



Africa RISING East and Southern Africa Project Book of Abstracts 2013 - 2023

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The [Africa Research In Sustainable Intensification for the Next Generation](#) (Africa RISING) program comprises three research-in-development projects supported by the United States Agency for International Development (USAID) as part of the U.S. Government's Feed the Future initiative.

Through action research and development partnerships, Africa RISING is creating opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three regional projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads the program's monitoring, evaluation and impact assessment.




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Introduction

This book summarizes the published journal articles, theses/dissertations, and book chapters from the research studies developed or supported by the Africa RISING East and Southern Africa Project. The content highlighted through this publication provides an insight of the breadth of scientific rigor of the Africa RISING projects and program over the past 11 years as they worked to contribute to the aspirations of the US Government's Feed the Future Initiative of improving agricultural production, strengthening the resilience of communities to shocks, reducing hunger, and improving nutrition. This publication has been prepared for review by all project stakeholders.

Year 2023

Extrapolation suitability index for sustainable vegetable cultivation in Babati district, Tanzania. {Journal article}

Citation

Muthoni, F. K., Delore, M.J., Lukumay, J. P. and Ochieng, J. 2023. Extrapolation suitability index for sustainable vegetable cultivation in Babati district, Tanzania. *Frontiers in Sustainable Food Systems* 7.

Abstract

Land suitability assessment matches crop requirements with available resources to promote sustainable production. Scaling out of sustainable agricultural intensification practices to suitable biophysical and socio-economic conditions reduces the risk of failure and increases their adoption rate. This study applies a geospatial framework to identify potentially suitable sites for extrapolating two improved vegetable cultivars grown under integrated management practices (IMP's) in Babati District of Tanzania. On-farm trial data on the yield and income of two cultivars were used as a reference. Extrapolation was based on the gridded biophysical and socio-economic layers that limit the production of the two improved vegetable cultivars'. The extrapolation suitability index (ESI) showed the areas where cultivation of the two improved vegetable cultivars under IMP's can be scaled-out with a potentially low risk of failure. We generate maps of the most important limiting factor for each cultivar in every pixel to guide the spatial targeting of appropriate remedial measures. Application of these maps will promote evidence-based scaling out of improved vegetable technologies by the extension and development agencies.

Keywords:

DOI: <https://doi.org/10.3389/fsufs.2023.1047505>

Year 2022

Agronomic and economic performance of legume-legume and cereal-legume intercropping systems in northern Tanzania **{Journal article}**

Citation

Kinyua, M.I, Kihara, J., Bolo, P., Mairura, F., Fischer, G. and Mucheru-Muna, M. 2022.
Agronomic and Economic Performance of Legume-Legume and Cereal-Legume Intercropping Systems in Northern Tanzania.

Abstract

Cereal-legume intercropping, a common practice among farmers in sub-Saharan Africa (SSA), is important for crop diversification, soil fertility improvement, household nutrition and climate adaptation. However, cereals often outcompete the intercropped legumes for growth resources resulting in low legume yields. The objectives of this study were: i) assessing the effects of different intercropping options (crop spatial configurations) and maize crop management innovations on productivity and economic benefits to farmers and ii) examining how farmers adapt new intercropping technologies to meet their household food security needs. The study was undertaken within 6 researcher-designed and managed trials in high and low rainfall agro-ecological zones of Babati District, northern Tanzania, during four cropping seasons (2018 - 2021). The cropping systems tested included a sole maize system rotated with a legume-legume intercrop (Doubled-up legume), an innovation involving two maize rows intercropped with two legume species (Mbili-Mbili), maize-legume intercrop both with and without de-topping, maize-legume intercrop (2 maize plants at 50 cm intra-space, de-topped), maize-legume system (maize with vertical leaf architecture) and a farmer practice. In 2019 season, 120 farmers were trained on testing Mbili-Mbili system in own fields. The number of participating farmers had grown to 225 by 2021 cropping season. A study was conducted to assess the adaptations farmers made on Mbili-Mbili technology. Overall, maize grain yields increased by up to 56% in improved compared to farmer intercropping practices ($P < 0.05$). There were no significant differences in maize grain yield among the improved practices. Significantly higher pigeonpea yields of between 71% and 113% in 2020 and between 65% and 140% in 2021 were observed under Doubled-up legume and between 63% and 124% under local farmer practices in 2020 than in the improved cereal-legume practices. Across the study period, net revenues of Sole maize and Doubled-up legume rotations were both the highest and lowest relative to other intercropping options, depending on the starting phase (US\$ 653 sole maize and US\$ 326 legume phase starting). These were also associated with the highest variances indicating instability. Mbili-Mbili intercropping system had not only high net revenue i.e., a mean of US\$623 per hectare, but also more stable. Farmers perceived that Mbili-Mbili increased food security and 96% were willing to implement the system without project support. Mbili-Mbili is recommended for adoption by farmer because of its potential economic benefits, food security and resilience in the current unpredictable weather and climate patterns.

Keywords: Mbili-Mbili, Doubled-up legume, cropping systems, competition, gender, Economics

Link: <https://dx.doi.org/10.2139/ssrn.4226643>

Conservation agriculture practices drive maize yield by regulating soil nutrient availability, arbuscular mycorrhizas, and plant nutrient uptake {Journal article}

Citation

Mhlanga, B., Pellegrino, E., Thierfelder, C. and Ercoli, L. 2022. Conservation agriculture practices drive maize yield by regulating soil nutrient availability, arbuscular mycorrhizas, and plant nutrient uptake. *Field Crops Research* 277: 108403

Abstract

Conservation agriculture (CA) can sustainably increase crop productivity through improved soil chemical, physical, and biological properties, among others. However, the implementation of all its three main components (i.e., no-tillage, organic soil cover/mulch, and crop diversification) in southern Africa is often challenging, resulting in variable yield responses. Disentangling the contributions of CA practices is necessary to understand the drivers of maize grain yield within the region. Here we analysed two 6-year long component omission experiments, one at a sandy soil location and the other at a clay soil location. In these two experiments, soil chemical parameters, total plant nutrient uptake, rate of crop residue decomposition, and arbuscular mycorrhizal fungi (AMF) colonization of maize roots were assessed. Soil chemical properties only differed across systems at the sandy soil location with the mulched systems under no-tillage (NT) resulting in increased soil organic carbon levels, total nitrogen, and soil available phosphorus as compared to conventional tillage with no mulch or rotation (CT). Conventional tillage-based systems resulted in fastest decomposition of maize residues, while systems with NT and rotation resulted in highest AM fungal root colonization rate of maize at the clay soil location. Total plant N uptake was almost 2-fold higher in tilled and no-tilled systems with both mulch (M) and rotations (R) (i.e., NT+M+R and CT+M+R) as compared to CT. Structural equation modeling was used to disentangle the links between cropping systems, soil chemical and biological properties, plant nutrient uptake, and maize grain yield. Cropping systems had direct and indirect influences on yield at both locations. At both locations, cropping systems influenced yield via plant N uptake, with the NT+M+R and CT+M+R systems having more beneficial effects compared to other systems, as shown by their higher path coefficients. In conclusion, we recommend a more holistic approach to cropping system assessment that includes a higher number of abiotic and biotic determinants. This would allow for a more rigorous evaluation of the drivers of yield and increase our understanding of the effects and performance of practices under the prevailing agro-ecological conditions.

Keywords: Conservation agriculture, No-tillage MulchCrop rotation, Nutrient uptake Residue decomposition

Contributions of integrated soil fertility management (isfm) to various sustainable intensification impact domains: A meta-analysis {Journal article}

Citation

Kihara, J., Manda, J., Kimaro, A.A., Swai, E., Mutungi, C., Kinyua, M., ... & Bekunda, M. (2022). Contributions of integrated soil fertility management (ISFM) to various sustainable intensification impact domains in Tanzania. *Agricultural Systems*, 203: 103496, 1-16.

Abstract

CONTEXT: The implementation of integrated soil fertility management varies widely among farmers, from none to full ISFM, with multiple computations in between. The intensity of ISFM is influenced by the number of ISFM components (improved germplasm, crop associations, organic resources, fertilizers and local adaptations e.g. soil and water conservation) used in a specific plot of a farmer's field. **OBJECTIVE:** This study 1) evaluated the current implementation status of ISFM by farmers in relation to the various ISFM components and 2) provided multi-dimensional multi-scale evidence of ISFM implications that can guide ISFM investments within SSA contexts, with a specific focus on Africa RISING intervention zones. We hypothesized that an increasing number of ISFM components is associated with increasing benefits across a large number of indicators of sustainable intensification domains.

METHODS: We used data collected from 1442 farms between 2013 and 2020 in two ecozones, semi-arid and sub-humid, in Tanzania. The data are mostly yield cuts from baby trials within a mother-baby trial design combined with detailed agronomic surveys. Response ratio of yield was calculated for analyses involving multiple years and sites. The data analyses consider that while ISFM is implemented primarily at plot level, the effects vary from plot to farm to household and landscape/community. The contributions to the domains of sustainable intensification and the interactions across the domains themselves are discussed, considering the social domain as a cross-cutting domain due to its influences on all other domains, e.g., equity.

RESULTS AND CONCLUSIONS: The intensity of ISFM is higher in sub-humid (1 to 4) than in semi-arid ecozone (0 to 3). Except for SWC applied by 40% of farmers in both ecozones, the proportion of farmers using intercropping (91%), improved seeds (95%) and manure (55%) in the sub-humid ecozone are more than double those applying these ISFM components in the semi-arid ecozone. Productivity and economic benefits increase with the number of ISFM components at the expense of higher labour demand unless where practices for drudgery reduction are employed. Differential access to resources, and decision making and control rights drive choice of the specific ISFM components and the intensity of the ISFM. **SIGNIFICANCE:** Concomitant analyses of ISFM impacts across domains and spatial scales is important to guide scaling of ISFM and is recommended in future studies.

Keywords: ISFM intensity, ISFM components, Impact domains, spatial scales

Link: <https://dx.doi.org/10.1016/j.agsy.2022.103496>

Do youth conceptualizations influence the inclusion of young people in sustainable agriculture intensification? Insights from Ghana and Malawi {Journal article}

Citation

Zulu, L.C., Djenontin, I.N.S., Kamoto, J.F. et al. Do youth conceptualizations influence the inclusion of young people in sustainable agriculture intensification? Insights from Ghana and Malawi. *Environ Dev Sustain* (2022). <https://doi.org/10.1007/s10668-022-02632-9>

Abstract

We examine local conceptualizations and definitions of the youth and how they influence youth inclusion in sustainable agriculture intensification (SAI) in Ghana and Malawi amidst challenges of high youth unemployment and underemployment, food insecurity, and rural out-migration. We use data from focus group discussions and key informant interviews. Definitions of youth(hood) varied among communities and agricultural officials based on age mediated by multiple socio-cultural, demographic, biological, economic, and relational factors. Conceptual mismatches between national formal and local definitions, and negative perceptions of youths undermined youth inclusion. Unpacking and harmonizing conceptualizations of youths as human capital and youth as transitional condition with local definitions that also foster positive youth identities and cultures, and treating dependent and independent youth separately, can reveal meaningful, youth-inclusive intervention points. It can enhance youth opportunity spaces and agency for their increased engagement in SAI and help to avoid misguided policies arising from conceptual reductionism of youth.

Keywords: Youth conceptualization, Sustainable agriculture intensification, Opportunity landscapes, Ghana, Malawi

Link: <https://doi.org/10.1007/s10668-022-02632-9>

Improved technologies for reducing post-harvest losses {Journal article}

Citation

Mutungu, C. et al. (2022) 'Improved technologies for reducing post-harvest losses', CABI Books. CABI International. doi: 10.1079/9781800621602.0007.

Abstract/introduction

Post-harvest food loss refers to a measurable reduction in the quantity or quality of the food produced after harvesting. This can amount to a significant proportion, with close to one third of global food production being lost or wasted every year. For many households, these losses threaten food, nutrition, and income security. Losses of quantity reduce food supply, cause high food prices, and reduce farmers' incomes when the produce is required for household consumption rather than being available for sale. Quality losses result in food being less nutritious or even posing risk to health, lower market prices and reduced incomes for farmers, and less available food (if the quality loss means food must be destroyed).

Africa RISING investigations showed that the overall post-harvest crop losses in Tanzania's maize-based systems are equivalent to 25–40%, with up to 47% losses for maize specifically. This is a significant proportion and equates to 560 kg/ha among households that produce only 1.2 t/ha on average. For many grains, most post-harvest losses occur during drying,

processing, and storage operations; for example, losses during maize drying, shelling, and winnowing were found to amount to 135 kg/ton. Poor storage alone accounted for between 15 and 25% of the harvest (equivalent to 150–200 kg/ton). These losses mean that to produce the originally intended amount of food, farmers must use more inputs and increase the area of land under maize cultivation.

Allowing post-harvest food losses to continue uncontrolled is wasteful and makes agricultural production unsustainable because more land, water, labor, energy, fertilizer, and other inputs must be used to produce more food. Post-harvest losses lower farm productivity and push farmers into a cycle of needing to expand into new ecosystems, with subsequent damage to biodiversity and the ecological balance. Some estimates suggest that food produced and harvested, but ultimately lost, consumes about 24% of total freshwater resources used in food crop production, 30% of total cropland area (about 1.4 billion ha), and 23% of total global fertilizer use annually, representing about 3.3 gigatons of CO₂ equivalent emissions (Kummu et al., 2012; FAO, 2013). It is therefore important for sustainable development that farmers reduce post-harvest losses, and more research, information, and demonstration are needed to ensure that farmers have proven and sustainable technologies at their disposal.

This chapter outlines several post-harvest loss reduction technologies validated by the Africa RISING program that will improve the efficacy of drying, threshing, and storage operations, and gives evidence of their potential impact. The chapter also provides evidence on the cumulative benefits of combining all three technologies. Figure 7.1 summarizes the potential post-harvest losses in a maize-based system in Tanzania. It indicates that maize grain losses of up to 32% can occur due to biological agents and physiological activities before harvest. These also need to be managed but are not covered in this chapter.

Keywords

Link: <http://dx.doi.org/10.1079/9781800621602.0007>

Nitrogen efficiency by soil quality and management regimes on Malawi farms: Can fertilizer use remain profitable?

{Journal article}

Citation

Burke, W.J., T.S. Jayne and S.S. Snapp. 2022. Nitrogen Efficiency by Soil Quality and Management Regimes on Malawi Farms: Can Fertilizer Use Remain Profitable? *World Development* 152, 105792.

Abstract

Maize is the primary economic and dietary staple crop for most poor farmers in Southern Africa, yet low yields have persisted in the region for decades. Intensifying maize production in a sustainable way using the same land will be increasingly important as virgin land becomes scarcer and fallowing becomes less common. This study investigates the sustainability of intensification underway in the African smallholder sector using a uniquely detailed panel survey that combines remote sensing data, soil analysis, yield cuts, GPS area measurements, and detailed field management surveys. Specifically, we quantify the on-farm yield response to nitrogen (N) fertilizer in relationship to 16 soil and field management regimes, adding to the scant literature that combines precise and objective measures of inputs, outputs, and ecological conditions on fields managed by farmers. Furthermore, we

examine drivers of soil health using a measure of labile carbon that, unlike total carbon, can be responsive to farm management over the observable time period. Results are based on a representative sampling of Malawi's diverse agroecosystems through a multi-year study for over 1000 fields. We find surprisingly low yield response to N applications, highlighting that fertilizer access alone is not sufficient for sustainable intensification. We find complimentary "good agronomy", including effective weed management, crop rotations, and organic fertilizer applications are positive influences on maize yield response to inorganic fertilizers. Encouragingly, results show management practices such as incorporating diverse crop residues and manure for a few years can raise labile carbon levels, improving the soil base on which factors jointly determine yields. These findings underscore the importance of education, livestock and crop diversification, and farmer utilization of good agronomy to improve fertilizer use efficiency as a means to promote sustainable agricultural productivity.

Keywords: Africa, Fertilizer efficiency, Maize, Malawi, Soil fertility management, Sustainable intensification, Agronomy

Link: <https://doi.org/10.1016/j.worlddev.2021.105792>

Nutritional benefits of improved post-harvest handling practices for maize and common beans in Northern Tanzania: A quantitative farm-level assessment {Journal article}

Citation

Christopher Mutungi, Judith Tungu, Juma Amri, Audifas Gaspar, Adebayo Abass, Nutritional benefits of improved post-harvest handling practices for maize and common beans in Northern Tanzania: A quantitative farm-level assessment. Journal of Stored Products Research, Volume 95,2022, 101918, ISSN 0022.

Abstract

The efficacy of improved post-harvest practices for reducing food losses is often reported, but the nutritional benefits remain much less expounded. Meanwhile, nutrient concentration changes during the post-harvest period can influence potential nutrition gains targeted to benefit households. We analyzed contents of selected nutrients in farmers' maize and common bean stocks under ordinary and improved practices at different post-harvest stages and related them to the physical quality. The improved practices comprised drying on tarpaulins, improved threshing, cleaning, and air-tight storage. By calibrating the actual nutrient contents against losses data, we estimated nutrient abundance levels and applied household farm production and nutrient demand data to estimate potential nutritional gains. Post-harvest stage (S), practice (P), and the S*P interaction significantly influenced physical quality, actual nutrient contents, and nutrient abundance.

The actual contents of most nutrients increased or decreased monotonically with grain damage. For maize, improved practices begot more calories (4.7%), protein (13.9%), and minerals (4–26%) at the mid stage of the post-harvest season and even more calories (40%), protein (34%), and minerals (2–105%) at the late stage. The gains were lower for beans—calories 6.5%, protein 8.7%, minerals 1–55%. Dry matter loss and nutrient enrichment effects were responsible for variable nutrient concentrations in the maize and beans.

The dry matter loss effect mainly influenced macronutrient abundance levels, especially in maize, whereas the enrichment effect mainly influenced minerals abundance with stronger influence on the beans than maize. Nutrients redeemed by improved practices at the late stage corresponded to 16–55 more days of calories and protein sufficiency for households,

and significant extra days of minerals sufficiency, including Zn (16–56), Cu (23–81), Mg (45–166), and K (7–26). The gains have relevance for nutritionally challenged households.

Keywords: Nutritional food loss, Calories, Protein, Micronutrients, Sustainable food production

Link: <https://doi.org/10.1016/j.jspr.2021.101918>

Participatory action research, social networks, and gender influence soil fertility management in Tanzania {Journal article}

Citation

Mponela, P., Manda, J., Kinyua, M., & Kihara, J. (2022). Participatory Action Research, Social Networks, and Gender Influence Soil Fertility Management in Tanzania. *Systemic Practice and Action Research*, 1-23.

Abstract

Transformation of knowledge systems and fostering learning among smallholder farmers such as through participatory action research (PAR) is key to agricultural growth in rural sub-Saharan Africa. We investigate how PAR influences uptake/use of integrated soil fertility management (ISFM) while accounting for gendered, bonding and bridging social capital. Stratified by engagement in a mother-baby PAR and by resource endowments, 607 smallholder farmers were sampled from northern Tanzania. Binary logistic and multinomial logit models revealed that full engagement in PAR was associated with early adoption of inorganic fertilizers, either as a dichotomous decision or an ISFM bundle with improved varieties, organic matter inputs and soil and water conservation. Bonding social capital through cooperatives, farmer groups, and farmer-farmer local networks supports soil and water conservation, especially among resource-poor farmers. Among the high-resource farmers, increased women's bargaining power in farm input purchases supports fertilizer and manure use while increased bargaining power in livestock tending supports crop residue incorporation. ISFM usage is constrained by age of decision-makers and a higher number of dependents per worker while education level and farm sizes increase its likelihood. In the resource-constrained, with low extension and technical support, and men-dominated patrilineal farming systems of Africa, the study places PAR, social networks, and gender inclusivity as key approaches for improving smallholder' ISFM.

Do youth farmers benefit from participating in contract farming? Evidence from French beans youth farmers in Arusha, Tanzania

Keywords: Participatory action research, Bonding social capital, Gendered social capital, Integrated soil fertility management, Adoption

Link: <https://doi.org/10.1007/s11213-022-09601-3>

DOI: <https://doi.org/10.1007/s11213-022-09601-3>

Profitability of gliricidia-maize system in selected dryland areas of Dodoma Region, Tanzania {Journal article}

Citation

Swamila, M., Philip, D., Akyoo, M., Manda, J., Mwinuka, L., Smethurst, P., Sieber, S. and Kimaro, A. 2022. Profitability of Gliricidia-maize system in selected dryland areas of Dodoma Region, Tanzania. *Sustainability* 14:53.

