Summary of Papers

This thesis is a synthesis of research conducted on smallholder Conservation Agriculture (CA) in the southern part of Zambia. Methods of data collection used were panel household surveys, semi-structured interviews, key informant interviews, focus group discussions, field assessments, soil sampling, and desk studies. The research results are presented in six journal style papers summarized as follows;

Paper One examined the agronomic practices of smallholder Conservation Agriculture (CA) farmers in the southern part of Zambia. The objective of this study was to evaluate CA under Zambian farming conditions by examining its application among smallholder farmers in order determine reasons for any deviations from recommended practices and where possible suggest options through which smallholder CA in Zambia could be improved. The results showed that partial adoption of CA was the trend as CA households only used minimum tillage techniques on about half of their total cultivated land. Crop residue were not retained in the fields as doing so conflicted with the socio-cultural practices of the communities while crop rotation on all the cultivated fields seemed difficult in light of the dominance of maize cultivation and the lack of markets for crop legumes. Weed management was reported to be more challenging under CA as weed pressure increased with minimum tillage. Hand weeding and herbicides were used by 99% and 18% of the sampled households as weed control measures. Very low concentrations of herbicides used as only 0.6 liters ha⁻¹ instead of the recommended 4-5 liters ha⁻¹ which reduced their efficacy. There were no significant differences in the total nitrogen, organic carbon, available phosphorus, potassium, bulk density and plant available water between soil samples from fields that had been under CA for at least five years and those from conventionally farmed fields (p≤ 0.05). Levels of mineral fertilizer amendments were low for both CA and conventionally farmed fields (30kg ha⁻¹ and 34 kg ha⁻¹ respectively). Possible options for improving smallholder CA systems identified were greater integration of livestock, correct herbicide application, market provision for crop legumes, farmer training in agri-business and better access to agricultural credit and subsidized inputs. CA promoters must incorporate the farmers’ local cultural contexts in order to better address the challenges associated with adopting CA.
Paper two documented the economic benefits of CA by studying the labour use and variable costs of two CA systems and their equivalent Conventional Agriculture (CV) systems in Southern Zambia. The paper found that while ripping utilized significantly less labour than ploughing, basin–digging was as labour intensive and did not result in labour saving compared to the CV hand-hoe tillage system. No differences were observed in the labour use at weeding time between the CA basins and CV hand hoe based tillage systems, while more labour was used for hand weeding ripped fields compared to ploughed fields. Overall, no labour saving benefit was observed for the complete farming cycle resulting from adoption of CA. Partial budget analysis results revealed higher gross margins and returns to labour under CA relative to CV. The drudgery associated with basin-digging and increased weed pressure under both CA sub-systems permeated the focus group discussions and may have also influenced households’ decisions to allocate smaller areas to CA despite the acknowledged higher yields. We argue that adoption of CA by smallholder farmers depends on more than their knowledge and opportunity to adopt it. They take several factors into consideration, which are not always aimed at profit maximization. These factors may hinder them from adopting CA despite having the knowledge of its agronomic and economic superiority over CV. We also argue that the way households cost inputs is different from the way economists do it as evidenced by the large variance in the costs calculated using partial budget analysis and as reported by the farmers presented in this paper. We conclude that promotion of conservation agriculture should be informed by local and contextual factors.

Paper three explored the effects of the leguminous tree *Faidherbia albida* on soil fertility in areas where Conservation Agriculture was practiced and mature stands of tree existed. Soil samples were collected from under and outside the canopies of 102 *F. albida* trees in four districts situated in the Southern and Eastern provinces of Zambia. Tests for differences in the soil reaction (pH), total nitrogen, potassium, phosphorus and organic carbon at increasing radial distance from the tree were conducted. Analysis using linear mixed models showed evidence of a negative linear relationship between total nitrogen, organic carbon, and potassium levels and distance from *F. albida* (p≤0.009) for all except for available phosphorus (p=0.26) and soil reaction pH (p=0.88). *F. albida* added significant amounts of the agriculturally important nutrients which most smallholders had difficulties replenishing to the soils through mineral fertilizer amendments because of their limited ability to purchase them. Challenges of managing *F. albida* included its susceptibility to termite attack, browsing of young plants by livestock, and the long time taken before benefits materialize. It was concluded that *F. albida* improved soil fertility in farmers’ fields and could be promoted in smallholder CA systems in Zambia.

