripper" and "Basins" to comply with the minimum soil disturbance requirement. Lastly, to ensure permanent organic soil cover, the simulated farm had the option to hire a cattle boy to protect crop residues, to annually build a bush fence or invest in a permanent wire fence. From these options the model identified the most economically implementations to fulfill the cultivation principles of CA.

Under a fixed parameter set-up, the farmstead simulated generated a total discounted income of N$ 257,342.06 after ten years and an annual cash availability of N$ 3,839 per year. To reach the optimal solution, staples of about 609 kg per annum had to be bought. The optimal production showed that 1.8 hectares of pearl millet were grown on the 4 hectare farmstead.

A fixed parameter set-up was modeled with an annual yield increase of 10% after year 3. The farmsteads simulated generated total discounted income was N$ 260,319. Annual simulated cash increased to N$ 5,743 and the need to buy staple foods decreased to 510 kg. All these results showed improvements to status-quo agriculture.

Looking only at yield and weeding labor responses of crops under CA, a first fixed parameter set-up with double weeding times compared to status-quo agriculture and an increase of ten percent in terms of yield showed improved incomes and also improved cash availability for farms. The fixed parameter set-up of CA further give insides to which CA options the farmer selected: The farmstead choose basins over ripper based systems, since basins do not come with additional input cost. Similarly, the farmer chooses bush fences over wire fences or permanent cattle boys to protect their field. The latter both come with additional monetary cost, while bush fences only come with additional labor. For this typical farm modeled it is therefore apparent, that labor is not necessarily a limiting factor. However, as the heterogeneity of household set-ups is undeniable, different farmsteads may display contrasting outcomes and responses to increased labor demands. In terms of the uncertainty of yield and labor, results heavily depended on the yield distribution which was chosen when drawing design points with the quasi-random Sobol algorithm. Here results indicate that CA shows positive income signals when uniform yield ranges are set to highest ever recorded yield of pearl millet under CA. It has to be mentioned though, that no differentiation was made between design points drawn for millet and design points drawn for cowpeas. When plotting income and cash developments of CA, modeling results indicates that farmsteads will only reap higher incomes after year 4, which is a somewhat expected result, based on the implementation of CA. From a policy point of view, it should be noticed that subsistence farmers may have short-planning horizons and future gains may not playa sufficient role in farmers' choice of adopting a technology.

A major finding of the thesis is that while CA can provide higher incomes for the simulated agricultural household in the long run, it is likely that income variability will increase. Particularly in the first few years after the implementation of CA, there were income fluctuations that had to be overcome. This result coincides with the current discussion around conservation cultivation in subtropical agricultural systems. This economic simulation model, gives conclusions about the best possible implementation of sustainable technology. and about barriers that small farmers are faced with in taking over and implementing them.

The GIZ-project in which framework the data for this thesis was collected is on-going and will conclude in 2019. Data of on-farm trials carried out may provide future modeling endeavors with more input data for concise model set-ups. There is a need to clarify crop yield responses, especially for pearl millet.