Abstract

Declining soil fertility and climatic extremes are among major problems for agricultural production in most dryland agro-ecologies of sub-Saharan Africa. In response, the agroforestry technology intercropping of Gliricidia (*Gliricidia sepium* (Jacq.)) and Maize (*Zea mays* L.) was developed to complement conventional soil fertility management technologies. However, diversified information on the profitability of Gliricidia-Maize intercropping system in dryland areas is scanty. Using data from the Gliricidia and maize models of the Next Generation version of the Agriculture Production Systems sIMulator (APSIM), this study estimates the profitability of the Gliricidia-Maize system relative to an unfertilized sole maize system. Results show significant heterogeneity in profitability indicators both in absolute and relative economic terms. Aggregated over a 20-year cycle, Gliricidia-Maize intercropping exhibited a higher Net Present Value (NPV = Tsh 19,238,798.43) and Benefit Cost Ratio (BCR = 4.27) than the unfertilized sole maize system. The NPV and BCR of the latter were Tsh 10,934,669.90 and 3.59, respectively. Moreover, the returns to labour per person day in the Gliricidia-Maize system was 1.5 times those of the unfertilized sole maize system. Sensitivity analysis revealed that the profitability of the Gliricidia-Maize system is more negatively affected by the decrease in output prices than the increase in input prices. A 30% decrease in the former leads to a decrease in NPV and BCR by 38% and 30%, respectively. Despite the higher initial costs of the agroforestry establishment, the 30% increase in input prices affects more disproportionately unfertilized sole maize than the Gliricidia-Maize system in absolute economic terms, i.e., 11.1% versus 8.8% decrease in NPV. In relative economic terms, an equal magnitude of change in input prices exerts the same effect on the unfertilized sole maize and the Gliricidia-maize systems. This result implies that the monetary benefits accrued after the first year of agroforestry establishment offset the initial investment costs. The Gliricidia-Maize intercropping technology therefore is profitable with time, and it can contribute to increased household income and food security. Helping farmers to overcome initial investment costs and manage agroforestry technologies well to generate additional benefits is critical for the successful scaling of the Gliricidia-Maize intercropping technology in dryland areas of Dodoma, Tanzania. [View Full-Text](#)

Keywords: APSIM; Gliricidia-Maize system; soil fertility; profitability; dryland areas

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DOI: <https://doi.org/10.3390/su14010053>

Short-term yield gains or long-term sustainability? – a synthesis of conservation agriculture long-term experiments in Southern Africa {Journal article}

Citation

Thierfelder, C. and Mhlanga, B. 2022. Short-term yield gains or long-term sustainability? – a synthesis of Conservation Agriculture long-term experiments in Southern Africa. *Agriculture, Ecosystems & Environment*. 326: 107812

Abstract

Southern Africa is likely to be heavily affected by a changing climate and the brunt will have to be shouldered by smallholder farmers in rural areas. Long-term experiments on climate-smart sustainable intensification practices offer the opportunity to evaluate and assess the potential impact of a more variable climate on crop productivity. Here, we used meta-analytic and meta-regression approaches to assess the response of different Conservation Agriculture (CA) systems across experiments as compared to conventional practices (CP) of varying experimental duration, established in trial locations of Malawi, Mozambique, Zambia, and Zimbabwe under an increasingly variable climate. We assessed how different agro-environmental yield response moderators such as type of crop diversification and amount of rainfall affect maize yield responses. Smallholder farmers, often living below the poverty line, are primarily concerned about short-term gains from agriculture systems accepting loss in longer-term sustainability. We therefore aim to identify cropping systems that may provide both short-term gains and longer-term sustainability. Results show that: a) long-term trends in yield performance are a result of many factors; b) the greatest yield gains between the best performing CA and least performing treatments at each location ranged between + 34% and + 117%; c) the greatest yields were found in direct seeded rotation systems; d) type of crop diversification and type of crop used in the diversification strategy affect yield response, with rotations involving legumes being more responsive than any practice without diversification; e) CA systems gains increase with time of practice as compared to CP and these responses are more pronounced under low to moderate rainfall, and in well drained soils. We therefore conclude that crop yield response under CA is determined by many yield defining agro-environmental factors and benefits of CA become more apparent with time.

Keywords: zero tillage; conservation agriculture; intensification; productivity; climate-smart agriculture; sustainable intensification

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DOI: <https://doi.org/10.1016/j.agee.2021.107812>

Soil erosion and sediment yield analysis in semi-arid Tanzania. A case study of Kongwa District {Thesis and dissertation}

Citation

Mbaga, D.A. 2022. Soil erosion and sediment yield analysis in semi-arid Tanzania (case study of Kongwa District). BSc thesis in Geoinformatics. Dar es Salaam, Tanzania: Ardhi University.

Abstract

Soil erosion is a most devastating geological hazard and it is a severe problem in central Tanzania especially in the semi-arid regions, and the resultant sediment yield creates threats to sustainable agriculture and ecosystems. But the execution of different mitigation initiatives and policies used to adopt conservation practises in agricultural lands are unsuccessful or in effective due to the lack of spatial information on soil erosion areas. This study attempts to analyze soil erosion prone areas and sediment yield in the Kongwa district using GIS and remote sensing technique. The Revised Universal Soil Loss Equation (RUSLE) was used to estimate potential soil losses and sediment yield by utilizing rainfall, soil, Normalized Difference Vegetation Index (NDVI) and Digital Elevation Model (DEM) datasets. The results obtained demonstrate high soil erosion prone areas in the southern part of the Kongwa district, with the average annual soil loss equal to 66.24ton/ha/year and sediment yield of about 13.58 ton/ha per year. Generally, soil erosion prone areas have been identified and sediment yield have been generated to support decision making processes regarding development of soil erosion control and adaptive measures for sustainable environment conservation measures. Based on the results obtained it is recommended that the sensitivity analysis of RUSLE model parameters should be carried out.

Key words: erosion; soil; geographical information systems

Permanent link to cite or share this item: <https://hdl.handle.net/10568/120476>

Sustainable Agricultural Intensification: A handbook for practitioners in East and Southern Africa {Handbook}

Citation

Bekunda, M., Hoeschle-Zeledon, I. and Odhong, J. 2022. Sustainable Agricultural Intensification: A handbook for practitioners in East and Southern Africa

Abstract

This book provides an insight into the background, lessons learned, and the methodology of facilitating the application of best-bet/best-fit agricultural technologies to smallholder farms in East and Southern Africa (ESA). All technologies highlighted within this book, except those on livestock feeding, were trialed and demonstrated in farmers' fields over an eight-year period [2012 - 2020] as part of the Feed the Future/USAID funded research-for-development Africa RISING ESA Project and supported by the CGIAR. The livestock feed technologies were compiled from Eastern Africa literature and included to offer a full set of technologies relevant for farmers in mixed farming systems. Topics covered include the introduction of resilient and nutrient-dense crops, better arrangement of crops in the field to amplify intercrop benefits, and the management of soils to improve soil fertility and minimize physical soil and nutrient loss.

The publication also features technologies for postharvest loss reduction, livestock feeding, food processing, and in the later chapters, important expositions on how multiple

technologies can be creatively integrated in a farming system and how key products of research can be taken to scale. In the first chapter and throughout the handbook, the importance of taking gender dynamics into account to ensure technologies produce equitable outcomes is emphasized.

This book: provides evidence-based descriptions of sustainable agricultural intensification technologies that have been validated iteratively with smallholder farmers; a convenient, easy-to-read, and science-based 'how-to' guide for successful deployment of improved agricultural technologies that will ensure readers from development/scaling agencies save time and resources for research trials and instead focus on technology deployment; gives evidence of how building research and development partnerships can be a critical element for successful delivery and scaling up of agricultural technologies. The book is aimed primarily at development practitioners who seek new competences in taking new technologies to scale. However, the breadth of topics covered makes this book an essential resource for agricultural scientists as well as university and college students aspiring to apply systems thinking in future agricultural research and development work.

Link: DOI: 10.1079/9781800621602.0000

<https://cabidigitallibrary.org/doi/epub/10.1079/9781800621602.0000>

Sustainable intensification in jeopardy: Transdisciplinary evidence from Malawi {Journal article}

Citation

Burke, W.J., S.S. Snapp, B. Peter, and T.S. Jayne. 2022. Sustainable Intensification in Jeopardy: Transdisciplinary Evidence from Malawi. *Science of the Total*

Abstract

In Africa, achieving sustainable agricultural intensification—increasing agricultural output without deleterious environmental impacts or converting more land for cultivation—will depend greatly on the actions of smallholder farmers and the policies that influence them. Whatever the future holds, the vast majority of farmers right now are small. Using multiple lines of evidence across disciplines, we examine trends in productivity of land and fertilizers in Malawi. Unfortunately, our effort uncovers disturbing trends that indicate intensification and sustainability are at risk. Two time-series datasets of satellite-based vegetative indices show a generally flat but highly variable trend in the productivity of agricultural land with epochs of steep decline. This is notably despite substantial (and successful) government effort to promote fertilizer use. We also compile evidence from several studies over three decades that use field-level data from farmers and suggest substantial declining maize yield response to fertilizer over time. These trends are consistent with soil degradation, the disappearance of fallow land and minimal investment in rehabilitation practices in densely populated areas, putting agricultural productivity in jeopardy. These signs of the harmful impacts that narrow approaches to productivity improvement may be having in Malawi are an early warning sign to policy makers in Malawi and around the continent that a more holistic and nuanced strategy is necessary for sustainable intensification in agriculture.

Keywords: Sustainable intensification, Fertilizers, Yield response, Nitrogen, Malawi

Link: <https://doi.org/10.1016/j.scitotenv.2022.155758>

Profitability of Gliricidia-Maize System in Selected Dryland Areas of Dodoma Region, Tanzania {Journal article}

Citation

Swamila, M., Philip, D., Akyoo, A.M., Manda, J., Mwinuka, L., Smethurst, P.J., Sieber, S. and Kimaro, A.A. 2022. Profitability of Gliricidia-Maize System in Selected Dryland Areas of Dodoma Region, Tanzania. Sustainability 14, 53.

Abstract

Declining soil fertility and climatic extremes are among major problems for agricultural production in most dryland agro-ecologies of sub-Saharan Africa. In response, the agroforestry technology intercropping of Gliricidia (*Gliricidia sepium* (Jacq.)) and Maize (*Zeamays* L.) was developed to complement conventional soil fertility management technologies. However, diversified information on the profitability of Gliricidia-Maize intercropping system in dryland areas is scanty. Using data from the Gliricidia and maize models of the Next Generation version of the Agriculture Production Systems sIMulator (APSIM), this study estimates the profitability of the Gliricidia-Maize system relative to an unfertilized sole maize system. Results show significant heterogeneity in profitability indicators both in absolute and relative economic terms. Aggregated over a 20-year cycle, Gliricidia-Maize intercropping exhibited a higher Net Present Value (NPV = Tsh 19,238,798.43) and Benefit Cost Ratio (BCR = 4.27) than the unfertilized sole maize system. The NPV and BCR of the latter were Tsh 10,934,669.90 and 3.59, respectively.

Moreover, the returns to labour per person day in the Gliricidia-Maize system was 1.5 times those of the unfertilized sole maize system. Sensitivity analysis revealed that the profitability of the Gliricidia-Maize system is more negatively affected by the decrease in output prices than the increase in input prices. A 30% decrease in the former leads to a decrease in NPV and BCR by 38% and 30%, respectively. Despite the higher initial costs of the agroforestry establishment, the 30% increase in input prices affects more disproportionately unfertilized sole maize than the Gliricidia-Maize system in absolute economic terms, i.e., 11.1% versus 8.8% decrease in NPV. In relative economic terms, an equal magnitude of change in input prices exerts the same effect on the unfertilized sole maize and the Gliricidia-maize systems. This result implies that the monetary benefits accrued after the first year of agroforestry establishment offset the initial investment costs. The Gliricidia-Maize intercropping technology therefore is profitable with time, and it can contribute to increased household income and food security. Helping farmers to overcome initial investment costs and manage agroforestry technologies well to generate additional benefits is critical for the successful scaling of the Gliricidia-Maize intercropping technology in dryland areas of Dodoma, Tanzania.

Keywords: APSIM; Gliricidia-Maize system; soil fertility; profitability; dryland areas

DOI: <https://doi.org/10.3390/su14010053>

Year 2021

A case for green-based vegetation indices: plot-scale sUAS imagery related to crop chlorophyll content on smallholder maize farms in Malawi {Journal article}

Citation

Peter, B.G., Messina, J.P., Carroll, J.W. and Chikowo, R. 2021. A case for green-based vegetation indices: Plot-scale sUAS imagery related to crop chlorophyll content on smallholder maize farms in Malawi. *Remote Sensing Letters* 12(8):778-787.

Abstract

Predictable outcomes from precision agriculture (PA) solutions require accurate measurements of crop status and a remote sensing knowledgebase that spans ecoregions. This paper evaluates the relationships between 20 multispectral vegetation indices derived from small, unmanned aircraft system (sUAS) image collection and on-farm measurements of crop chlorophyll content at two smallholder experimentation maize farms in Malawi with varied nitrogen fertilizer treatments. Results of this analysis show that prominent, green-based multispectral indices, such as the green normalized difference vegetation index (GNDVI), were among the models with the strongest correlations. This study is consistent with other research in this field, contributes to mounting evidence supporting a shift in status quo for greater adoption of green-based indices in PA, and offers data specific to the semi-arid sub-Saharan context.

Keywords: Remote sensing; chlorophyll; farming systems; maize; crops; intensification

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DOI: <https://doi.org/10.1080/2150704X.2021.1938733>

Adoption of sustainable agricultural technologies for vegetable production in rural Tanzania: trade-offs, complementarities, and diffusion {Thesis and Dissertation}

Citation

Ochieng, J., Afari-Sefa, V., Muthoni, F., Kansime, M., Hoeschle-Zeledon, I., Bekunda, M. and Thomas, D. 2021. Adoption of sustainable agricultural technologies for vegetable production in rural Tanzania: trade-offs, complementarities, and diffusion. *International Journal of Agricultural Sustainability*.

Abstract

Sustainable agricultural technologies have impacted positively on staple crop yields in Asia and some parts of Sub-Saharan Africa. However, the adoption of similar technologies in vegetable subsector is still low among small-scale farmers in Tanzania. Several efforts aimed at promoting the adoption of the technologies such as improved vegetable varieties, mineral fertilizers, manure and pest management practices to raise output, have not yielded the desired impacts. We examine dynamics of farmers' adoption of these technologies and the factors influencing technology choice. We also predict the peak level and speed of adoption of these sustainable technologies. Findings show that complementarities exist among improved varieties, fertilizers and pest management practices, while tradeoffs exist between manure and mineral fertilizers. These complementarities and tradeoffs should be sufficiently

exploited for farmers to adopt technologies that are suited for their specific circumstances. Better knowledge, access to credit, group membership, farmer participation in demonstration trials, and, more substantial livestock holdings drive technology adoption decision. Technologies have different peak levels of adoption, which are reached at different time intervals. The policy option is to strengthen collaborative efforts to scale out sustainable agricultural technologies to respond to the increasing demand for nutrient-dense vegetables for income, food and nutrition security.

Keywords: sustainable intensification; vegetables; traditional African vegetables; diffusion
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DOI: <https://doi.org/10.1080/14735903.2021.1943235>

Allometric equations for estimating on-farm fuel production of *Gliricidia sepium* (*Gliricidia*) shrubs and *Cajanus cajan* (pigeon pea) plants in semi-arid Tanzania {Journal article}

Citation

Hafner, J.M., Steinke, J., Uckert, G., Sieber, S. and Kimaro, A.A. 2021. Allometric equations for estimating on-farm fuel production of *Gliricidia sepium* (*Gliricidia*) shrubs and *Cajanus cajan* (pigeon pea) plants in semi-arid Tanzania. *Energy Sustain Soc* 11, 43 (2021).

Abstract

Background

Fuelwood is considered to be the primary source of cooking energy in Tanzania and, due to ongoing deforestation, access to fuelwood is becoming more cumbersome. On-farm agroforestry systems can reduce dependency on off-farm fuel; however, the output of on-farm produced fuel is typically uncertain as production potentials are often not known. In this paper, we have developed allometric equations to model the above-ground woody biomass (AGWB) production from intercropped *Gliricidia sepium* (Jacq.) Kunth ex Walp (*Gliricidia*) shrubs and *Cajanus cajan* (L.) Millsp. (pigeon pea) plants.

Methods

We used a destructive sampling approach, for measuring the dendrometric characteristics, such as the root collar diameter at a 20 cm stem height (RCD₂₀) and the stem height to estimate the AGWB production. The models are based on 112 *Gliricidia* and 80 pigeon pea observations from annually pruned plants. Seven allometric equations were fitted to derive the best-fit models for the AGWB production.

Results

We found that using a natural log-transformed linear model with RCD₂₀ as a single predictor variable provides the highest explanatory value to estimate the AGWB production (*Gliricidia*: $R^2 = 95.7\%$, pigeon pea: $R^2 = 91.4\%$) while meeting Ordinary Least Square (OLS) estimator requirements. Adding stem height as an additional variable to predict the AGWB production does not improve model accuracy enough to justify the extra work for including it.

Conclusions

While on-farm pigeon pea plants produced a stable amount of woody biomass per annum, annual fuelwood production from *Gliricidia* shrubs increased over the years. Compared to the annual fuelwood consumption data from the literature, our results show that on-farm

produced fuelwood can substantially offset the demand for off-farm fuel, potentially resulting in household fuelwood autarky.

Keywords: Agroforestry, Intercropping, Energy self-sufficiency, Smallholder farmer, Energy mix, Food security

DOI: <https://doi.org/10.1186/s13705-021-00310-8>

Assessment of land degradation in semiarid Tanzania using multiscale remote sensing datasets to support sustainable development goal 15.3 {Journal article}

Citation

Reith, J., Ghazaryan, G., Muthoni, F.K. & Dubovyk, O. 2021. Assessment of land degradation in semiarid Tanzania—using multiscale remote sensing datasets to support sustainable development goal 15.3. *Remote Sensing*, 13(9), 1754: 1-21.

Abstract

Monitoring land degradation (LD) to improve the measurement of the sustainable development goal (SDG) 15.3.1 indicator (“proportion of land that is degraded over a total land area”) is key to ensure a more sustainable future. Current frameworks rely on default medium-resolution remote sensing datasets available to assess LD and cannot identify subtle changes at the sub-national scale. This study is the first to adapt local datasets in interplay with high-resolution imagery to monitor the extent of LD in the semiarid Kiteto and Kongwa (KK) districts of Tanzania from 2000–2019. It incorporates freely available datasets such as Landsat time series and customized land cover and uses open-source software and cloud-computing. Further, we compared our results of the LD assessment based on the adopted high-resolution data and methodology (AM) with the default medium-resolution data and methodology (DM) suggested by the United Nations Convention to Combat Desertification. According to AM, 16% of the area in KK districts was degraded during 2000–2015, whereas DM revealed total LD on 70% of the area. Furthermore, based on the AM, overall, 27% of the land was degraded from 2000–2019. To achieve LD neutrality until 2030, spatial planning should focus on hotspot areas and implement sustainable land management practices based on these fine resolution results.

Keywords: land degradation; sustainable development goals; land productivity; land cover; landsat; vegetation; soil organic carbon

Permanent link to cite or share this item: <https://hdl.handle.net/10568/114159>

DOI: <https://doi.org/10.3390/rs13091754>

Assessment of sustainable land use: linking land management practices to sustainable land use indicators {Journal article}

Citation

Nziguheba, G., Adewopo, J., Masso, C., Nabahungu, N. L., Six, J., Sseguya, H., Taulya, G. and Vanlauwe, B. 2021. Assessment of sustainable land use: linking land management practices to sustainable land use indicators. *International Journal of Agricultural Sustainability*

Abstract

Land degradation threatens food production especially in smallholder farming systems predominant in sub-Saharan Africa. Monitoring the effects of agricultural land uses is critical to guide sustainable intensification (SI). There are various indicators of sustainable land use (SLU), but conventional methods to quantify their metrics are complex and difficult to deploy for rapid and large-scale assessments. Considering that SLU indicators are dependent on agricultural practices, which can be rapidly identified and quantified, we propose a framework for SLU assessment that includes indirect quantifications of prioritized indicators (crop productivity, soil organic carbon (SOC), acidification, erosion, nutrient balance) using agricultural practices; and a SLU index derived from the integration of these indicators. The application of the framework to a case study, consisting of 1319 farm plots in Tanzania, reveals that SOC and N balance were the main contributors to the SLU gap. Only 2.2% of the plots qualified as being used sustainably. The framework proved to be sensitive to practices commonly used by farmers, thus providing an opportunity to identify practices needed to revert land degradation. Further application of the framework as a decision-support tool can enhance the efficiency of SI investments, by targeting practices which effectively enhance food production and preserve land.

Keywords: acidification; erosion; crops; soils; carbon; crop production; sustainable land use

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Broadening farmer options through legume rotational and intercrop diversity in maize-based cropping systems of central Malawi {Journal article}

Citation

Gwenambira-Mwika, C.P., Snapp, S. and Chikowo, R. 2021. Broadening farmer options through legume rotational and intercrop diversity in maize-based cropping systems of central Malawi. *Field Crops Research* 270:108225.