Paper Four investigated the land degradation minimizing benefits of CA as promoted among smallholder Zambian farmers. It found no evidence of CA associated improvements in soil fertility after seven years of CA practice, most probably because crop residues were removed...
from the fields. The study reports high phosphorus (15.53 mg kg^-1) and potassium (0.75 cmol kg^-1) levels, and no plough/hoe pans in soils from both CA and conventionally (CV) managed fields. This was in part contrary to the dominant land degradation narratives which have been the basis for CA promotion in the study areas. With grain yields ranging between 2.4 and 3.8 tons per hectare, biomass production was estimated between 2.9 and 4.6 tons per hectare for CA systems. In order to meet the requirement of 30 % soil cover under CA, biomass production and retention of 3 tons per hectare is needed to meet this threshold. This is difficult to achieve due to the dominance of crop-livestock systems which demand use of crop residues as fodder. Government subsidies on mineral fertilizer and hybrid seed were promoting maize monocropping and remain unsupportive of CA. The paper concluded that the dominant land degradation narrative which posits population induced land degradation may not hold in this case. Rather removal of crop residues and low levels of mineral fertilizer and manure amendments may better explain the soil fertility status of the study areas. The long term environmental benefits associated with CA will only be actualized if practices that return or supply nutrients to the soil and improve its fertility are adopted. There is also a need for the government of Zambia to implement its agricultural and supportive policies in ways that enhance the adoption of CA in particular and soil and water conserving practices in general.

Paper five discussed the experiences emerging from the promotion and expansion of CA in Zambia by analyzing the empirical evidence from the study areas. This was achieved through the use of a framework for Conservation Agriculture Production System (CAPS) consisting of inputs and outputs from the system in the context of mediating factors. The paper documented evidence of CA’s potential to improve household food security among its adopters. It reported on benefits such as increased maize yields, more diversified crop production, improvements in labour productivity, increased incomes and input use efficiency among others. CA systems also reportedly reduced vulnerability of smallholders to extreme weather events such as droughts and floods through early planning, diversified crop production which included increased production of the drought resistant crop, cassava, which also performed well under flooding conditions. The paper noted that introduction of CA into varied biophysical, socio-economic and policy contexts entail flexibility and adaptations are cardinal if its benefits are to be optimized and adoption levels increased. More research on validation of the innovation, optimization of its benefits and overcoming of the current bottlenecks is recommended. Increased budgetary allocations towards research would go a long way in the development of conservation agriculture that is more tailored towards the needs of resource constrained farmers.

Paper six was based on the author’s reflections on field experiences and numerous discussions with CA and non-CA smallholder families, local leadership of rural Zambian communities, experts on CA and agricultural development in general, academicians and scientists working
with smallholder families from all over the world and extensive literature review on the subject. It attempted to synthesize a theory on the decision making and behaviour of smallholder CA households of Zambia by drawing on a range of theories on household production choices and tried to interpret the empirical evidence obtained from own field work and from literature in the context of these theories. The paper found that smallholder CA households in the studied areas do not aim to maximize profits. Rather, they try to secure household consumption from own production first before other considerations. Although they do respond to economic incentives, their responses are contingent upon ‘safety first’, minimizing risks associated with securing a minimum level of livelihood and investments by investing into local practices that serve as insurance.

Their practice of farming prioritizes own consumption before other considerations such as deciding whether and what to grow for sale. The amount and type of foods to be produced for own consumption is mediated by the size of the households and the access to needed resources. In response to the pervasive risks and uncertainty, practices and norms aimed at minimizing risk and the adverse effects of calamitous events have been developed and are consciously maintained. These include strong local institutions for reciprocity, labour pooling, communal grazing for livestock during the post harvest season etc. Added to these are livelihood diversification strategies. Most smallholders have a diverse portfolio of activities that are engaged in by different household members at different times of the year. Decisions on whether to adopt CA and how many of the prescribed practices to adopt and over what area are made in consideration of the impact on the whole range of other livelihood strategies engaged in by the household, and also in light of local norms and practices.