Abstract

Smallholder farmers across southern Africa have limited access to adequate quantities of inorganic fertilizers, and this limits crop productivity. Integration of legumes such as groundnut (*Arachis hypogaea* L.) and pigeonpea (*Cajanus cajan* L.) improve soil fertility and subsequent cereal crop productivity through biological nitrogen fixation (BNF), and high-quality residues. The objective of this four-year, multi-site, on-farm study in Malawi was to evaluate diverse legume systems, quantify crop production, economic viability, and total N accumulation in groundnut and pigeonpea. The study involved six research sites with different agricultural productivity potential based on precipitation, elevation, and temperature; to evaluate crop performance by environment. The six cropping systems evaluated were sole pigeonpea or sole groundnut rotated with maize (*Zea mays* L.) (PP-MZ

and GN-MZ), groundnut/pigeonpea intercrop rotated with maize (GNPP-MZ), maize/pigeonpea intercrop (MZPP), continuous unfertilized maize (MZ-MZ), and fertilized maize (MZ+F). Total N accumulated by cropping system was in the order GNPP > PP > MZPP > GN at 180, 130, 103 and 87 kg N/ha respectively. In the groundnut/pigeonpea intercrop, despite a reduction of pigeonpea biomass, pigeonpea was still the main driver for N cycling in the systems. The average percentage of N derived from BNF (BNF-N%) from all plant components and across sites was 66% for groundnut and 52% for pigeonpea. Average maize grain yield for response years when rotated with legumes was 4.82, 3.25, and 2.16 Mg/ha for sites with high (Linthipe), medium (Kandeu), and low (Golomoti) agricultural productivity potential. System performance in terms of gross margins ranged from \$1145 (pigeonpea-maize rotation) to \$1407/ha (groundnut/pigeonpea-maize rotation). The pigeonpea-maize rotation produced the most biomass but had modest economic and agronomic returns during the legume phase. This study highlighted that, for hot and dry environments, groundnut was the most effective species at increasing maize yield in a subsequent year. The groundnut/pigeonpea-maize rotation system met multiple goals including high pigeonpea biomass, profitable groundnut grain, and high maize yields during the rotational year. This system is recommended for ecological intensification, as it provided an economically feasible means to enhance BNF on smallholder farms, while ensuring multiple grain harvest goals in different environmental contexts.

Keywords: Cropping system Intercropping, Legumes, Maize, On-farm, Rotation
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DOI: <https://doi.org/10.1016/j.fcr.2021.108225>

Combining local knowledge and soil science for integrated soil health assessments in conservation agriculture systems {Thesis and Dissertation}

Citation

Hermans, T.D.G., Dougill, A.J., Whitfield, S., Peacock, C.L., Eze, S., and Thierfelder, C. 2021. Combining local knowledge and soil science for integrated soil health assessments in conservation agriculture systems. *Journal of Environmental Management*, 286, 112192

Abstract

The challenges of soil degradation and climate change have led to the emergence of Conservation Agriculture (CA) as a sustainable alternative to tillage-based agriculture systems. Despite the recognition of positive impacts on soil health, CA adoption in Africa has remained low. Previous soil health studies have mainly focused on 'scientific' measurements, without consideration of local knowledge, which influences how farmers interpret CA impacts and future land management decisions. This study, based in Malawi, aims to 1) combine local knowledge and conventional soil science approaches to develop a contextualised understanding of the impact of CA on soil health; and 2) understand how an integrated approach can contribute to explaining farmer decision-making on land management. Key farmers' indicators of soil health were crop performance, soil consistence, moisture content, erosion, colour, and structure. These local indicators were consistent with conventional soil health indicators. By combining farmers' observations with soil measurements, we observed that CA improved soil structure, moisture (Mwansambo 7.54%–38.15% lower for CP; Lemu 1.57%–47.39% lower for CP) and infiltration (Lemu CAM/CAML 0.15 cms⁻¹, CP 0.09 cms⁻¹; Mwansambo CP/CAM 0.14 cms⁻¹, CAML 0.18 cms⁻¹). In the conventional practice, farmers perceived ridges to redistribute nutrients,

which corresponded with recorded higher exchangeable ammonium (Lemu CP 76.0 mgkg⁻¹, CAM 49.4 mgkg⁻¹, CAML 51.7 mgkg⁻¹), nitrate/nitrite values (Mwansambo CP 200.7 mgkg⁻¹, CAM 171.9 mgkg⁻¹, CAML 103.3 mgkg⁻¹). This perception contributes to the popularity of ridges, despite the higher yield measurements under CA (Mwansambo CP 3225 kgha⁻¹, CAML 5067 kgha⁻¹, CAM 5160 kgha⁻¹; Lemu CP 2886 kgha⁻¹, CAM 2872 kgha⁻¹, CAML 3454 kgha⁻¹). The perceived carbon benefits of residues and ridge preference has promoted burying residues in ridges. Integrated approaches contribute to more nuanced and localized perceptions about land management. We propose that the stepwise integrated soil assessment framework developed in this study can be applied more widely in understanding the role of soil health in farmer-decision making, providing a learning process for downscaling technologies and widening the evidence base on sustainable land management practices.

Keywords: conservation agriculture; climate-smart agriculture; soil quality; intensification

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DOI: <https://doi.org/10.1016/j.jenvman.2021.112192>

Comparative analysis of groundnuts and maize seed value Chains in semi-arid agro-ecologies of central Tanzania {Thesis and Dissertation}

Citation

Kenjewala, V.G. 2021. Comparative analysis of groundnuts and maize seed value Chains in semi-arid agro-ecologies of central Tanzania; Msc Thesis, Sokoine University of Agriculture.

Abstract

The groundnut sub-sector in Tanzania is characterized by low productivity compared to the maize sub-sector. Among other things, the low productivity is due to the use of low-quality seeds. This study is therefore attempted to compare the profit of groundnuts and maize seeds value chains in semi-arid agro-ecologies of central Tanzania. Specifically, the study mapped the seed value chain of groundnut and maize sub-sectors; compared the profitability of groundnut and maize seed farmers as well as seed companies operating under an out-grower scheme model by using a gross margin approach. Further, it assessed the factors influencing investment in the two seed sub-sectors using a binary logistic regression model. Generally, the study covered 291 respondents where 120 were groundnut seed farmers, 120 were maize seed farmers, 17 agro-dealers, 19 extension officers, 4 research institutes, 5 seed companies and 4 regulatory organizations. Both qualitative and quantitative methods of data analysis were employed. Using gross margin analysis, the study reveals that, groundnut seed farmers realize a high gross margin i.e a difference of 914 953 TZS compared to maize seed farmers. Also, seed companies operating under the out-grower model scheme realize higher gross margins than individual seed farmers. Results from binary logistic regression revealed that level of education, household size, frequency of extension services, and training has positive and significantly influence investment in the groundnut and maize seed value chain. For the improvement of the groundnut and maize seed value chain in the study area, the study recommends that the government should come up with policies aimed at subsidizing the cost of farm inputs such as fertilizer and pesticides to lower the cost of production.

Keywords:

Link: <http://www.suaire.sua.ac.tz/handle/123456789/4653>

Conservation agriculture improves adaptive capacity of cropping systems to climate stress in Malawi {Journal Article}

Citation

Komarek, M.A., Thierfelder, C., and Steward, R.P. 2021. Conservation agriculture improves adaptive capacity of cropping systems to climate stress in Malawi. *Agricultural Systems* 190: 103117.

Abstract

Context Adaptation to climate stress is an unprecedented challenge facing cropping systems. Most adaptation assessments focus on how adaptation options affect yields of a single crop under different weather or climate conditions. Yet, cropping systems often comprise more than one crop, and holistic assessments should consider all crops grown in a cropping system. One adaptation option is Conservation Agriculture that is commonly defined around a set of three principles: minimum mechanical soil disturbance, permanent soil organic cover, and crop species diversification. Objective Here we estimated the statistical effect of Conservation Agriculture on cropping-system yields under historical climate conditions. Methods The cropping-system yields considered all crops grown including maize (*Zea mays* L.) and legumes in intercropping or rotation, or both.

The climate conditions included conditions of heat stress for maize and precipitation balances during the maize growing season. Heat stress for maize was studied using growing degree days over 30 °C. Precipitation balance was the difference between precipitation and reference evapotranspiration. Data included 6296 yield observations from on-farm trials in farmer plots conducted over 14 seasons (2005–2006 to 2018–2019) in ten communities in Malawi. These yield data were coupled with daily weather data. We studied three treatments: (1) a Control Practice treatment where the soil was tilled, crop residues were removed, and there was no crop species diversification, (2) a No-Tillage treatment where the soil was not tilled, crop residues were retained, and there was no crop species diversification, and (3) a Conservation Agriculture treatment where the soil was not tilled, crop residues were retained, and there was crop species diversification through legume intercropping.

The use of maize varieties and legume rotation changed over time; however, the treatments studied remained the same over the entire length of the on-farm trials period in all individual communities. Results and conclusions Results of our study showed that heat stress for maize had a negative effect on cropping-system yields for non-stress-tolerant maize varieties and no legume rotation, although the Conservation Agriculture treatment reduced this negative effect compared with the Control Practice treatment. With the use of stress-tolerant maize varieties and legume rotation and Conservation Agriculture, our results suggest that heat stress for maize did not have a negative effect on cropping-system yields. Significance Our results demonstrate how Conservation Agriculture can improve the adaptive capacity of cropping systems and this provides urgently needed evidence on how farmers can adapt to climate stress.

Keywords: intercropping; maize; zero tillage; rotation irrigation; conservation agriculture; climate; crops

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DOI: <https://doi.org/10.1016/j.agry.2021.103117>

Disparate access to quality land and fertilizers explains Malawi's gender yield gap {Thesis and Dissertation}

Citation

Burke, J.W. and Jayne, T.S. 2021. Disparate access to quality land and fertilizers explain Malawi's gender yield gap. *Food Policy* 100:102002

Abstract

Grain yields on land managed by women in developing countries are usually lower than those on male-managed fields. This is usually attributed to unequal access to productive inputs, highlighting the systemically inequalitarian distribution of opportunities between men and women. This study examines the yield differences between male-, female- and jointly managed maize fields in Malawi. We test the hypothesis that there is no yield gap after controlling for access to higher quality soils, fertilizer, and other inputs. Furthermore, we explicitly test for significant differences in the endowment of soil quality and the likelihood of employing soil improving management practices between male-, female- and jointly managed fields. We employ field-level data on field managers, production, and input use, coupled with lab-assessed field-specific soil characteristics from 912 observations in Malawi's Central and Southern regions that were collected during the 2018 harvest season. Unlike many previous studies, we measure yield using a combination of yield cuts, plant population density, mid-season chlorophyll measurements, and satellite data (versus using farmer-reported data). Soil quality endowments are measured using total carbon, an effectively fixed condition. Farming effects on soil quality are measured using labile carbon fractions. We find women are disproportionately likely to be farming with lower quality seeds and less fertilizer on lower quality soils, and there is no yield gap after controlling for these factors. Our results will be beneficial to policy makers in Malawi because they highlight potential interventions that can be both productivity-enhancing and advance the goal of gender equality.

Keywords: Gender yield gap, Productivity, Soil quality, Sub-Saharan Africa Malawi

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DOI: <https://doi.org/10.1016/j.foodpol.2020.102002>

Drivers of millet consumption among school aged children in central Tanzania {Journal article}

Citation

Chande, M., Muhimbula, H., Mremi, R., Muzanila, Y., Kumwenda, N., Msuya, J. and Gichohi-Wainaina, W.N. 2021. Drivers of millet consumption among school aged children in central Tanzania. *Frontiers in Sustainable Food Systems*, 5, 694160: 1-13.

Abstract

Background: Iron and zinc deficiency are common public health problems in low-income countries largely due to poor consumption of iron and zinc rich foods. It has previously been observed that 57% of school aged children (SAC) in Tanzania suffer from anemia. In addition, estimates indicate that over 25% of the population have inadequate zinc intake. Pearl millet is an example of a nutrient dense, resilient cereal crop, that can be promoted to diversify diets and combat iron and zinc deficiency. This study overall aim was to increase pearl millet consumption among school aged (5 – 12 years) children. As part of the study, we investigated, the drivers of food choice relating to pearl millet consumption. Methods: The

study was a cross-sectional study of randomly selected households in Kongwa district, Dodoma region of Tanzania. In total, 128 women of reproductive age (20 – 49 years) were randomly selected for the study. A study questionnaire consisting of 66 items, was developed and validated. The constructs in the questionnaire were categorized in two groups: internal and external factors. Respondents were asked to indicate their level of agreement or disagreement with statements read to them by interviewers. The scores on intention and behavior constructs were based on the number of times caregivers intended to, or had fed their school going children with pearl millet in the referent month. Intention was considered high if it was higher than the median intention score of the group, and low if it was equal to or lower than the median scores. Correlations and multiple linear regressions were performed to measure association between constructs and to identify predictive constructs. The Mann-Whitney U test was used for score comparison. Results: There was a significant difference between intention and behavior among those who did not consume pearl millet ($P = 0.003$), and those who consumed pearl millet two or more times a week, in the same month ($P = 0.01$). Knowledge was significantly correlated with behavior identity ($r = 0.58$, $P = 0.001$), while health behavior identity was significantly correlated with intention ($r = 0.31$, $P = 0.001$). Intention of caregivers was significantly and positively correlated ($r = 0.44$, $P = 0.001$) with and predicted consumption of pearl millet ($r = 0.87$, $P = 0.067$).

Conclusion: Increasing knowledge or awareness on nutritional benefits of pearl millet among caregivers may increase consumption of pearl millet by children of school going age.

Keywords: millets; food; children; Tanzania; pearl millet; food choice

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DOI: <https://doi.org/10.3389/fsufs.2021.694160>

Economic analysis of integrated vegetable – poultry production systems in the Babati District of Tanzania {Journal Article}

Citation

Habiyaremye, N., Ochieng, J., and Heckelei, T. 2021. Economic analysis of integrated vegetable–poultry production systems in the Babati District of Tanzania. *Agriculture & Food Security* 10, 1 (2021).

Abstract

Background

Integrated vegetable–poultry production system has recently attracted attention both from the scientific and policy making communities for its potential contribution to food security as well as the opportunities it offers in improving the livelihoods of smallholder farmers in Tanzania. Despite the efforts made, its benefits and costs in heterogeneous and real-world settings are not fully understood. Despite the promising design of the vegetable–poultry production system, rather little is known of its profitability and its contribution to better living conditions of rural households in different real-world settings. The same applies regarding the knowledge on factors influencing the decision to adopt such an integrated system.

Methods

Using cross-sectional data collected from 250 households in Babati district of Tanzania, we employ a gross margin analysis and a logit model to evaluate the profitability and to

investigate the factors influencing the decision to integrate vegetable and poultry production systems.

Results

We find that the integrated vegetable–poultry production system is more profitable than vegetable farming alone and the profitability increases as the poultry flock size increases. An integrating household should keep 18 birds to get significant higher profit than non-integrator. Furthermore, gender and education level of the household head, awareness of integration benefits, land owned, household size, off-farm income, and total income received by the household influence the decision to integrate vegetable and poultry.

Conclusion

The study strongly promotes the integration of vegetable–poultry production system and highlights the influence of gender and awareness of integration benefits on the decision to integrate vegetable and poultry. Hence, the policy implication is to empower women and provide capacity building through training and extension services such as provision of affordable and improved vegetable seeds and poultry breeds.

Keywords: Vegetable–poultry integration, Profitability, Gross margin, Logit model

DOI: <https://doi.org/10.1186/s40066-020-00272-8>

Effect of pumpkin (*Cucurbita maxima*) seed meal as a supplementing diet to free-ranging goats on growth performance and semen quality {Journal article}

Citation

Maselema, D., Chigwa, F. and Chingala, G. 2021. Effect of pumpkin (*Cucurbita maxima*) seed meal as a supplementing diet to free-ranging goats on growth performance and semen quality. *Livestock Research for Rural Development* 33(1): Article #2.

Abstract

Range forages consumed by free-range goats are commonly deficient in protein, energy and minerals resulting in low productivity of the goats. The main objective of this study was to evaluate the effect of whole pumpkin seed meal supplementing diet on growth performance and semen quality of free-range goats. Thirty Malawian local bucks with an initial weight of 12.4 ± 0.3 kg and age of 6 months were studied in completely randomised design. The treatments were: free grazing with either supplementing diet of pumpkin seed meal or soybean meal and grazing only. The supplementing diets were mixed with maize bran to make them comparable. The supplementing diets were offered to goats (500 g each goat) before grazing (7:00 am) in individual pens followed by free graze for 7h. The experiment ran for 150 days. The measurements included: feed and refusals of the supplementing diet, live body weight, scrotal circumference, and semen quality characteristics. The intake of supplementing diets was high in bucks consuming soybean supplementing diet than pumpkin seed meal supplementing diet ($P = 0.0489$). Bucks supplemented with either soybean or pumpkin seed meal had higher final weight and average daily gain ($P < 0.05$) than the non-supplemented goats. However, the final live body weight and average daily gain did not differ ($P = 0.639$) between goats on soybean and pumpkin seed meal supplementing diets. The bucks supplemented with pumpkin seed meal had the widest scrotal circumference ($P < 0.05$) of all the treatments studied. The bucks fed a supplementing diet containing pumpkin seed meal had higher semen pH ($P < 0.05$) than bucks on sole grazing

group and soybean supplementing diet. Bucks on pumpkin seed supplementing diet had the greatest scores ($P < 0.05$) on total sperm motility and progressive motility; and sperm concentration followed by the bucks on soybean and the bucks on grazing only had the lowest score. The whole pumpkin seed meal could be used to improve productive performance and semen quality characteristics of free-ranging bucks.

Keywords: supplementary feeding; small ruminants; animal feeding; forage; goats; animal production

DOI:

Effect of seed generation, rhizobia inoculation and plant density on productivity and seed quality of soybean [*Glycine max (l.) merril*] and groundnut [*Arachis hypogea (L.)*] in Dedza and Machinga Districts of Malawi {Thesis and Dissertaion}

Citation

Kalumba. P.J. 2021. Effect of seed generation, rhizobia inoculation and plant density on productivity and seed quality of soybean [*Glycine max (l.) merril*] and groundnut [*Arachis hypogea (l.)*] in Dedza and Machinga districts of Malawi. . MSc Thesis in Agronomy. Lilongwe University of Agriculture and Natural Resources. Lilongwe. Malawi

Abstract

Two on-farm, researcher designed-farmer managed trials were arranged in split-plot in a randomised complete block design (RCBD) with seed generation as main plot factor while inoculation and plant density were subplot factors for soybean and groundnut trials, respectively, in Dedza and Machinga districts in the 2017/2018 season. Following the field trials, Screen house experiments were conducted at Bunda College, Crop and Soil Sciences Students research farm to evaluate the effect of mother environment on seed quality of soybean and groundnut. This study was laid out in a completely randomised design (CRD). The overall objective of these trials was to investigate effects of seed generation, inoculation, plant density and mother environment on soybean and groundnut productivity and seed quality.

In Machinga, soybean response to inoculation for BNF and grain yield was 67 % ($p=0.002$) and 27 % ($p=0.016$) high in recycled than certified seed, respectively. In Dedza inoculating soybean significantly increased BNF by 74 % ($p=0.004$) and grain yield by 21 % ($p=0.029$), while planting certified soybean increased grain yield by 18 % ($p=0.031$). In Dedza, planting recycled groundnut seed significantly increased BNF by 21 % ($p=0.011$) and grain yield by 24% ($p=0.041$) while planting groundnut in twin rows increased BNF by 38.5 % ($p=0.004$) and grain yield by 146 % ($p<0.001$), respectively. In Machinga, planting groundnut in twin rows increased BNF by 32.5 % ($p=0.025$) and grain yield by 87 % ($p<0.001$). Due to poor germination of certified groundnut seed, a covariate analysis controlling for plant density revealed that use of certified seed increased BNF and yield of groundnut ($p<0.001$). Results of screen house experiments showed that mother environment significantly affected seed quality of both soybean and groundnut and this implies that site selection should be considered in seed production.

Keywords: biological nitrogen fixation, seed quality, seed generation, soybean, groundnut

Link:

Farm performance evaluation: Holistic impact assessment of project promoted sustainable intensification innovations at farm-level in Tanzania {Thesis and Dissertation}

Citation

Massop, E. 2021. Farm performance evaluation: Holistic impact assessment of project promoted sustainable intensification innovations at farm-level in Tanzania. MSc thesis in Farming Systems Ecology. Wageningen, The Netherlands: Wageningen University and Research Centre.

Abstract/Description

Smallholder farmers in Sub-Saharan Africa are characterized by low inputs and consequently low productivity. They are mostly self-sufficient but struggle to meet their own nutritional demand. With a fast-growing population there are even more mouths to feed, but agricultural production is threatened by the consequences of climate change. Sustainable intensification is considered a solution for this complex situation, and the Africa Research in Sustainable Intensification for the Next Generation is one of several projects promoting sustainable intensification. This thesis provides a holistic assessment of the project in Tanzania, based on a household survey which included 579 households in Babati, Kilolo, Kongwa and Mbozi districts. The aim was to identify whether farms with a better sustainable intensification performance had more innovations implemented and which combinations of innovations could contribute to this performance. Hierarchical Cluster Analysis was used to identify combinations of innovations and based on the Sustainable Intensification Assessment Framework several indicators were used to assess performances per cluster. Positive Deviant analysis, based on Pareto-optimality and above average performances for selected indicators, was used to identify farms that performed extraordinarily better. Ten innovation clusters were identified, and the farms in five clusters that used more innovations also had a better performance. A large majority of farms in the better performing clusters made more use of fertilizers, compared with lower performing clusters. There were 52 farms identified as Positive Deviants, and these farms made more use of innovations which were not widely represented in the innovation clusters. The majority of the farms was found in well performing clusters, however the most of these well performing farms and the Positive Deviant farms still used considerable amounts of pesticides, which conflicts with sustainable intensification and thus requires attention for future improvements.

Keywords: sustainable intensification; smallholders; innovation; farming systems; impact assessment

Healthy soils, healthy plants, healthy humans: A holistic exploration of sustainable intensification effects on farming systems in Malawi {Thesis and Dissertation}

Citation

Mathews, M. 2021. Healthy soils, healthy plants, healthy humans: A holistic exploration of sustainable intensification effects on farming systems in Malawi. MSc thesis in Earth Sciences. Amsterdam, The Netherlands: University of Amsterdam.

Abstract

Smallholder farmers in Malawi are faced with resource and space constraints, low soil fertility, and vulnerability to climatic shocks. This has led to poor nutritional standing of farmers and their households, and very little ability to break through experienced feedback loops that keep them locked in a state of food and resource insecurity. The connection between soil-land and the human-health axis is only recently gaining momentum, however promising programs focused on sustainable intensification (SI) have begun to be implemented in sub-Saharan Africa to address root causes that lead to multi-dimensional poverty. Approaches such as SI, aim to provide farmers with low-cost accessible technologies that have the potential to optimize spatial resource allocation, increase production, and harness natural processes to mend degraded soils. As there are many SI technologies the scope of this research was to understand the holistic effect that incorporating biologically nitrogen fixing legumes within crop configurations can have on a farm system. Specifically, by looking at the differences in space allocated to legume intercropping in the form of legume-legume, maize-legume, and doubled-up legume rotations (DLR). Due to the complex and dynamic nature of farming systems, one change in management may lead to spillover effects throughout the entire farming system. Therefore, it was essential that a systems approach was used to analyze not just lower scale processes within the soil, but also higher-level analysis at the household and farm level. To do this, the application of an innovative bio-economic model, FarmDESIGN was employed, which allows for the integration of data at multiple levels. A case study approach was taken between two treatment groups (a mother and baby farm) in Central Malawi, with an additional exploration component carried out to understand potential opportunities, tradeoffs, and synergies that exploratory farm configurations could generate. In the case study analysis of the two treatments, a clear trade off was seen between farms that adopt more space for cash crops, and those that adopt more space for legume-intercropping. With a greater area dedicated to cash crops associated with increased financial standing, but less improvement in soil organic matter and dietary energy yield. While the farm with more space allocated to legume intercropping, was associated with increased levels of environmental and nutritional standing, evidenced by the indicators of increased soil organic matter, and increased dietary energy yield. In exploratory runs the results show when optimizing holistic objectives of nutrition, economic, environment, and social standing the model allocates increased space to legume intercropping configurations. For the mother farm this was seen in increased area to DLR and for the baby farm, legume-maize area. It can be concluded from this that a farms holistic standing increases the more area there is dedicated to legume intercrops.

Impact of sustainable intensification practices adoption on farm income of smallholder farmers: empirical evidence from Africa RISING project in Malawi {Thesis and Dissertation}

Citation

Maviko, I. 2021. Impact of sustainable intensification practices adoption on farm income of smallholder farmers: empirical evidence from Africa RISING project in Malawi. MSc Thesis in Agricultural and Applied Economics. Lilongwe University of Agriculture and Natural Resources. Lilongwe. Malawi

Abstract

Sustainable intensification technologies (SI) have been promoted by various organizations as a way of mitigating the impacts of climate change and increasing crop productivity. In Malawi, SI technologies are also promoted to enhance crop production, farm income and food security among farmers. The practices are deemed as a solution to improving the livelihood of resource poor farmers. Despite the fact that SI technologies have the potential to improve the welfare of farmers, it remains an empirical question in Malawi as to whether adoption of such technologies improves income of farmers. Thus, the study was conducted to assess the adoption and impact of SI technologies on farm income. Multistage sampling method was applied to sample 27 smallholder farmers in Linthipe, Golomoti and Kandeu Extension Planning Area (EPA), Dedza and Ntcheu districts. The results from the study has revealed that most of the farmers were aware of improved maize varieties, crop rotation and maize-legume intercropping. However, adoption rate was high for maize-legume intercropping and maize hybrid seed. The results further revealed high crop productivity for mother trial fields followed by mother own fields, baby and then control farmer's field. For instance, maize productivity is 4133 kg/ha, 2230 kg/ha, 2305 kg/ha and 1932 kg/ha for mother trial fields, mother own fields, baby and control farmer's field respectively. The results on crop sales revealed significant differences in income of farmers obtained from crop sales. The average crop sales realized by mother, baby and control farmers is MK76,889. MK32,000 and MK7,700 respectively. Based on these findings the study has recommended the need to increase farmer's access to profitable market, designing strategies to foster collective action among farmers and promoting of multiple adoption of SI practices. This is imperative if the livelihood of resource-constrained smallholder farmers is to be improved in Malawi.

Keywords: sustainable intensification, farm incomes, legumes, maize

Improved nutrition and resilience will make conservation agriculture more attractive for Zambian smallholder farmers {Journal article}

Citation

Mhlanga, B., Mwila, M. and Thierfelder, C. 2021. Improved nutrition and resilience will make conservation agriculture more attractive for Zambian smallholder farmers. *Renewable Agriculture and Food Systems*

Abstract

Food and nutrition insecurity in southern Africa call for improvements in traditional agriculture systems. Conservation Agriculture (CA) based on minimum soil disturbance, permanent soil cover and crop diversification has been implemented as a strategy to maintain yields while safeguarding the environment. However, less focus has been placed on potential synergistic benefits on nutrition security. Maize-based systems may increase household income through selling but may not lead to proportionate reduction in malnutrition. Crop diversification in CA systems can have a direct impact on the nutritional status of farm households due to improved dietary diversity. Here we assess how the integration of grain legumes, cowpeas and soybeans, in maize-based CA systems either as intercrops or rotational crops affects maize grain yield and stability, total energy yield, protein yield and surplus calories after satisfying the daily requirement per household. The experiments were carried out from 2012 to 2020 (nine consecutive cropping seasons) in six eastern Zambian on-farm communities using 966 observations. Results show that intercropping compromises maize yields with marginal yield penalties of -5% compared to no-till monocropping. However, intercropped yields were more stable across environments. Total system caloric energy and protein yield were highest in intercropping systems due to higher productivity per unit land area owing to the additive contribution of both maize and legumes. Total system caloric energy and protein yield reached yearly averages of 60 GJ ha⁻¹ and 517 kg ha⁻¹, respectively, for the intercropping system as compared to 48 GJ ha⁻¹ and 263 kg ha⁻¹ in monocropped maize systems. Tillage-based monocrop resulted in the least stable yields. Our results suggest that intercropping maize with grain legumes in CA systems is a promising option for smallholder farming households to improve dietary diversity, dietary quality and stability of yields thus contributing to sustainable agriculture intensification while maintaining food and nutrition security.

Keywords: crop diversification, dietary diversity, food security
no-tillage, nutrition, sustainable intensification

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Intensifying cropping systems through doubled-up legumes in eastern Zambia {Journal article}

Citation

Mwila, M., Mhlanga, B. and Thierfelder, C. 2021. Intensifying cropping systems through doubled-up legumes in eastern Zambia. *Scientific Reports* 11:8101.

Abstract

Declining soil fertility and negative impacts of climate effects threaten the food security of millions in Africa. Conservation Agriculture (CA) is a promising strategy to address these challenges. However, lack of viable economic entry points and short-term benefits for smallholders limit its adoption. Legume intensification can possibly increase the output per unit area, thus making the system more attractive. Rotations of maize with intensified legume systems were tested for three consecutive years under ridge and furrow (RF) tillage and CA to investigate: (a) increases in productivity of legumes and the subsequent maize crop; (b) changes in land equivalent ratios (LERs) and (c) improved total system productivity. Results showed an increase in legume yields when growing two legumes simultaneously, leading to greater LERs (ranging between 1.13 and 1.29). However, there was only a significant season and not a main treatment effect as CA did not outperform RF in both phases of the rotation. Full populations of companion legumes improved overall system productivity, yielding 76.8 GJ ha⁻¹ in a more conducive season while sole cropping of pigeonpea yielded only 4.4 GJ ha⁻¹. We conclude that the doubled-up legumes systems have great potential to improve household food security when integrated into current smallholder farming.

Keywords: conservation agriculture; natural resources management; soil fertility; intensification; farming systems; legumes

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DOI: <https://doi.org/10.1038/s41598-021-87594-0>

Long-term conservation agriculture improves water properties and crop productivity in a Lixisol {Journal article}

Citation

Mhlanga, B. and Thierfelder, C. 2021. Long-term conservation agriculture improves water properties and crop productivity in a Lixisol. *Geoderma* 398:115107.

Abstract

Climate variability increasingly affects smallholder farmers in southern Africa. Conservation Agriculture (CA) practices have been proposed to improve the resilience of farming systems against the adversities of climate, specifically moisture stress. However, lack of detailed field data on soil water and chemical dynamics leads to over-reliance on simulation models without concrete evidence and ground-truthing of results. Here, we test the effects of different CA and conventional tillage (CP) practices on soil moisture content and water infiltration rate over a 14-year trial period. We also report soil chemical properties measured over 10 years from 0 to 30 cm soil depth. As study object, we used a CA long-term trial at the Monze Farmer Training Centre in Southern Zambia as it included different cropping systems and had parallel infiltration, soil moisture, soil chemical and crop yield measurements. Our results showed significant differences in average soil moisture in the first 60 cm among the cropping systems in different years with the basins plus mulching system having highest

moisture content in most of the years. The interaction of cropping systems and years significantly affected water infiltration rate with highest final infiltration rates averaging 48.5 mm h⁻¹ in the CA-based systems and the lowest in CP which averaged 12.6 mm h⁻¹. Soil chemical properties did not significantly differ across the systems but across seasons and depths or their interaction. For crop yield, a direct seeded maize-cotton rotation (DS-MC) consistently had the highest grain yields across most of the years as compared to the CP practice. Maize grain yield significantly differed among the years with a strong influence from the rainfall. Regression analysis revealed significant effect of seasonal rainfall on both soil moisture content and crop yield. The DS-MC system showed high responses of grain yield to rainfall and moisture. This was caused by increased available water and a greater buffering capacity against water stress in the cotton rotation. Systems that conserve moisture, increase infiltration and yield are of paramount importance in environments of variable rainfall. CA-based systems may therefore have the potential to buffer the effects of climate variability and may provide greater resilience.

Keywords: Climate-smart agriculture, Sustainable intensification, Long-term trials, Climate resilience, No-tillage Southern Africa

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Marginal more than mesic sites benefit from groundnut diversification of maize: Increased yield, protein, stability, and profits {Journal article}

Citation

John, I., Snapp, S., Nord, A., Chimonyo, V., Gwenambira, C. and Chikowo, R. 2021. Marginal more than mesic sites benefit from groundnut diversification of maize: Increased yield, protein, stability, and profits. *Agriculture, Ecosystems & Environment* 320:107585

Abstract

Sustainable Intensification (SI) interventions are urgently required, particularly those suited to resource poor farms in Africa. Legume crops have been promoted as a key ingredient for SI of rainfed grain production on smallholder farms, with variable results. There is a need to explore the extent to which legume diversification of maize production impacts stability, nutrition, and income. This is particularly so for marginal environments. On-farm experimentation was conducted in Central Malawi over two to seven years on 29 farm sites (120 year-site combinations). The farms were located within four areas that included lakeshore, dissected hills (two locations) and upland plain. Maize diversification included a long-duration legume pigeonpea and a medium duration legume groundnut, grown in rotation or intercropped with maize, and as a doubled-up legume rotation (DLR). To quantify the performance of systems under low, medium, and high yield environments, we used long-term average maize yield to categorize each farm site. All legume diversified systems supported stable grain production in the low yield environment, as shown by 37–41% coefficient of variation for yield, in comparison to 62% for sole maize. The groundnut systems consistently produced the highest grain yield, protein, stable yields, and economic returns, and this performance held up in marginal, low yield environments. In this multi-site, multi-year, on-farm replicated study, the performance of groundnut systems (GnRot and DLR) stood out for high protein (0.529 T ha⁻¹ 2 yr⁻¹ and 0.615 T ha⁻¹ 2 yr⁻¹, respectively over two years) versus unfertilized maize (0.169 T ha⁻¹ 2 yr⁻¹). These two groundnut-based systems were produced with half-fertilizer rates compared to sole maize and were

economically high performers. However, there was a barrier to adoption of GnRot and DLR in that improved groundnut seed was expensive (USD 157 ha⁻¹ 2 yr⁻¹), this initial investment being beyond the means of many farmers, despite the cost largely offset by the generation of high income (USD 1636–1993 ha⁻¹ 2 yr⁻¹). Long-term sustainability was assessed by monitoring soil organic carbon (SOC), which was found to be markedly influenced by soil texture (sites with SOC >1.5% had sand content <50%). Legume diversification effects on SOC were not discerned, possibly due to high sand content on the oldest trial sites. This study highlights the value of longitudinal data and including a wide range of soil texture sites in on-farm experimentation to identify overall legume diversification effects within maize systems.

Keywords: agroecology; sustainable agriculture; sustainable intensification; groundnut; resilience; pigeon peas; maize

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DOI: <https://doi.org/10.1016/j.agee.2021.107585>

Modeling interventions to reduce deforestation in Zambia

{Journal article}

Citation

Richardson, R. B., Olabisi, L. S., Waldman, K. B., Sakana, N., and Brugnone, N. G. 2021. Modeling interventions to reduce deforestation in Zambia. *Agricultural Systems* 103263

Abstract

Agriculture faces tremendous pressure to supply both growing and wealthier populations with more food, fiber, and fuel, while recognizing the limits of agricultural ecosystems. But it remains unclear whether it is possible to increase agricultural and food production without increasing deforestation and associated greenhouse gas emissions.

Objective

The objective of this study was to advance the understanding of landscape-level implications of sustainable intensification of agriculture on forest conservation in Zambia. Sustainable intensification aims to increase agricultural yields and reduce deforestation. Miombo woodlands, a dry forest ecosystem common throughout the region, are the dominant biome in much of Zambia, and they are suitable for the production of charcoal, a commonly used cooking fuel among urban households.

Methods

We used participatory system dynamics modeling to examine the drivers of deforestation in two provinces in Zambia. We modeled four scenarios to examine their effects on reducing deforestation over a 50-year simulation period: (i) an increase in maize yield from adoption of SI practices, and (ii) occasional moderate and severe drought events, (iii) adoption of efficient charcoal cookstoves, and (iv) full electrification.

Results and conclusion

We found no effects of adoption of sustainable intensification practices on agricultural encroachment into forested ecosystems. The clearing of forested land for agriculture was found to be largely driven by the rising demand for wood fuels for cooking and heating, particularly charcoal in urban areas. Charcoal was increasingly dominant as a driver of

deforestation in both provinces such that changes in land practices and economic returns to farmers are unlikely to reveal measurable changes in land use.

The findings have implications for the development of integrated approaches to address the challenges of food and energy insecurity, as well as for national-level policies aimed at climate change mitigation and reducing greenhouse gas emissions. This study provides a unique and innovative approach to integrating social and biophysical/ecological data through the application of system dynamics modeling. Furthermore, the study contributes to the literature on the environmental implications of agricultural land use and the drivers of deforestation.

Keywords: Sustainable intensification, Land use change, System dynamics modeling, Deforestation, Miombo woodlands, Zambia, sustainable intensification; land use; land use change; deforestation

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Opportunities for building resilience of African farming systems {Book chapter}

Citation

Chikowo, R., Olwande, J., Wanzala, M., Lubungu, M., Ngoma, H. and Sanchez, P. 2021. Opportunities for building resilience of African farming systems. IN: AGRA. 2021. Africa Agriculture Status Report 2021: A Decade of Action: Building Sustainable and Resilient Food Systems in Africa. Nairobi, Kenya: Alliance for a Green Revolution in Africa.

Abstract

The United Nations Food Systems Summit (UNFSS) has thrust food systems transformation onto the main stage of international discourse in 2021. Concepts of resilience, sustainability, and “green growth” have also gained tremendous traction internationally. Consensus is emerging across the globe that our livelihoods, jobs, and indeed the health of the planet, are fundamentally dependent on developing resilient and sustainable economies. Food systems are a fundamental part of the global economic system – the world’s population depends on them for sustenance. As is the case elsewhere, in Africa, many people depend entirely on food systems for employment and incomes as well. For these reasons, building resilient and sustainable food systems is crucial to ensuring sustainable economies and achieving the Sustainable Development Goals (SDGs) and Agenda 2063 Goals. However, Africa remains food insecure, accounting for 256 million of the world’s 795 million people suffering from hunger. Against this challenge, this 2021 African Agriculture Status Report (AASR21) provides evidence and insights on the prospects of achieving resilience and sustainability in Africa’s food systems.

Keywords: sustainable agriculture; food systems; resilience

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External link to download this item: <https://agra.org/resource-library/africa-agriculture-status-report/>

Performance of elite cereal and legume genotypes in varying potential agro-ecologies in Central Tanzania {Thesis and Dissertation}

Citation

Wabwire, S. 2021. Performance of elite cereal and legume genotypes in varying potential agro-ecologies in Central Tanzania; Msc Thesis, Sokoine University of Agriculture.

Abstract

Grain legumes and cereals are widely grown in many semi-arid areas of the tropics by smallholder farmers who derive from the crops multiple benefits such as nutritious food, soil fertility, and household income. Communities in these areas are highly vulnerable to weather and other natural disaster-related challenges thus facing a problem of low crop productivity. Field experiments were conducted during the 2019-2020 cropping season in different sub agro-ecologies of central Tanzania aiming to: - (i) identify legume and cereal genotypes of higher productivity in varying potential agro-ecologies (ii) determine the stability and GxE interaction of the legume and cereal genotypes in the different agro-ecologies (iii) identify relatively more efficient and productive cropping system in varying potential agro-ecologies of central Tanzania.

Experiments were laid down in two villages of each potential agro-ecology following an incomplete randomized block design with farmers as replications. Grain yield, yield components and growth data on fourteen genotypes in total of the four crops (groundnut, pigeon pea, sorghum and pearl millet) were collected and Land equivalent ratios (LERs) calculated for intercrops amongst the crops. Findings Results from the experiments generally revealed that G x M x E interactions were insignificant ($p \leq 0.05$) in terms of grain yield for all the crop genotypes studied. For groundnut and pigeon pea genotypes, significant differences ($p \leq 0.05$) were observed across the sub-ecologies while significant genotypic effects were observed in both sorghum and pearl millet genotypes. Genotype ICGV-SM 05650 of groundnut had the highest grain yield of 2105.08 kg ha⁻¹, while ICGV-SM 02724 recorded the lowest grain yield of 1538.87 kg ha⁻¹ in the high potential sub-ecology. Pearl millet genotype IP 8774 had the highest yield of 1049.4 kg ha⁻¹ and the local check had the lowest yield of 388.9 kg ha⁻¹. Though non-significant differences ($P \leq 0.05$) among genotypes tested for grain yield were observed in pigeon pea and sorghum genotypes however, pigeon pea genotype ICEAP 00040 had a slightly higher grain yield of 779.17 kg ha⁻¹ compared to ICEAP 00557 with 770.83 kg ha⁻¹ grain yield and sorghum genotype GAMBELLA 1107 outperformed the other genotypes with grain yield of 1420.8 kg ha⁻¹ followed by IESV 23010 DL of 1038.0 kg ha⁻¹. Early planting outperformed late planting for the crop genotypes tested however, non-significant differences ($p \leq 0.05$) in planting dates were observed. Furthermore, crop genotypes in the high potential generally out performed those under the moderate and low potential sub-ecologies. In terms of LERs, pigeon pea - sorghum, pigeon pea - groundnut and pigeon pea - pearl millet intercrops had higher LER values of 1.59 (high), 1.65 (moderate) and 2.36 (low potential agro-ecologies), respectively compared to LERs of 1.00 in their respective sole crops.

Findings of the study revealed that generally elite materials outperformed the local landraces. Furthermore, intercropping systems proved to be more efficient and productive compared to sole cropping systems. From the above findings, ICGV-SM 05650 (groundnut), ICEAP 00040 (pigeon pea), GAMBELLA 1107 (sorghum) and IP8774 (pearl millet) were recommended for deployment in these varying potential agro-ecologies due to their stable and superior performance in terms of grain yield. Intercrops Pigeon pea - Sorghum, Pigeon

pea - Groundnut and Pigeon pea - Pearl millet were the more efficient and productive cropping systems therefore recommended for deployment in the high, moderate and low potential agro-ecologies respectively.

Link: <https://www.suaire.sua.ac.tz/handle/123456789/3947>

Power relation dynamics among actors in the groundnuts seed value chain: a case of Kongwa and Kiteto districts, Tanzania {Thesis and Dissertation}

Citation

Mulokozi. G. 2021. Power relation dynamics among actors in the groundnuts seed value chain: a case of kongwa and kiteto districts, Tanzania; Msc Thesis, Sokoine University of Agriculture.

Abstract

Groundnut crop production being highly practised in semi-arid areas of Shinyanga, Tabora, Dodoma and Mtwara Regions of Tanzania, has been gradually falling. The trends show that the groundnuts production has fallen from 1.13 million tons in 2015 to less than 1 million tons in 2017. The production of groundnuts like any other crops depends on seed availability while constraints associated with seed availability have altered the overall groundnut crop and its seed value chain performances. The constraints associated with the groundnut seed value chain that contribute to the poor performance of the groundnuts crop are linked with the levels of influence and importance of actors in the groundnut seed value chain. As a result of these levels, there are power relational dynamics that the chain actors exert on one another.

The study aimed to identify actors in the groundnuts seed value chain, their roles, linkages and relational power dynamics in the chain as a result of the linkages they have. This study was descriptive and adopted a cross-sectional research design as it employed qualitative research methods that included semi-structured interviews with key informants. Focus group discussions were conducted to acquire in- depth information on relations and ties amongst actors that would explain the power actors possess.

Data analysis involved identifying the extent of linkages in terms of importance and influence by analyzing the actor-to-actor two-dimensional linkage matrixes using the UCINET statistical software package integrated with the NETDRAW program. The identification of actors and their roles in the groundnuts seed value chain was done through content analysis while linkage and relational centrality measures were used to explain power relational changes in the chain set-up. All these aimed at determining the strength of relationships and interactions between actors hence explain the power that actors have in the value chain. Qualitative data obtained from semi-structured interviews were subjected to content analysis. The analysis involved breaking, comparing and categorising to identify levels, number of ties, linkages and extent of power in term of influence and importance the identified actors have. Findings show that, there are different actors in the groundnuts seed value chain that are differentiated by jurisdictional levels (i.e. the village and district levels). The prominent actors included Researchers, Traders, Climate Department Officials, Central Government, Agro- dealer, Agro-processors and Consumers. These were found to occupy both village and district levels. On the other hand, Farmers, Extension Officers, NGOs and CBOs, Village leaders and Middlemen were only identified at the village level. Each of these

actors had different roles from which they are interconnected to form a network of linkage in two aspects, namely knowledge and income that dictate the extent of linkage among actors in-term of influence and importance. This determined the power they possess through these linkages based on the number of linkages identified among identified actors. In the knowledge aspect, NGOs, CBOs, Local Government, Researchers and Traders were found to have a higher level of influence and importance in both at the district (Kongwa and Kiteto) and village (Mlali and Moleti) levels while farmers and extension officers were more influential at the village level only. The same actors showed to have a higher level of betweenness with values 100 and 88.89 respectively, compared to other actors. On the income aspect, Organisations (NGOs and CBOs), farmers and the climate department had a relatively higher power in terms of influence at the village level (Moleti and Mlali).

The same was depicted by the Local Government and Agro-traders at the district levels (Kongwa and Kiteto). Results showed middlemen and farmers had a higher betweenness value, 9.524 and 14.856 respectively compared to other actors. This explained the power to connect other actors in terms of influence and importance in the chain set up. The study concluded that, the existence of power relational changes affects linkages among actors, the performance of the groundnuts seed value chain and it plays a key function in the overall performance of the groundnuts crop. It is therefore recommended that a more emphasis on actors' inclusion is improved through actors' involvement in the chain set up in the innovation platforms. This can go hand in hand with the government boosting linkages through the improvement of strategies and policies.

Productivity of newly released common bean (*Phaseolus vulgaris* L.) varieties under sole cropping and intercropping with maize (*Zea mays* L.) {Journal article}

Citation

Nkhata, W., Shimelis, H. and Chirwa, R. 2021. Productivity of newly released common bean (*Phaseolus vulgaris* L.) varieties under sole cropping and intercropping with maize (*Zea mays* L.). *Frontiers in Sustainable Food Systems* 5:741177.

Abstract

Intercropping maize (*Zea mays* L.) with common bean (*Phaseolus vulgaris* L.) is one of the predominant farming practices in eastern and southern Africa (ESA) for effective use of resources and continuous household food supply. The productivity of sole or intercropped crops is subject to variety, location, year, and their interaction. Therefore, the objective of this study was to determine the productivity of newly released common bean varieties NUA45 and SER83 under sole cropping and intercropping with a maize hybrid variety SC672 as a guide to large-scale production. Experiments were conducted at Chitedze Agricultural Research Station (13.85°S; 33.38°E) and Linthipe Extension Planning Area (12.06°S; 33.25°E) in 2019 and 2020 in Malawi using a factorial arrangement laid out in a randomized complete block design (RCBD) with four replications. The numbers of pods per plant (NPP) and seeds per pod (NSP), grain yield (GYD), and 100-seed weight were collected for common bean included, while GYD was recorded for maize. The main effects for genotype, location, year, and intercropping system were significant ($p < 0.05$) for GYD in common bean.

The effects of the year and cropping system and location by intercropping system interaction were significant for maize GYD. The maize yield did not vary between sole cropped and intercropped systems. The total land equivalent ratios (LERs) for NUA45 and SER83 were

1.59 and 1.77, respectively. The LER-values showed a significant difference ($p < 0.034$), suggesting a considerably higher benefit of maize and common bean intercropping. Overall, intercropping maize with common bean rendered higher yields in the SER83/SC672 intercropping system than the sole crop in the study areas. Therefore, intra-row intercropping of the newly released common bean variety SER83 with a maize hybrid variety SC672 is recommended in the study area and other similar agro-ecologies for stable and sustainable production of both crops.

Keywords: grain yield, intercropping system, land equivalent ratio, maize, sole crop

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Sustainable agricultural intensification and gender-biased land tenure systems: an exploration and conceptualization of interactions {Journal article}

Citation

Fischer, G., Darkwah, A., Kamoto, J., Kampanje-Phiri, J., Grabowski, P. and Djenontin, I. 2021. Sustainable agricultural intensification and gender-biased land tenure systems: an exploration and conceptualization of interactions, *International Journal of Agricultural Sustainability*, 19:5-6, 403-422.

Abstract

How does sustainable agricultural intensification's (SAI) tenet of increased productivity on the same area of land relate to prevailing gender-biased land tenure systems? How can one conceptualize the interactions between intensified land use and control over land, labour, crops and benefits – and how can equitable outcomes be facilitated? These questions (which have not yet received sufficient attention in SAI research) are explored in this study using a qualitative methodology and a gender-transformative approach. Semi-structured interviews and focus group discussions with a total of 248 respondents were conducted in matrilineal and patrilineal intensification contexts in Ghana and Malawi. We develop a conceptual framework that extends Kabeer's institutional analysis to include gender implications of SAI. Selected cases reveal how farmers and key actors link land use intensification to existing land-related institutions with diverse outcomes. We conclude that SAI interventions should adopt gender-transformative approaches. These facilitate equitable outcomes by supporting consensus-based institutional changes and creating positive synergies between multiple scales.

Keywords: Gender, land, sustainable, agricultural, intensification, Ghana, Malawi

DOI: [10.1080/14735903.2020.1791425](https://doi.org/10.1080/14735903.2020.1791425)

Sustainable and equitable agricultural mechanization? A gendered perspective on maize shelling {Journal article}

Citation

Fischer, G., Kotu, B., and Mutungi, C. 2021. Sustainable and equitable agricultural mechanization? A gendered perspective on maize shelling. *Renewable Agriculture and Food Systems*, 36(4), 396-404. doi:10.1017/S1742170521000016

Abstract

How can agricultural mechanization be accomplished in a sustainable and equitable way? This question has gained increased prominence in mechanization research over the past few years. In this study, we apply the question to mechanized maize shelling in Tanzania as a case in point. Data from a survey with 400 farmers and from semi-structured interviews with 21 key informants are combined for a gender analysis that relies on Kabeer's concept of four institutional sites (household, community, market and government). The findings reveal that although mechanization reduces men's and women's perceived drudgery of shelling, relief depends on gendered patterns of labor allocation and decision-making at the household level. As a result, the transformation of inequitable norms emerges as paramount. Key informants identified additional aspects that would make mechanized shelling more equitable and sustainable, such as mainstreaming gender and mechanization in comprehensive agricultural training, or the sensitization of mechanized input suppliers and manufacturers to farmers' preferences (including gender-sensitive machine design). Concerted efforts in multiple institutional sites are needed to achieve lasting change in respect of equity in mechanization.

Keywords: Gender, labor, maize, mechanization, post-harvest processes, sustainability, Tanzania

Link: <https://doi.org/10.1017/S1742170521000016>

The effect of integrating nutrition education, food budgeting and food processing and preparation on household dietary diversity: a case of Ntcheu and Dedza districts in Malawi {Thesis and Dissertation}

Citation

Liguluwe, R. 2021. The effect of integrating nutrition education, food budgeting and food processing and preparation on household dietary diversity: a case of Ntcheu and Dedza districts in Malawi. MSc Thesis in Human Nutrition. Lilongwe University of Agriculture and Natural Resources. Lilongwe. Malawi

Abstract

Lack of dietary diversity remains a problem in most developing countries especially for rural communities. This has been attributed to inadequate knowledge on diet among households. The aim of this study was to examine the effect of integration of nutrition education, food budgeting and food processing and preparation on household dietary diversity (HDD). The interventions were implemented in four Extension Planning Areas (EPAs) namely Kandeu, Nsipe, Golomoti and Linthipe in Dedza and Ntcheu districts for a period of 12 months. The study had two groups of participants (intervention vs comparison). Intervention group received nutrition education concurrently with food budgeting, food processing and

preparation. Repeated cross-sectional surveys were conducted in August/September 2017 (pre-intervention) and in September 2018 (post-intervention).

A total of 617 and 597 households were interviewed at baseline and end line, respectively. The percentage of households with high dietary diversity increased in the intervention groups in all the EPAs. The significant improvements of HDD can mainly be supported by the increase in consumption of pulses and nuts and fruits across all the EPAs. Despite that the overall household dietary diversity increased, the consumption of animal-source foods, particularly milk and milk products (1.7%), meats (10.8%), eggs (5.1%) and fish (17.7%) remained at low level among the households, although farmers took part in the interventions. Difference in household food processing and preparation were statistically significantly ($p < 0.001$) between intervention and comparison at end line. However, food budgeting was not effectively adhered by farmers in the intervention areas. The factors that influence HDD were education level, formal employment, and crop production diversity on HDD, among smallholder farmers in Dedza and Ntcheu districts.

The impact of demonstration plots on improved agricultural input purchase in Tanzania: Implications for policy and practice {Journal article}

Citation

Sseguya, H., Robinson, D.S., Mwango, H.R., Flock, J.A., Manda, J., Abed, R. and Mruma, S.O. 2021. The impact of demonstration plots on improved agricultural input purchase in Tanzania: Implications for policy and practice. PLOS ONE 16(1):e0243896.

Abstract

In this paper, the authors use survey data from over 800 households to examine the impact of demonstration plots and associated activities (distribution of small packs of agricultural inputs) on smallholder farmers' decisions to buy agricultural inputs in Tanzania. Using propensity score matching and inverse probability-weighted adjustment models, the authors estimated the effect of access to demonstration plots alone and demonstration plots combined with small packs of agricultural inputs on a household's decision to purchase improved inputs. The results indicate that access to demonstration plots and demonstration plots with small packs increased the probability of purchasing improved inputs by 13–17 percentage points. This paper suggests that demonstration plots and demonstration plots with small packs are an effective model for enhancing improved technology adoption and are further increased when those inputs are available within a 5km radius. The results point to the importance of strengthening farmers' organizations and last-mile agricultural input suppliers in order to enhance and facilitate access to information, appropriate production techniques, and improved inputs. The results also indicate the importance of investing in infrastructure to reduce transportation costs that limit market efficiency for appropriate technologies.

Keywords: agricultural workers; livestock; agriculture; farming systems; intensification

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DOI: <https://doi.org/10.1371/journal.pone.0243896>

Toward greater sustainability: How investing in soil health may enhance maize productivity in Southern Africa {Journal article}

Citation

Thierfelder, C., Paterson, E., Mwafurirwa, L., Daniell, T., Cairns, J., Mhlanga, B. and Baggs, E. 2021. Toward greater sustainability: How investing in soil health may enhance maize productivity in Southern Africa. *Renewable Agriculture and Food Systems*

Abstract

Climate change and soil fertility decline are major threats to smallholder farmers' food and nutrition security in southern Africa and cropping systems that improve soil health are needed to address these challenges. Cropping systems that invest in soil organic matter, such as no-tillage (NT) with crop residue retention, have been proposed as potential solutions. However, a key challenge for assessing the sustainability of NT systems is that soil carbon (C) stocks develop over long timescales, and there is an urgent need to identify trajectory indicators of sustainability and crop productivity. Here we examined the effects of NT as compared with conventional tillage without residue retention on relationships between soil characteristics and maize (*Zea mays* L.) productivity in long-term on-farm and on-station trials in Zimbabwe.

Our results show that relationships between soil characteristics and maize productivity, and the effects of management on these relationships, varied with soil type. Total soil nitrogen (N) and C were strong predictors of maize grain yield and above-ground biomass (i.e., stover) in the clayey soils, but not in the sandy soils, under both managements. This highlights context-specific benefits of management that fosters the accumulation of soil C and N stocks. Despite a strong effect of NT management on soil C and N in sandy soils, this accrual was not sufficient to support increased crop productivity in these soils. We suggest that sandy soils should be the priority target of NT with organic resource inputs interventions in southern Africa, as mineral fertilizer inputs alone will not halt the soil fertility decline. This will require a holistic management approach and input of C in various forms (e.g., biomass from cover crops and tree components, crop residues, in combination with mineral fertilizers). Clayey soils on the other hand have greater buffering capacity against detrimental effects of soil tillage and low C input.

Keywords: Climate change adaptation, climate-smart agriculture conservation agriculture, no-tillage, soil health indicators and sustainable intensification

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Welfare impacts of smallholder farmers' participation in multiple output markets: empirical evidence from Tanzania

{Journal article}

Citation

Manda, J., Azzarri, C., Feleke, S., Kotu, B., Claessens, L. and Bekunda, M. 2021. Welfare impacts of smallholder farmers' participation in multiple output markets: empirical evidence from Tanzania. Plos one, 16(5), e0250848: 1-20.

Abstract

A relatively large body of literature has documented the welfare effects of smallholder farmers' participation in single-commodity output markets. However, limited empirical evidence is available when smallholder farmers participate in multiple-commodities output markets. We tried to fill this gap in the literature by estimating the impacts of smallholder farmers' contemporaneous participation in both maize and legume markets vis-à-vis in only maize or legume markets using household-level data from Tanzania. Applying a multinomial endogenous switching regression model that allows controlling for observed and unobserved heterogeneity associated with market participation in single-commodity and multiple-commodity markets, results showed that smallholder farmers' participation in both single- and multiple-commodity markets was positively and significantly associated with household income and food security. Moreover, the greatest benefits were obtained when farmers participated in multiple-commodity markets, suggesting the importance of policies promoting diversification in crop income sources to increase welfare and food security.

Our findings also signal the complementary—rather than substitute—nature of accessing multiple-commodity markets for enhancing household livelihoods under a specialization strategy. Finally, important policy implications are suggested, from promoting and supporting public infrastructure investments to expanding road networks to reduce transportation costs, especially in remote communities, to enhance smallholder farmer access to profitable maize and legume markets in Tanzania.

Keywords: Small holders; farmers; markets; food security; sub-Saharan Africa; Tanzania; welfare

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Year 2020

An evolving agricultural extension model for lasting impact: How willing are Tanzanian farmers to pay for extension services? [Journal article]

Citation

Abed, R., Sseguya, H., Flock, J., Mruma, S. And Mwango, H. 2020. An evolving agricultural extension model for lasting impact: How willing are Tanzanian farmers to pay for extension services? Sustainability 12(20):8473.

Abstract

Community-based extension services (CES) are vital for improving farmers' livelihoods, but most of them face a challenge of sustainability after phasing out of the externally funded initiatives that they are part of. This study estimated farmer's willingness to pay (WTP) for four types of agricultural extension services (AES) in the cereals' value chains provided as a part of two United States Agency for International Development (USAID)-funded Feed the Future initiatives in Tanzania. Data were collected from 595 smallholder cereal farmers using a primary survey in four districts of the Southern Highlands. We implemented a double-bounded dichotomous choice contingent valuation method. Average WTP figures ranged from 20,000 to 24,000 TZS (8–10 USD) depending on the type of AES. Several socioeconomic and agriculture-related variables influenced smallholders' WTP for the extension services. This research explored the feasibility of a farmer-led model as a pathway to delink extension services from public and donor funding to achieve sustainable rural development. Farmers place a monetary value on extension services indicating that policymakers and practitioners should make further efforts to enhance a community's ability to achieve self-reliance through investments in CES.

Keywords: agricultural extension; extension activities; sustainable agriculture

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An in-depth examination of maize yield response to fertilizer in Central Malawi reveals low profits and too many weeds {Journal article}

Citation

Burke, W.J., S.S. Snapp and T.S. Jayne. 2020. An in-depth examination of maize yield response to fertilizer in Central Malawi reveals low profits and too many weeds. *Agricultural Economics* 51 (6): 923-940.

Abstract

We examine the productivity of fertilizer used on maize in Central Malawi using field-level panel data from over 1,200 observations on more than 500 fields over 4 harvest years. There are several novel aspects of this analysis compared to other on-farm fertilizer efficiency studies, including (a) precise and accurate yield measurement using crop cuts, (b) estimating the impact of timely weeding, (c) the use of data on multiple soil characteristics from a panel of soil samples, and (d) the ability to control for field-level fixed effects by tracking the same land over time. We find critical ecological and management threshold effects on fertilizer effectiveness at 0.94% soil carbon content, 57–58% sandiness, and weeding within 4 weeks of planting. Overall, we estimate lower yield response to fertilizer than reported in earlier studies: 2.6 maize kg/N kg under ideal circumstances, and statistically nil under many other conditions. We discuss the implications of our findings for farmers, policymakers, and researchers.

Keywords: fertilizer efficiency, maize, Malawi, profitability, soil quality, sustainable intensification, threshold model, weed management

DOI: <https://doi.org/10.1111/agec.12601>

Assessment of land degradation in semi-arid Tanzania: Using remote sensing to inform the Sustainable Development Goal 15.3 {Thesis and Dissertation}

Citation

Reith, A. J. 2020. Assessment of land degradation in semi-arid Tanzania: Using remote sensing to inform the Sustainable Development Goal 15.3. MSc thesis in Geography. Bonn, Germany: University of Bonn.

Abstract

Monitoring land degradation (LD) to inform the sustainable development goal (SDG) 15.3.1 ("proportion of land that is degraded over total land area") is key to ensure a more sustainable future. At the moment, there are only default medium-resolution datasets available to assess LD in Tanzania. They do not reflect local characteristics and cannot help to target exposed areas spatially. Therefore, this thesis adapts local datasets in interplay with high-resolution imagery to find out how much land is degraded in the semi-arid districts of Kiteto and Kongwa (KK). This approach follows the recommended practice by the United Nations Convention to Combat Desertification (UNCCD). It incorporates freely available datasets like Landsat and uses open-source software in interplay with cloud-computing. Human-induced LD was assessed using the Normalized Difference Vegetation Index (NDVI) correcting it for precipitation variability with the Rain Use Efficiency (RUE). Based on Mann-

Kendall's tau and using the mean NDVI per growing season, evidence suggests that 18.9% of the study area degraded, while further 14.9% showed early signs of decline.

The land cover map by the Regional Centre for Mapping of Resource for Development (RCMRD) spans the years 2000-2018. It showed that in 9.3% of the area there was land cover change and in 7.8% degradation could be found. Forests lost a quarter of their initial size and grasslands decreased by 9.5 %, while croplands increased by over 30 %. Lastly, soil organic carbon (SOC) declined in 8.6% of the study area. A total of 2.6 million tons SOC was lost, most of it in grass- and forestlands. In total, 16.4% of the area in KK districts is degraded for the LDN baseline period. The LD rose to 27.7% for the first monitoring period in 2019. Thus, the regional baseline for the SDG 15.3.1 indicator is set and the first target period assessed. In order to verify these results and make the assessment more precise, an additional collection of SOC data and larger scale ground truth is necessary. To nonetheless achieve LD neutrality until 2030, spatial planning should focus on hotspot areas and implement sustainable land management practices.

Keywords: sustainable development goals; natural resources management; land degradation
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Bridging the disciplinary gap in conservation agriculture research, in Malawi: A review {Journal article}

Citation

Hermans, T.D.G., Whitfield, S., Dougill, A.J. and Thierfelder, C. 2020. Bridging the disciplinary gap in conservation agriculture research, in Malawi: A review. *Agronomy for Sustainable Development* 40:3.

Abstract

Conservation Agriculture has emerged as a popular form of climate smart agriculture aimed at enhancing climate change resilience for smallholder farmers across Africa. Despite positive biophysical results, adoption rates remain low. It has been acknowledged that improved understanding of farmer decision-making is needed due to the variation in socio-economic and agro-ecological contexts which drives the research agenda to answer the question 'what forms of Conservation Agriculture work, where, and why?'. To fully understand this question, we need to approach the study of Conservation Agriculture within complex farming systems by collating and integrating different forms of knowledge. In this paper, we discuss (1) a comparison of disciplinary approaches to evaluating Conservation Agriculture in Malawi, (2) the identification of the knowledge gaps that persist at the intersection of these disciplines and (3) recommendations for alternative and interdisciplinary approaches in addressing these knowledge gaps.

With a focus on published studies from Malawi, we show that the Conservation Agriculture literature represents two distinct approaches to addressing the question 'what forms of Conservation Agriculture work, where, and why?', namely agro-ecological and socio-economic and that neither of these approaches can address the full scope of this question, in particular its 'why' component. To overcome these challenges, there is a need for access to compatible, comprehensive data sets, methodological approaches including farmer participation and ethnography, through on-farm trial research as a middle ground between disciplinary approaches.

Keywords: farming systems; climate-smart agriculture; no-tillage; intensification

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DOI: <https://doi.org/10.1007/s13593-020-0608-9>

Conservation agriculture as a climate change mitigation strategy in Zimbabwe {Journal article}

Citation

O'Dell, D., Eash, N.S., Hicks, B.B., Oetting, J.N., Sauer, T.J., Lambert, D.M., Thierfelder, C., Muoni, T., Logan, J., Zahn, J.A. and Goddard, J.J. 2020. Conservation agriculture as a climate change mitigation strategy in Zimbabwe, *International Journal of Agricultural Sustainability*

Abstract

There is a need to quantify agriculture's potential to sequester carbon (C) to inform global approaches aimed at mitigating climate change effects. Many factors including climate, crop, soil management practices, and soil type can influence the contribution of agriculture to the global carbon cycle. The objective of this study was to investigate the C sequestration potential of conservation agriculture (CA) (defined by minimal soil disturbance, maintaining permanent soil cover, and crop rotations). This study used micrometeorological methods to measure carbon dioxide (CO₂) flux from several alternative CA practices in Harare, central Zimbabwe. Micrometeorological methods can detect differences in total CO₂ emissions of agricultural management practices; our results show that CA practices produce less CO₂ emissions. Over three years of measurement, the mean and standard error (SE) of CO₂ emissions for the plot with the most consistent CA practices was 0.564 ± 0.0122 g CO₂ m⁻² h⁻¹, significantly less than 0.928 ± 0.00859 g CO₂ m⁻² h⁻¹ for the conventional tillage practice. Overall CA practices of no-till with the use of cover crops produced fewer CO₂ emissions than conventional tillage and fallow.

Keywords: conservation agriculture; climate change; carbon dioxide; farming systems; intensification

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DOI: <https://doi.org/10.1080/14735903.2020.1750254>

Crop climate suitability mapping on the cloud: a geovisualization application for sustainable agriculture Springer Nature {Journal article}

Citation

Peter, B.G., Messina, J.P., Lin, Z. and Snapp, S.S., 2020. Crop climate suitability mapping on the cloud: A geovisualization application for sustainable agriculture. *Scientific Reports*, 10(1), pp.1-17.

Abstract

Climate change, food security, and environmental sustainability are pressing issues faced by today's global population. As production demands increase and climate threatens crop productivity, agricultural research develops innovative technologies to meet these challenges. Strategies include biodiverse cropping arrangements, new crop introductions, and genetic modification of crop varieties that are resilient to climatic and environmental stressors. Geography in particular is equipped to address a critical question in this pursuit—when and where can crop system innovations be introduced?

This manuscript presents a case study of the geographic scaling potential utilizing common bean, delivers an open access Google Earth Engine geovisualization application for mapping the fundamental climate niche of any crop, and discusses food security and legume biodiversity in Sub-Saharan Africa. The application is temporally agile, allowing variable growing season selections and the production of 'living maps' that are continually producible as new data become available. This is an essential communication tool for the future, as practitioners can evaluate the potential geographic range for newly developed, experimental, and underrepresented crop varieties for facilitating sustainable and innovative agroecological solutions.

Keywords:

Link DOI: <https://www.nature.com/articles/s41598-020-72384-x>

Drought resistance and resource use efficiency in diversified cropping systems {Thesis and Dissertation}

Citation

Renwick, L. 2020. Drought Resistance and Resource Use Efficiency in Diversified Cropping Systems. PhD. Candidate, Horticulture & Agronomy/**M.S. International Agricultural Development**, Department of Plant Sciences, University of California, Davis

Abstract

Greater dependence of crop production on ecosystem processes instead of external inputs—or ecological intensification—can help make agriculture more resilient as climate changes without exceeding planetary environmental boundaries, or when inputs are unavailable or inaccessible. Drought already limits crop production and food security, and rising temperatures and crop evapotranspiration without concurrent gains in precipitation will magnify these challenges. The overarching adage from unmanaged ecosystems that greater biodiversity begets stress resilience has inspired interest, but little empirical testing to date, in using higher crop diversity to enhance internal regulation and functioning of agricultural systems in the face of environmental stress. What testing there is has focused mostly on how crop diversity lowers risk through a portfolio effect whereby different crops respond differently to stress. It has largely not yet addressed another way crop diversity could lower risk: through emergent ecosystem properties like higher resilience due to improved functioning during or after stress.

This dissertation targets these gaps by evaluating the impact of crop diversity in time and space on plant-soil processes in maize-based systems, and outcomes for crop drought resistance and system-scale resource use efficiency. In Chapter 1, we build a conceptual framework and outline the paths by which greater crop rotation diversity in temperate annual systems capitalizes on fundamental linkages between water and nitrogen cycling, retention, losses, and plant uptake to ultimately enhance system-scale water and nitrogen use efficiencies. In Chapter 2, we empirically tested potential shifts in drought resistance with adoption of diversified rotations and reduced disturbance by imposing drought at a long-term crop rotation and no-till trial representing the North American Corn Belt. We found that rotation diversity mitigated maize water stress and enhanced yield drought resistance through soil organic matter gains. Chapter 3 pivots to low-input maize-based cropping systems in semiarid Tanzania, where we found in a manipulative drought experiment at a medium-term intercropping and agroforestry trial that maize-pigeonpea intercropping consistently outperformed maize monoculture across drought and non-drought conditions regardless of fertilization level. Intercropping maximized nutritional yield across rainfall levels and required less land than monocultures to achieve the same food production. Taken together, this dissertation provides support for the idea that diversifying cropping systems in time and space can enhance agroecosystem functioning, yield resistance to drought, and system-scale resource use efficiency.

Keywords:

Link:<https://www.proquest.com/openview/19001cce9d14275b52ac6e57c2a4c3ba/1.pdf?pq-origsite=gscholar&cbl=18750&diss=y>

Efficiency of three-stone fire and improved cooking stoves using on-farm and off-farm fuels in semi-arid Tanzania

{Journal article}

Citation

Hafner, J.M., Uckert, G., Hoffmann, H.K., Rosenstock, T.S., Sieber, S., and Kimaro, A.A. 2020. Efficiency of Three-Stone Fire and Improved Cooking Stoves using on-farm and off-farm fuels in semi-arid Tanzania. *Energy for Sustainable Development* 59: 199-207.

Abstract

In Tanzania, fuelwood availability for cooking is an increasing challenge for rural households struggling to meet this need. Here, a possible pathway for smallholder farmers to reduce their dependency on off-farm fuelwood is evaluated. We compare the cooking performance of on-farm produced fuels, like wood from *Gliricidia sepium* (Jacq.) Kunth ex Walp. and *Cajanus cajan* (L.) Millsp. (pigeonpea stalks) with the off-farm fuelwood species *Mimusops obtusifolia* (Lam. Sapotaceae). Fuel performance was tested using Three-Stone Fire stoves and artisan-made Improved Cooking Stoves. We conducted 75 cooking tasks, cooking a standardized pre-defined meal with two pots in five villages in Chamwino and Kongwa districts, Dodoma region.

The Controlled Cooking Test design assessed four key performance indicators: (1) *time until water is boiling in pot A*, (2) *time until food item in pot A is ready to be consumed*, (3) *total cooking time per meal, including food items in pots A and B*, (4) *total fuel consumption per meal, including food items in pots A and B*. Compared to the off-farm fuel, on-farm fuels perform better across the four key performance indicators.

The results show that with regard to *total cooking time per meal, including food items in pots A and B* and *total fuel consumption per meal, including food items in pots A and B*, Improved Cooking Stoves used less time and fuel than Three-Stone Fire stoves. Regarding the key performance indicators *time until water is boiling in pot A* and *time until food item in pot A is ready to be consumed*, Three-Stone Fire stoves are faster than Improved Cooking Stoves, thus suggesting that Three-Stone Fire stoves are beneficial when cooking with only one pot. In order to reduce fuel and time consumption during cooking, the results suggest switching from off-farm to on-farm fuels; however, the choice of stove will depend on the cooking task performed.

Keywords: Controlled cooking test, Agroforestry, *Gliricidia sepium* (Jacq.) Kunth ex Walp., *Cajanus cajan* (L.) Millsp. (pigeonpea), *Mimusops obtusifolia* (Lam. Sapotaceae), Energy-efficiency

DOI: <https://doi.org/10.1016/j.esd.2020.10.012>

Evaluation of feed resources for local goat production under traditional management systems in Golomoti EPA Dedza and on-station at Bunda Campus, LUANAR, Malawi {Thesis and Dissertation}

Citation

Mkutche, C.D. 2020. Evaluation of feed resources for local goat production under traditional management systems in Golomoti EPA Dedza and on-station at Bunda Campus, LUANAR, Malawi. MSc thesis in Animal Science. Lilongwe: Lilongwe University of Agriculture and Natural Resources.

Abstract

The on-station study was conducted at Sakhula, Bunda College (LUANAR), and on-farm in Golomoti Extension Planning Area (EPA). The objectives of the study were to assess constraints to goat production, to assess pre-weaning body weights of local Malawi goat kids, to analyze the nutrient content of selected tree and grass fodder species and to evaluate effect of feeding goats with *Faidherbia albida* pods and *Gliricidia sepium* based supplements on feed intake, growth rate and carcass quality. The results on constraints to goat production and pre-weaning body weights of local Malawi goat kids were based on a survey of 47 and 79 sample households, respectively. In Golomoti EPA, indigenous goat type was dominant (95.74%); natural grass formed a major feed resource (57.40%); the major disease was diarrhoea (59.6%).

The majority of farmers (74.5%) had a shelter constructed for goats on the ground level and the main source of water was the river (91.5%) in wet season and (68.10%) in dry season. The on-farm flock monitoring study on birth weight, weekly body weight and pre-weaning average daily gain, used approximately 67 males and 56 females' local goats owned by farmers, to evaluate the growth performance of kids grazing on natural forages with no supplementation. The study revealed that under farm condition, average birth weight of male and female local goat kids was 3.11 ± 0.04 and 2.49 ± 0.05 kg, with pre-weaning average daily gain (ADG) of 116.78 ± 2.99 and 115.00 ± 3.39 g/day, respectively. The diets used in the feeding study were Diet 1= Grazing plus 410g maize bran (MB), Diet 2 = Grazing plus 405g *Gliricidia sepium* leaf hay plus 410g maize bran (GLM), Diet 3 = Grazing plus dry 405g *Faidherbia albida* pods plus 410g maize bran (FDM) and Diet 4 = Grazing plus 202.5g *Gliricidia sepium* leaf hay plus 202.5g dry *Faidherbia albida* pods plus 410g maize bran (GFM). Diet 1 had the lowest CP (109 ± 1.99 g/kgDM) than the rest of the diets, while Ash, NDF and ADF in supplement diets were highest in diet 4 with 65.0 ± 5.47 , 339.0 ± 9.61 and 246.0 ± 6.92 g/kg DM, respectively. For the selected common feed stuff, the mean CP content was highest with legumes and browse trees than grasses; 261.5 ± 7.5 and 57 ± 6.12 g/kgDM, respectively. NDF was highest in grasses (717 ± 18.16 g/kgDM) than in legumes (450 ± 56 g/kgDM). In the feeding trial, thirty-two intact local male goats with average initial live weight of 12-15kg, 7-8 months old were used. Eight goats were randomly allocated to each of the four diets.

The study revealed that there was a significant ($p < 0.05$) difference on daily supplement intake between diet 1 and the rest of the diets. Goats on diets 2, 3 and 4 had similar ($p > 0.05$) daily growth rate. The supplemented goats attained better skin percentage gain which were 7.57 ± 0.34 and $5.69 \pm 0.24\%$ in diet 4 and diet 2 for on-station and on-farm study than non-supplemented ones 7.15 ± 0.19 and $5.03 \pm 0.98\%$, respectively. The percentage of some GIT and viscera, like heart, spleen and kidney differed ($P < 0.05$) significantly between diets. The

pre-dissection carcass measurements and proportions of quarters were affected ($P < 0.05$) by fodder supplementation. Goats under diet 3 and diet 4 had dressing percent of 43.5 ± 0.536 and $44.38 \pm 1.8\%$ for on-station and on-farm, respectively. All in all, goats under fodder supplementation had better feed intake, growth rate, improved body condition and better carcass characteristics than unsupplemented goats.

Keywords: animal feeding; supplementary feeding; feed resources; goats; livestock

Link: <https://hdl.handle.net/10568/108504>

Gliricidia agroforestry technology adoption potential in selected dryland areas of Dodoma Region, Tanzania {Journal article}

Citation

Swamila, M., Philip, D., Akyoo, A. M., Sieber, S., Bekunda, M., and Kimaro, A. A. 2020. Gliricidia Agroforestry Technology Adoption Potential in Selected Dryland Areas of Dodoma Region, Tanzania. Agriculture.

Abstract

Declining soil fertility is one of the major problems facing producers of field crops in most dryland areas of Sub-Saharan Africa. In response to the declining soil fertility, extensive participatory research has been undertaken by the World Agroforestry (ICRAF) and smallholder farmers in Dodoma region, Tanzania. The research has, amongst others, led to the development of Gliricidia agroforestry technology. The positive impact of Gliricidia intercropping on crop yields has been established. However, information on farmers' willingness and ability to adopt the Gliricidia agroforestry technology on their farms is limited.

This study predicts the adoption of Gliricidia agroforestry and conventional mineral fertilizer use technology. Focus Group Discussions (FGDs) were conducted with groups of farmers, purposively selected based on five sets of criteria: (i) at least 2 years of experience in either trying or using Gliricidia agroforestry technology, (ii) at least 1 year of experience in either trying or using the mineral fertilizer technology (iii) at least 10 years of living in the study villages, (iv) the age of 18 years and above, and (v) sex.

The Adoption and Diffusion Outcome Prediction Tool (ADOPT) was used to predict the peak adoption levels and the respective time in years. A sensitivity analysis was conducted to assess the effect of change in adoption variables on predicted peak adoption levels and time to peak adoption. The results revealed variations in peak adoption levels with Gliricidia agroforestry technology exhibiting the highest peak of 67.6% in 12 years, and that the most influential variable to the peak adoption is the upfront cost of investing in Gliricidia agroforestry and fertilizer technologies. However, in Gliricidia agroforestry technology most production costs are incurred in the first year of project establishment but impact the long term biophysical and economic benefits. Moreover, farmers practicing agroforestry technology accrue environmental benefits, such as soil erosion control.

Based on the results, it is plausible to argue that Gliricidia agroforestry technology has a high adoption potential, and its adoption is influenced by investment costs. We recommend two actions to attract smallholder farmers investing in agroforestry technologies. First,

enhancing farmers' access to inputs at aordable prices. Second, raising farmers' awareness of the long-term environmental benefits of Gliricidia agroforestry technology.

Keywords: agroforestry; innovation adoption; soil fertility; intensification; technology transfer; drylands

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DOI: <https://doi.org/10.3390/agriculture10070306>

Global priorities of environmental issues to combat food insecurity and biodiversity loss {Journal article}

Citation

Scherer, L., Svenning, J.C., Huang, J., Seymour, C., Sandel, B., Mueller, N., and Van Bodegom, P.M. 2020. Global priorities of environmental issues to combat food insecurity and biodiversity loss. *Science of the Total Environment*, 730, 1-9.

Abstract

Various environmental challenges are rapidly threatening ecosystems and societies globally. Major interventions and a strategic approach are required to minimize harm and to avoid reaching catastrophic tipping points. Setting evidence-based priorities aids maximizing the impact of the limited resources available for environmental interventions. Focusing on protecting both food security and biodiversity, international experts prioritized major environmental challenges for intervention based on three comprehensive criteria – importance, neglect, and tractability. The top priorities differ between food security and biodiversity. For food security, the top priorities are pollinator loss, soil compaction, and nutrient depletion, and for biodiversity conservation, ocean acidification and land and sea use (especially habitat degradation) are the main concerns. While climate change might be the most pressing environmental challenge and mitigation is clearly off-track, other issues rank higher because of climate change's high attention in research. Research and policy agendas do not yet consistently cover these priorities. Thus, a shift in attention towards the high-priority environmental challenges, identified here, is needed to increase the effectiveness of global environmental protection.

Keyword: prioritization; environmental protection; agriculture; ecosystems; biodiversity; food security; biodiversity conservation; environmental factors

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DOI: <https://doi.org/10.1016/j.scitotenv.2020.139096>

Growth performance, carcass characteristics, meat quality and profitability of local Malawi goats under pen fattening conditions {Thesis and Dissertation}

Citation

Chilanga, F. 2020. Growth performance, carcass characteristics, meat quality and profitability of local Malawi goats under pen fattening conditions. MSc thesis in Animal Science. Lilongwe: Lilongwe University of Agriculture and Natural Resources.

Abstract

A study was conducted to evaluate the effect of feeding different fattening diets based on locally available non-conventional feed resources on growth performance, carcass characteristics, meat quality and profitability of local Malawi goats fattened under pen feeding. Fifty uncastrated local Malawi goat weaners (5 – 6 months old) with initial body weight of 11.55 ± 2.04 kg were divided into five groups of 10 animals each and randomly allocated to five treatment categories as follows: S = 60% Rhodes grass (*Chloris gayana*) hay + 40% soya bean (*Glycine max*)-based concentrate; SA = 60% Rhodes grass (*Chloris gayana*) hay + 40% soya bean (*Glycine max*) and white thorn tree (*Acacia polyacantha*) leaf meal-based concentrate; B= 60% Rhodes grass hay (*Chloris gayana*) + 40% baobab (*Adansonia digitata*) seedcake-based concentrate; BA= 60% Rhodes grass hay (*Chloris gayana*) + 40% baobab (*Adansonia digitata*) seedcake and white thorn tree (*Acacia polyacantha*) leaf meal-based concentrate; and C = grazing only. Animals in S, SA, B and BA were under pen feeding with total confinement for the entire 84 days trial period while those in C were under extensive management. At the end of the feeding trial, goats were slaughtered for evaluation of carcass and meat quality. Pen fed goats on baobab only-based diet had significantly higher daily gains, final weights and total weight gain, and better feed conversion ratio than the rest of the treatments ($P < 0.05$). Grazing goats had the least daily gains, carcass weight, final weight and total weight gain. Lightness (L^*) and yellowness (b^*) of the meat was higher in goats under baobab-based pen feeding diets as compared to all other diets. Goat meat from the control diet was darker than that from the rest of diets (lowest L^*). Estimated gross margins were high in grazing animals followed by baobab only-based pen feeding diet. However, baobab only-based pen feeding diet had the highest estimated net profit. Current findings indicate that pen feeding of local Malawi goats based on locally available non-conventional feed resources like baobab seedcake improves growth performance, carcass characteristics, meat quality, and profit.

Keywords: animal feeding; feed resources; supplementary feeding; goats

Growth performance, carcass characteristics, meat quality and profitability of local Malawi goats under pen fattening conditions {Thesis and Dissertation}

Citation

Chilanga. F. 2020. Growth performance, carcass characteristics, meat quality and profitability of local Malawi goats under pen fattening conditions. MSc Thesis in Anima Science. Lilongwe University of Agriculture and Natural Resources. Lilongwe. Malawi

Abstract

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Keywords: local goats, feed, pen feeding, meat quality, profitability

Link:<https://cgspace.cgiar.org/bitstream/handle/10568/108418/Frank%20Chilanga%20 MSc Thesis.pdf?sequence=1>

Improvement of smallholder farming systems in Africa {Journal article}

Citation

Wortmann, C., Amede, T., Bekunda, M., Ndung'u-Magiroyi, K., Masikati, P., Snapp, S., Stewart, Z.P., Westgate, M., Zida, Z., and Kome, C.E. 2020. Improvement of smallholder farming systems in Africa. *Agronomy Journal*

Abstract

This forum paper provides a synthesis and discussion of 14 categories of lessons learned from experiences for achieving farm-level impact with smallholder farmers in Africa. These lessons were reported in a symposium hosted by the Agronomy in Africa community of the American Society of Agronomy. The lessons, listed in order of frequency of reporting, were the need to: have adequate infrastructure and services; enable spontaneous adoption; have multi-disciplinary and institutional collaboration; build on previous adoption of good agronomic practices (GAP); have farmer participation in research; encourage and learn from smallholder adaptations; make GAP promotion demand-driven; allow GAP choices; address challenges and trade-offs to GAP adoption; enable GAP-by-GAP adoption; reconcile conflicting messages; offer adequate profit potential with acceptable risk; reduce labor needs, especially for women; and build capacity for farming system improvement along the chain from farmer to research. The lessons are discussed, and conclusions are reported.

Keywords: sustainable agriculture; agricultural practices; farming systems; intensification

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Leveraging big data for public health: Mapping malaria vector suitability in Malawi with Google Earth Engine {Journal article}

Citation

Frake, A.N., Peter, B.G., Walker, E.D. and Messina, J.P., 2020. Leveraging big data for public health: Mapping malaria vector suitability in Malawi with Google Earth Engine. *Plos one*, 15(8), p.e0235697.

Abstract

In an era of big data, the availability of satellite-derived global climate, terrain, and land cover imagery presents an opportunity for modeling the suitability of malaria disease vectors at fine spatial resolutions, across temporal scales, and over vast geographic extents.

Leveraging cloud-based geospatial analytical tools, we present an environmental suitability model that considers water resources, flow accumulation areas, precipitation, temperature, vegetation, and land cover. In contrast to predictive models generated using spatially and temporally discontinuous mosquito presence information, this model provides continuous fine-spatial resolution information on the biophysical drivers of suitability. For the purposes of this study the model is parameterized for *Anopheles gambiae* s.s. in Malawi for the rainy (December-March) and dry seasons (April-November) in 2017; however, the model may be repurposed to accommodate different mosquito species, temporal periods, or geographical boundaries. Final products elucidate the drivers and potential habitat of *Anopheles gambiae* s.s. Rainy season results are presented by quartile of precipitation; Quartile four (Q4) identifies areas most likely to become inundated and shows 7.25% of Malawi exhibits suitable water conditions (water only) for *Anopheles gambiae* s.s., approximately 16% for

water plus another factor, and 8.60% is maximally suitable, meeting suitability thresholds for water presence, terrain characteristics, and climatic conditions. Nearly 21% of Malawi is suitable for breeding based on land characteristics alone and 28.24% is suitable according to climate and land characteristics. Only 6.14% of the total land area is suboptimal. Dry season results show 25.07% of the total land area is suboptimal or unsuitable. Approximately 42% of Malawi is suitable based on land characteristics alone during the dry season, and 13.11% is suitable based on land plus another factor. Less than 2% meets suitability criteria for climate, water, and land criteria. Findings illustrate environmental drivers of suitability for malaria vectors, providing an opportunity for a more comprehensive approach to malaria control that includes not only modeled species distributions, but also the underlying drivers of suitability for a more effective approach to environmental management.

Link: <https://doi.org/10.1371/journal.pone.0235697>

Limits to grain-legume technology integration by smallholder farmers: The case of time-sensitive labor demands and food security primacy in Malawi {Journal article}

Citation

Anders, E.J., Zulu, L.C. and Jambo, E.R. 2020. Limits to grain-legume technology integration by smallholder farmers: The case of time-sensitive labor demands and food security primacy in Malawi. *Agricultural Systems* 184:102879.

Abstract

Over the last two decades, researchers and farmers have been actively co-developing soil-amelioration technologies in Malawian maize-based smallholder systems, specifically grain-legume technologies (GLT) for the purpose of sustainable intensification. Despite farmers' expressed interest and researchers' technological adaptations to reflect newly discovered on-farm constraints, farmers' adoption of these technologies remains limited, as does researchers' understanding of associated barriers. We investigate Malawian-smallholder farmers' incorporation of co-designed GLT into their maize-based systems after four years of intentional on-farm experimentation, focusing on understanding farmers' (n = 366) continued low levels of integration. We used mixed qualitative and quantitative methods within participatory action research to examine the potential effects of farmers' stated preferences and perceptions of GLT on their adoption choices. We found that farmers' adoption of GLT continues to remain low. Farmers preferred their traditional maize-dominated system to the majority of the studied GLT, for its perceived superiority in meeting farmers' food security and yield needs. Additionally, although GLT were less labor intensive than farmers' traditional maize systems in aggregate, farmers' cropping system choices prioritized food security needs and were restricted by increased labor demand during timesensitive labor tasks that have the potential to impact food security by decreasing on-farm maize production, specifically the task of planting. We identify potential entry points for future research that prioritize reducing the planting complexity of GLT in maize-dominated systems.

Keywords: adoption; intensification; farming systems; food security; smallholders; legumes

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DOI: <https://doi.org/10.1016/j.agsy.2020.102879>

Longitudinal analysis of a long-term conservation agriculture experiment in Malawi and lessons for future experimental design {Journal article}

Citation

Lark, R.M., Ligowe, I.S., Thierfelder, C., Magwero, N., Namaona, W., Njira, K., Sandram, I., Chimungu, J.G. and Nalivata, P.C. 2020. Longitudinal analysis of a long-term conservation agriculture experiment in Malawi and lessons for future experimental design. *Experimental Agriculture*

Abstract

Resilient cropping systems are required to achieve food security in the presence of climate change, and so several long-term conservation agriculture (CA) trials have been established in southern Africa – one of them at the Chitedze Agriculture Research Station in Malawi in 2007. The present study focused on a longitudinal analysis of 10 years of data from the trial to better understand the joint effects of variations between the seasons and particular contrasts among treatments on yield of maize. Of further interest was the variability of treatment responses in time and space and the implications for design of future trials with adequate statistical power.

The analysis shows treatment differences of the mean effect which vary according to cropping season. There was a strong treatment effect between rotational treatments and other treatments and a weak effect between intercropping and monocropping. There was no evidence for an overall advantage of systems where residues are retained (in combination with direct seeding or planting basins) over conventional management with respect to maize yield. A season effect was evident although the strong benefit of rotation in El Niño season was also reduced, highlighting the strong interaction between treatment and climatic conditions.

The power analysis shows that treatment effects of practically significant magnitude may be unlikely to be detected with just four replicates, as at Chitedze, under either a simple randomised control trial or a factorial experiment. Given logistical and financial constraints, it is important to design trials with fewer treatments but more replicates to gain enough statistical power and to pay attention to the selection of treatments to give an informative outcome.

Keywords: intensification; climate change; sustainable agriculture; conservation agriculture; experimental design

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DOI: <https://doi.org/10.1017/S0014479720000125>

Maize-Pigeonpea Intercropping Outperforms Monocultures Under Drought {Journal article}

Citation

Renwick, L.L.R., Kimaro, A.A, Hafner, J.M., Rosenstock, T.S. and Gaudin, A.C.M. 2020. Maize-pigeonpea intercropping outperforms monocultures under drought. *Front. Sustain. Food Syst.* 4:562663.

Abstract

There is an urgent need to develop resilient agroecosystems capable of helping smallholder farmers adapt to climate change, particularly drought. In East Africa, diversification of maize-based cropping systems by intercropping with grain and tree legumes may foster productivity and resilience to adverse weather conditions. We tested whether intercropping enhances drought resistance and crop and whole-system yields by imposing drought in monocultures and additive intercrops along a crop diversity gradient—sole maize (*Zea mays*), sole pigeonpea (*Cajanus cajan*), maize-pigeonpea, maize-gliricidia (*Gliricidia sepium*, a woody perennial), and maize-pigeonpea-gliricidia—with and without fertilizer application. We developed and tested a novel low-cost, above-canopy rainout shelter design for drought experiments made with locally sourced materials that successfully reduced soil moisture without creating sizeable artifacts for the crop microenvironment. Drought reduced maize grain yield under fertilized conditions in some cropping systems but did not impact pigeonpea grain yield. Whole-system grain yield and theoretical caloric and protein yields in two intercropping systems, maize-pigeonpea and maize-gliricidia, were similar to the standard sole maize system. Maize-pigeonpea performed most strongly compared to other systems in terms of protein yield. Maize-pigeonpea was the only intercrop that consistently required less land than its corresponding monocultures to produce the same yield (Land Equivalent Ratio >1), particularly under drought. Despite intercropping systems having greater planting density than sole maize and theoretically greater competition for water, they were not more prone to yield loss with drought. Our results show that maize-pigeonpea intercropping provides opportunities to produce the same food on less land under drought and non-drought conditions, without compromising drought resistance of low-input smallholder maize systems.

Keywords:

Link: <https://www.frontiersin.org/articles/10.3389/fsufs.2020.562663/full>

On-station and on-farm evaluation of fodder tree resources for local goats production under extensive management systems in Malawi {Journal article}

Citation

Mkhutche, C.A. 2020. On-station and on-farm evaluation of fodder tree resources for local goats production under extensive management systems in Malawi. MSc Thesis I Anima Science. Lilongwe University of Agriculture and Natural Resources. Lilongwe. Malawi

Abstract

The study was set to identify constraints of goat production, monitoring pre-weaning growth performance of goats and evaluating supplementation of intact male Malawian goats with fodder tree resources (*Faidherbia albida* pods and *Gliricidia sepium* hay). To identify constraints to goat production, a structure questionnaire was administered to capture information on common diseases, available feed resources, types of goat housing in Golomoti Extension Planning Area (EPA). To study preweaning growth performance, 145 kids from 47 households in one cluster with common grazing area in Golomoti EPA were monitored from birth to 8 weeks of age. Two feeding experiments were done one on-farm (Golomoti) and other on-station (Bunda College) to evaluate effects of supplementing locally available protein supplements. In both experiments intact male goats on grazing were randomly allocated to three local protein supplements; (1) 50:50 *Gliricidia sepium* leaf hay to maize bran; (2) 50:50 *Faidherbia albida* pods to maize bran; and (3) 25:25:50 *Gliricidia sepium* leaf hay to *Faidherbia albida* pods to maize. The experiments on-farm and on-station used 48 and 24 goats, respectively and lasted for 60 days. More than half of the farmers reported that diarrhoea was the major disease in Golomoti EPA. The main source of feed resource in the dry season was natural pastures. Ground level goat pens constituted (74.5 % of the respondents) of the goat pen in Golomoti. There was an interactive effect of birth type, sex and parity on birth weight ($P < 0.05$). The heaviest kids were obtained from male born at third parity and singly ($P < 0.05$). However, there was no interactive effect of birth type, sex and parity at weight of kids at 8 weeks old and average daily gain. Goats fed supplement containing 25:25: 50 *Gliricidia* leaf hay to *Faidherbia* pods to maize bran was superior on average daily gain, pre-dissection measurement and proportions of quarters ($P < 0.05$).

Key words: *Faidherbia*, *gliricidia*, goats, local, Malawi

Link

Participation in and gains from traditional vegetable value chains: A gendered analysis of perceptions of labour, income and expenditure in producers' and traders' households {Journal article}

Citation

Fischer, G., Patt, N., Ochieng, J. and Mvungi, H. 2020. Participation in and gains from traditional vegetable value chains: A gendered analysis of perceptions of labour, income and expenditure in producers' and traders' households. European Journal of Development Research

Abstract

Horticulture is one of the fastest growing subsectors of agriculture in Tanzania. Gender relations in vegetable-producing and vegetable-trading households need to be understood to make value chain development equitable. This study, carried out in northern and central Tanzania, is based on data from surveys, focus group discussions and semi-structured interviews. The perceptions of men and women traders and producers are investigated with regard to labour participation in traditional vegetable value chains and gains (income and expenditure) from it. Farmers were found to report more balanced intra-household labour arrangements paired with less-balanced income and expenditure shares, while traders indicated less-balanced labour contributions that went hand in hand with more-balanced shares of benefits. Farmers related limited household development not only to imbalances in benefits but also to a lack of trust and cooperation between spouses. The importance of gender-transformative approaches in agricultural value chains is emphasized herein.

Keywords: gender; vegetables; labour; farming systems; intensification; horticulture; value chains

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Productivity or stability? Exploring maize-legume intercropping strategies for smallholder Conservation Agriculture farmers in Zimbabwe {Journal article}

Citation

Madembo, C., Mhlanga, B. and Thierfelder, C. 2020. Productivity or stability? Exploring maize-legume intercropping strategies for smallholder Conservation Agriculture farmers in Zimbabwe. *Agricultural Systems* 185:102921.

Abstract

Increasing threats of climate change and soil fertility decline enhance the risk of crop failure for smallholder farmers in southern Africa. The quest is to find cropping systems that provide yield stability while being sustainable. One of the strategies to use is intercropping legumes in maize-based Conservation Agriculture systems. Here, we present results of a three-year study in on-farm and on-station trials of Zimbabwe. We tested sole cropping compared to intercropping with different grain legumes and green manures as well as fertilizer application (in the case of on-station trials) on associated crop yields, total system yield, and yield stability. As methods, we used mixed modelling, best linear unbiased

predictors estimation and additive main effects and multiplicative interaction analysis to analyse the data.

The results show that intercropping systems with the selected legumes resulted in yield penalties. However, on-station sites showed maize/pigeonpea intercropping to be comparable to the sole maize in maize grain and biomass yield and to be superior in total system yield (108 GJ ha⁻¹ vs. 74 GJ ha⁻¹). Comparison of intercropping against sole cropping revealed that sole maize out-yielded all intercropping strategies in all environments on-farm while the maize/pigeon intercropping strategy out-yielded sole maize in almost all environments on-station. In general, total system yield of intercrops out-yielded sole maize in most environments signifying the ability of intercrops to enhance cropping system yields. Stability analysis on-farm showed that intercropping with cowpea and jack bean was more stable compared to sole maize as a result of better systems performance across the environments. On-station, the maize/pigeonpea intercropping strategy was in general the most stable. We conclude that intercropping is a viable option for smallholder farmers. However, there is need to investigate other crop arrangements to reduce competition for both maize and the intercrop and double-row strip cropping may be an option.

Keywords: mixed farming; maize; legumes; farming systems; intensification; sustainable intensification; green manures; intercropping

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Realizing Inclusive SAI: Contextualizing indicators to better evaluate gender and intergenerational inequity in SAI processes and outcomes - Cases from Southern and Western Africa {Journal article}

Citation

Zulu, L., Djenontin, I.N.S., Darkwah, A., Kamoto, J., Kampanje-Phiri, J., Fischer, G., Grabowski, P. and Egyir, I. 2020. Realizing Inclusive SAI: Contextualizing indicators to better evaluate gender and intergenerational inequity in SAI processes and outcomes—Cases from Southern and Western Africa. *International Journal of Agricultural Sustainability*

Abstract

Despite increasing sustainable agricultural intensification (SAI) investments, indicators for detecting gender and intergenerational inequities in SAI costs and benefits sharing often remain overgeneralized, theoretical, or locally irrelevant. We examine the relative value of, and how to, customize standard SAI indicators to detect such inequities in specific socio-cultural contexts to enhance data collection for evidence-based decision making in fostering gender/youth inclusive SAI. Using focus-group discussions and key informant interviews among farmers and diverse government, NGO, private sector, and academic stakeholders in two districts in Malawi and three in Ghana, we assess the perceived roles, differentiated needs/ priorities of men, women and youth, and the sharing of SAI burdens and benefits within farming households. We investigate what context-appropriate questions to ask, to whom, and how, to collect reliable information on indicators of SAI investment inequities. Results illuminate context-specific, gendered and intergenerational factors shaping access to and ownership of productive resources, household decision making, SAI participation, and appropriateness of selected indicators. Combining farmers' and local field-expert' perspectives offers practical insights for customizing inequity indicators. Findings highlight

advantages of local contextualization of SAI indicators, including insights on appropriate data-collection approaches that challenge orthodox survey/quantitative methods for detecting and assessing gender/age inequities to foster inclusive SAI.

Keywords: Sustainable agricultural intensification (SAI); gender inequity; youth inequity; participatory contextualization; SAI indicators; Malawi; Ghana

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Sustainable agricultural intensification and gender-biased land tenure systems: An exploration and conceptualization of interactions {Journal article}

Citation

Fischer, G., Darkwah, A., Kamoto, J., Kampanje-Phiri, J., Grabowski, P. and Djenontin, I.N.S. 2020. Sustainable agricultural intensification and gender-biased land tenure systems: An exploration and conceptualization of interactions. *International Journal of Agricultural Sustainability*

Abstract

How does sustainable agricultural intensification's (SAI) tenet of increased productivity on the same area of land relate to prevailing gender-biased land tenure systems? How can one conceptualize the interactions between intensified land use and control over land, labour, crops and benefits – and how can equitable outcomes be facilitated? These questions (which have not yet received sufficient attention in SAI research) are explored in this study using a qualitative methodology and a gender transformative approach. Semi-structured interviews and focus group discussions with a total of 248 respondents were conducted in matrilineal and patrilineal intensification contexts in Ghana and Malawi. We develop a conceptual framework that extends Kabeer's institutional analysis to include gender implications of SAI. Selected cases reveal how farmers and key actors link land-use intensification to existing land-related institutions with diverse outcomes. We conclude that SAI interventions should adopt gender-transformative approaches. These facilitate equitable outcomes by supporting consensus-based institutional changes and creating positive synergies between multiple scales.

Keywords: gender; gender analysis; land; land resources; land ownership

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Quality and storability of common beans in small-holders farm stores in Northern Tanzania: A multivariate analysis of agro-location, variety, and storage method effects {Journal article}

Citation

Mutungi, C., Chamwilambo, M., Masanja, S., Massam, C., Wayda, P., Tungu, J., Gaspar, A., Bekunda, M. and Abass, A. 2020. Quality and storability of common beans in small-holders farm stores in northern Tanzania: A multivariate analysis of agro-location, variety, and storage method effects. *Journal of Stored Products Research* 89:101723.

Abstract

Incessant interactions between biotic and abiotic factors affect the physical quality of harvested, stored, and marketed beans. We investigated the interactions between variety and method of storage on the quality of harvested and stored beans in four contrasting agro-locations. Focus group discussions identified three varieties - a local speckled purple variety (Sp), and two improved ones: oval-shaped yellow (Oy) and round-shaped yellow (Ry), preferred by farmers for different reasons. Moisture, mechanical damage, bruchid infestation, bruchid damage, moldy/disease/discoloration (MDD), shriveling, impurities, and weight loss were analyzed at harvest and during storage in woven polypropylene (PP) or air-tight PICS bags. The average overall damage at harvest exceeded the limits set by local standards 2–3-fold, and the effect of variety was significant. The total damage of Ry (11.9 ± 0.7) surpassed that of Sp and Oy by factors of 2.8 and 2.5, respectively. Furthermore, the mean pre-storage bruchid infestation of Ry (1.4 Log counts/kg) surpassed Sp and Oy infestations by factors of 1.5 and 15, respectively. In storage, the quality was also dependent on variety. In the PP bags, the varietal differences were evident in all the attributes except MDD and insect damage, and the interaction between variety and location was significant on bruchid counts and bruchid damage. Variety Ry suffered more bruchid damage across all locations while Sp was attacked more in the cooler/humid agro-locations, compared to Oy, which was attacked more in the warmer/drier locations. With PICS bags, the varieties differed on the overall weight loss (Ry: $8.5 \pm 4.1\%$, Sp: $2.3 \pm 0.4\%$, Oy: $2.9 \pm 2.7\%$). Results suggest that the air-tight storage bags are not suitable for some bean varieties. Further, careful pre-storage handling, and sorting for quality improvement, and actions to disinfest the beans before bagging need emphasis. In this regard, the cooler/humid agro-locations require closer attention.

Keywords: food production; food losses; markets; grain legumes; smallholders

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DOI: <https://doi.org/10.1016/j.jspr.2020.101723>

Unlocking maize crop productivity through improved management practices in Northern Tanzania {Journal article}

Citation

Kihara J.; Kizito F.; Jumbo M.; Kinyua M.; Bekunda, M. 2020. Unlocking maize crop productivity through improved management practices in Northern Tanzania. African Journal of Food, Agriculture, Nutrition & Development 20(7) p. 17095-17112. ISSN: 1684-5374

Abstract

Addressing the problem of low crop productivity and food insecurity can be accelerated through community-centered implementation of good agricultural management practices. This study was conducted in Babati, Northern Tanzania. The objective of the study was to determine nitrogen (N) and phosphorus (P) application requirements for maize, and demonstrate economically viable best bet yield-improving management technologies under three ecozones namely; 'low elevation low rainfall', 'medium elevation high rainfall' and 'medium elevation low rainfall' ecozone. Two sets of trials were conducted: N (0, 45, 90, 120 and 150 kg ha⁻¹) and P (0, 15, 30, 40 kg ha⁻¹) response trials in 16 representative fields in three seasons of 2013/14, 2014/2015 and 2015/16 and demonstration trials in 8 farmer-selected fields in 2015/16 season. Combined N and P application increased maize yields by 32 to 62% over single nutrient applications. In the medium elevation low rainfall ecozone, 60-86% yield response to nitrogen was observed. Largely, modest applications of 50 kg N ha⁻¹ and 20 kg P ha⁻¹ resulted in profitable (marginal rate of return (MRR) of 2.4 to 3.0) yield increases of up to 214% over the farmers practice (unfertilized), varying with variety and ecozone. The source of P (DAP or Minjingu Mazao) had little influence on maize productivity except under low altitude low rainfall where Minjingu Mazao is unprofitable. Farmer rankings and agronomic indices showed new maize hybrids namely Meru H513, Meru H515, and SC627 as a priority across the ecozones; Mams H913 is suitable mainly in medium elevation low rainfall ecozone. The conclusion is that the use of new maize hybrids and appropriate rates of locally available N and P nutrient sources can bridge existing yield gaps and reduce food insecurity. Technologies from community-driven research in development are easily adopted by a large number of farmers and could result in quick, yet lasting productivity gains

Keywords: Phosphorus sources, ecozones, profitability, farmer preferences, innovation

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Why we should rethink 'adoption' in agricultural innovation: Empirical insights from Malawi {Journal article}

Citation

Hermans, T.D.G., Whitfield, S., Dougill, A.J. and Thierfelder, C. 2020. Why we should rethink 'adoption' in agricultural innovation: Empirical insights from Malawi. Land Degradation and Development

Abstract

The challenges of land degradation, climate change and food insecurity have led to the introduction of conservation agriculture (CA) aimed at enhancing yield and soil quality. Despite positive biophysical results, low adoption rates have been the focus of studies identifying constraints to wider uptake. While the adoption framework is popular for measuring agricultural innovation, objective adoption measurements remain problematic and do not recognize the contextual and dynamic decision-making process. This study uses a technographic and participatory approach to move beyond the adoption framework and understand: (a) how agricultural decision-making takes place including the knowledge construction, (b) how agriculture is performed in a context of project intervention and (c) how practice adaptation plays out in the context of interacting knowledge. Findings confirm that farmer decision-making is dynamic, multidimensional and contextual. The common innovation diffusion model uses a theory of change, showcasing benefits through training lead farmers as community advocates and demonstration trials. Our study shows that the assumed model of technology transfer with reference to climate-smart agriculture interventions is not as linear and effective as assumed previously. We introduce four lenses that contribute to better understanding complex innovation dynamics: (a) social dynamics and information transfer, (b) contextual costs and benefits, (c) experience and risk aversion, and (d) practice adaptation. Investments should build on existing knowledge and farming systems including a focus on the dynamic decision process to support the 'scaling up, scaling out and scaling deep' agenda for sustainable agricultural innovations.

Keywords: climate-smart agriculture; agriculture; innovation systems

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Year 2019

A Bayesian analysis of longitudinal farm surveys in Central Malawi reveals yield determinants and site-specific management strategies {Journal article}

Citation

Wang, H., Snapp, S.S., Fisher, M. and Viens, F. 2019. A Bayesian analysis of longitudinal farm surveys in Central Malawi reveals yield determinants and site-specific management strategies. PLoS ONE 14(8): e0219296.

Abstract

Understanding the challenges to increasing maize productivity in sub-Saharan Africa, especially agronomic factors that reduce on-farm crop yield, has important implications for policies to reduce national and global food insecurity. Previous research on the maize yield gap has tended to emphasize the size of the gap (theoretical vs. achievable yields), rather than what determines maize yield in specific contexts. As a result, there is insufficient evidence on the key agronomic and environmental factors that influence maize yield in a smallholder farm environment.

In this study, we implemented a Bayesian analysis with plot-level longitudinal household survey data covering 1,197 plots and 320 farms in Central Malawi. Households were interviewed and monitored three times per year, in 2015 and 2016, to document farmer management practices and seasonal rainfall, and direct measurements were taken of plant and soil characteristics to quantify impact on plot-level maize yield stability. The results revealed a high positive association between a leaf chlorophyll indicator and maize yield, with significance levels exceeding 95% Bayesian credibility at all sites and a regression coefficient posterior mean from 28% to 42% on a relative scale. A parasitic weed, *Striga asiatica*, was the variable most consistently negatively associated with maize yield, exceeding 95% credibility in most cases, of high intensity, with regression means ranging from 23% to 38% on a relative scale. The influence of rainfall, either directly or indirectly, varied by site and season.

We conclude that the factors preventing *Striga* infestation and enhancing nitrogen fertility will lead to higher maize yield in Malawi. To improve plant nitrogen status, fertilizer was effective at higher productivity sites, whereas soil carbon and organic inputs were important at marginal sites. Uniquely, a Bayesian approach allowed differentiation of response by site for a relatively modest sample size study (given the complexity of farm environments and management practices). Considering the biophysical constraints, our findings highlight management strategies for crop yields, and point towards area-specific recommendations for nitrogen management and crop yield.

Keywords: intensification; agronomy; farming systems; crop yield; yield gap

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A cost-benefit analysis of climate-smart agriculture options in southern Africa: Balancing gender and technology {Journal article}

Citation

Mutenje, M.J., Farnworth, C.R., Stirling, C., Thierfelder, C., Mupangwa, W. and Nyagumbo, I. 2019. A cost-benefit analysis of climate-smart agriculture options in Southern Africa: Balancing gender and technology. *Ecological Economics* 163: 126–137.

Abstract

Climate change and extreme weather events undermine smallholder household food and income security in southern Africa. Climate Smart Agriculture (CSA) technologies comprise a suite of interventions that aim to sustainably increase productivity whilst helping farmers adapt their farming systems to climate change and to manage risk more effectively. Cost-benefit analysis (CBA) and a mixed methods approach were used to assess the likelihood of investment in various CSA technology combinations. The data were drawn respectively from 1440, 696, and 1448 sample households in Malawi, Mozambique, and Zambia, covering 3622, 2106 and 5212 maizelegume plots in these countries over two years. The cost-benefit analysis and stochastic dominance results showed that CSA options that combined soil and water conservation management practices based on the principles of conservation agriculture (CA), improved varieties, and associations of cereal-legume crop species were economically viable and worth implementing for risk averse smallholder farmers. A dynamic mixed multinomial logit demonstrated that women's bargaining power, drought shock, and access to CSA technology information positively influenced the probability of investing in CSA technology combinations. This study provides evidence of the importance of cultural context, social relevance, and intra-household decision-making in tailoring suitable combinations of CSA for smallholder farmers in southern Africa.

Keywords: gender; decision making; climate-smart agriculture; cost benefit analysis; technology; women

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DOI: <https://doi.org/10.1016/j.ecolecon.2019.05.013>

Agro-ecological options for fall armyworm (*Spodoptera frugiperda* JE Smith) management: Providing low-cost, smallholder friendly solutions to an invasive pest {Journal article}

Citation

Harrison, R.D., Thierfelder, C., Baudron, F., Chinwada, P., Midega, C., Schaffner, U. and Van den Berg, J. 2019. Agro-ecological options for fall armyworm (*Spodoptera frugiperda* JE Smith) management: Providing low-cost, smallholder friendly solutions to an invasive pest. *Journal of Environmental Management* 243:318–330.

Abstract

Fall armyworm (FAW), a voracious agricultural pest native to North and South America, was first detected on the African continent in 2016 and has subsequently spread throughout the continent and across Asia. It has been predicted that FAW could cause up to \$US13 billion per annum in crop losses throughout sub-Saharan Africa, thereby threatening the livelihoods

of millions of poor farmers. In their haste to respond to FAW governments may promote indiscriminate use of chemical pesticides which, aside from human health and environmental risks, could undermine smallholder pest management strategies that depend to a large degree on natural enemies.

Agro-ecological approaches offer culturally appropriate low-cost pest control strategies that can be readily integrated into existing efforts to improve smallholder incomes and resilience through sustainable intensification. Such approaches should therefore be promoted as a core component of integrated pest management (IPM) programmes for FAW in combination with crop breeding for pest resistance, classical biological control and selective use of safe pesticides. Nonetheless, the suitability of agro-ecological measures for reducing FAW densities and impact need to be carefully assessed across varied environmental and socio-economic conditions before they can be proposed for wide-scale implementation. To support this process, we review evidence for the efficacy of potential agro-ecological measures for controlling FAW and other pests, consider the associated risks, and draw attention to critical knowledge gaps.

The evidence indicates that several measures can be adopted immediately. These include (i) sustainable soil fertility management, especially measures that maintain or restore soil organic carbon; (ii) intercropping with appropriately selected companion plants; and (iii) diversifying the farm environment through management of (semi)natural habitats at multiple spatial scales. Nevertheless, we recommend embedding trials into upscaling programmes so that the costs and benefits of these interventions may be determined across the diverse biophysical and socio-economic contexts that are found in the invaded range.

Keywords: Biodiversity Biological control, Climate smart agriculture, Conservation agriculture, CornIPM Push-pull, Natural enemies, No-till Sustainable development, Sustainable land management

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Diversifying conservation agriculture and conventional tillage cropping systems to improve the wellbeing of smallholder farmers in Malawi {Journal article}

Citation

TerAvesta, D., Wandschneiderb, P.R., Thierfelderc, C. and Reganolda, J.P. 2019. Diversifying conservation agriculture and conventional tillage cropping systems to improve the wellbeing of smallholder farmers in Malawi. *Agricultural Systems* 171:23-35.

Abstract

Food production and the wellbeing of smallholder farmers are constrained by their limited financial resources, poor market access, and inadequate institutional support in southern and eastern Africa. Conservation agriculture (CA)—minimal soil disturbance, year-round ground cover, and diverse crop rotations—is being promoted to sustainably boost crop production, increase household income, and diversify diets for better nutrition. In this study, three cropping systems—continuous no-till maize, CA rotation, and conventional tillage rotation—were established on smallholder farms in the Nkhotakota and Dowa districts, two distinct agroecological zones in Malawi. Diverse three-year crop rotations in CA and conventional tillage systems included the alternative food crops sweet potato and cassava

and the grain legumes common bean, soybean, cowpea, and pigeonpea. The effects of cropping system on labor use and financial returns, which served as a rough indicator of feasibility and farmer wellbeing, were analyzed for three years from 2011 to 2014.

Over the three years of the study, continuous no-till maize produced the greatest gross and net revenues, despite also having greater production costs than CA and conventional systems. Although substantially less profitable than continuous no-till maize, the diversified CA and conventional tillage rotations were profitable for smallholder farmers, partially due to lower production costs. Sensitivity analysis was used to test the robustness of each cropping system under varying labor, input, and output price scenarios. Altering farmgate prices had the greatest impact on profitability, regardless of the crop grown.

The input and output prices for maize were stable over the course of the study so that continuous no-till maize was the most robust cropping system. In contrast, high input cost and output price variability for alternative crops increased risk compared to maize, which may reduce their appeal to smallholder farmers. Reducing the risk of conservation agriculture rotations could provide smallholder farmers with more diversified diets and greater ecosystem services, such as greater rainwater infiltration and storage to withstand dry spells. Based on the results of this study, policies that reduce input price variability and increase farmgate prices of alternative food crops would have the greatest impact on the adoption of diverse crop rotations in Malawi.

Keywords: Conservation agriculture, Crop rotation, Smallholder wellbeing, Tillage, Residue retention

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DOI: <https://doi.org/10.1016/j.agsy.2019.01.004>

Effects of maize residue and mineral nitrogen applications on maize yield in conservation-agriculture-based cropping systems of Southern Africa {Journal article}

Citation

Mupangwa, W., Thierfelder, C., Cheesman, S., Nyagumbo, I., Muoni, T., Mhlanga, B., Mwila, M., Sida, T. and Ngwira, A., 2019. Effects of maize residue and mineral nitrogen applications on maize yield in conservation-agriculture-based cropping systems of Southern Africa. *Renewable Agriculture and Food Systems*, 1-14.

Abstract

Conservation agriculture (CA) and no-till (NT)-based cropping systems could address soil degradation and fertility decline in southern Africa. A multi-location and multi-year experiment was carried out between 2008 and 2014 to assess the effects of different levels of maize residue biomass (0, 2, 4, 6 and 8 t ha⁻¹) and nitrogen (N) fertilizer (0, 30, 90 kg ha⁻¹) on maize performance under no-tillage. In some sites, different (N) fertilizer levels were superimposed to test their effects on maize grain yield and leaf chlorophyll content under different maize residue biomass levels. The different residue levels had no significant effect on maize yield in most growing seasons. Maize residue cover increased grain yield in eight out of 39 site-years across the sites used. However, in some sites, maize yield decreased with increases in residue level in cropping seasons that had average to above average rainfall. At a few sites maize yield increased with increase in residue level.

Seasonal rainfall pattern influenced the effect of different residue levels on grain yield at most sites. Nitrogen fertilizer increased maize yield regardless of the residue level applied. This study demonstrates that mulching with maize residues in CA/NT systems results in limited maize yield gains – at least within the first 6 years in different agro-ecological conditions of southern Africa.

Keywords: farming systems; crop residues; intensification; sustainable agriculture

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DOI: <https://doi.org/10.1017/S174217051900005X>

Effective communication for disseminating soil and water management practices to bring about sustainable smallholder agriculture in Tanzania: Case study of Manyara and Dodoma regions {Thesis}

Citation

Ndibalema, G. 2019. Effective communication for disseminating soil and water management practices to bring about sustainable smallholder agriculture in Tanzania: Case study of Manyara and Dodoma regions. MSc Communication, Health and Life Sciences. Wageningen, Netherlands: Wageningen University and Research Centre.

Abstract

This study investigated effective communication for disseminating soil and water management (SWM) practices for sustainable smallholder agriculture. Higher uncertainties in precipitation and land degradation are potentially the most limiting reasons for poor performance of rainfed agricultural sectors in Tanzania. Despite the increased focus on sustainable intensification of African agriculture and an increase of agricultural innovations with potential to alleviate these, adoption by smallholder farmers is slow. This includes soil and water management practices designed to minimize land degradation and increase productivity which few farmers implement. Studies note that although researchers generate good technologies, the lack of appropriate communication strategies, tools and methodologies lead to poor extension information and technologies resulting in low adoption of the innovations. Therefore, to find a solution to this problem, this study was guided by four research questions: 1) How is the communication flow between stakeholders through channels for disseminating SWM practices? 2) What are the common and preferred communication channels in disseminating SWM practices? 3) What are the motivations for using the communication channels in disseminating SWM practices? 4) How can the communication on disseminating of SWM practices be improved to support sustainable agriculture? The study was conducted in Kongwa District in Dodoma Region and Babati District, Manyara Region of Tanzania.

A net-map tool, questionnaires and semi structured interviews were used to collect both qualitative and quantitative data for this study. Mass media and interpersonal communication are used in disseminating SWM practices information to farmers in Babati and Kongwa districts. But farmers preferred interpersonal channels as sources of SWM information including from extension officers, researchers, fellow farmers, village meetings and mobile phones. The preference was because these channels are not only informative compared to mass media but they are interactive and inclusive, which gives farmers the opportunity for giving feedback on the information disseminate. This influences farmers to not only get information but also trigger their learning and adoption of the innovation.

Agricultural exhibition events should be organised at village or ward levels to provide practical backstops against which the experts can deliver information and knowledge to farmers, and give opportunity to farmers to access knowledge. It will be helpful to increase the number of extension officers who will facilitate effective communication and dissemination of the information as they seem to be an important link for interpersonal between farmers and other agricultural stakeholders.

Keywords: SWM, practices, communication, dissemination, effectiveness, channels, knowledge, information, adoption

Link: <https://hdl.handle.net/10568/101928>

Exploring the profitability of improved storage technologies and their potential impacts on food security and income of smallholder farm households in Tanzania {Journal article}

Citation

Kotu, B.H., Abass, A., Hoeschle-Zeledon, I., Mbwambo, H. and Bekunda, M. 2019. Exploring the profitability of improved storage technologies and their potential impacts on food security and income of smallholder farm households in Tanzania. *Journal of Stored Products Research* 82, 98-109.

Abstract

This study assesses the profitability of selected improved grain storage technologies and the potential impact of their adoption on food security and income of smallholder maize producers in Tanzania. We used on-farm experiment data, time series maize price data, and household survey data to address the objectives. For the improved technologies, we considered Purdue Improved Crop Storage (PICS) bags, metallic silos of different sizes, and polypropylene (PP) bags treated with Actellic Super[®]. We compared them with PP bags without insecticide treatment as the control. Results show that PICS bags and PP bags plus Actellic Super are profitable in all locations and not significantly different. While the feasible period varies by location, profit is most likely negative if farmers sell their maize in the first two months after harvest and in the last two months before the next harvest. There are mixed results with regards to the profitability of metallic silos; bigger silos are profitable for farmers who have economies of scale to use them while smaller ones are profitable only within the context of higher grain price and bigger seasonal price gap. The results also show that PICS bags (or PP bags plus Actellic Super) are useful to address food security and income objectives among poor rural households whereas metallic silos with bigger storage capacity can increase the income of those farmers who have bigger surplus grain to sale.

Keywords: maize; postharvest technology

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DOI: <https://doi.org/10.1016/j.jspr.2019.04.003>

From plot to scale: Ex-ante assessment of conservation agriculture in Zambia {Journal article}

Citation

Komarek, A.M., Kwon, H., Haile, B., Thierfelder, C., Mutenje, M.J. and Azzarri, C. 2019. From plot to scale: ex-ante assessment of conservation agriculture in Zambia. *Agricultural Systems* 173: 504-518.

Abstract

This study combined bottom-up and top-down approaches to assess the ex-ante effects of conservation agriculture (CA)-based systems in Zambia considering both biophysical and economic factors and prevailing farm systems characteristics. For continuous maize cropping we compared a CA-based system of no-tillage with crop residue retention to a control system of conventional tillage with crop residue removal. First, we simulated yield effects that were calibrated and evaluated against multiple datasets, including on-farm agronomic trials from two seasons and six sites. Next, we extrapolated our simulations to all maize-growing areas in Zambia using gridded climate and soil datasets. Then simulated yields (in kg ha⁻¹) were combined with economic data from a nationally representative household survey to construct economic indicators including benefit-cost ratios (based on gross benefits and variable costs both in \$ ha⁻¹) that captured the implicit value of crop residues and labor demands. The field scale (per ha) indicators were scaled out using harvested areas as an expansion factor. All indicators were calculated over 3-, 10-, and 20-year simulation periods using an interpolated sequence of historical climate data. Finally, we conducted a spatial farm typology analysis to help understand the spatial variation in our field-scale indicators and provide insights into trade-offs and the suitability of CA-based systems for farmers. Average changes in yield from using CA-based systems (compared with the control) at the district scale ranged from -37% to 70% (average 33%), with a similar range of changes in benefit-cost ratios once economic factors were included, in addition to intra-district yield variability. Combining the changes in benefit-cost ratios with maize harvested area resulted in an average annual change in district-scale net benefit ranging from US \$ - 3.9 to US \$9.9 million (with an average of US \$1.1 million). The heterogeneity in biophysical and economic factors gave a ranking of provinces different according to biophysical or economic indicators, reinforcing the importance of coupling biophysical and economic approaches. The spatial farm typology analysis highlighted the specific contexts of farmers relevant to the suitability of CA, such as their mineral fertilizer applications rates, ownership of livestock, and prevailing soil texture and rainfall.

Keywords: farming systems; agriculture; intensification; impact assessment; livestock; mixed farming

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DOI: <https://doi.org/10.1016/j.agsy.2019.04.001>

Legume diversification and weed management in African cereal-based systems {Journal article}

Citation

Silberg, R.T., Chimonyo, V.G.P., Richardson, R.B., Snapp, S.S. and Renner, K. 2019. Legume diversification and weed management in African cereal-based systems. *Agricultural Systems* 174:83-94

Abstract

Weed abundance in cereal-based systems has increased in recent years across sub-Saharan Africa for smallholder farmers (cultivating less than two hectares). Smallholders can employ numerous practices to control weeds such as intercropping cereal crops with legumes. We conducted a review to identify the possible mechanisms responsible for weed control according to legume species, weed species and agroecosystem. In the review, we first present common weed species found in specific agroecological contexts. Then, we propose several legume intercrops that provide some control of these species and the reasons why. Finally, we highlight possible social and biophysical tradeoffs for cultivating legumes as a weed control practice in smallholder cereal systems. The review found that while many studies explained the effect a certain legume-intercrop had upon weeds (e.g., emergence rates), few identified the mechanism or mechanisms (e.g., increased predation) behind their control. Without understanding these mechanisms, it is difficult to propose management recommendations for intercropping (e.g., seeding rates). Furthermore, few studies have investigated how legume intercrops affect multiple components of farming systems, including the smallholders that cultivate them. Determining how these components connect and impose tradeoffs for smallholders unveils the drivers (or barriers) behind legume intercropping as a weed control practice.

Keywords: legumes; maize; intercropping; weeds; smallholders

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DOI: <https://doi.org/10.1016/j.agsy.2019.05.004>

Maize response to leguminous biomass composted with phosphate rocks in the northern zone of Tanzania {Journal article}

Citation

Shitindi, M., Kpomblekou-A, K., McElhenney, W.H., Ankumah, R., Semoka, J., Bekunda, M. and Bonsi, C. 2019. Maize response to leguminous biomass composted with phosphate rocks in the northern zone of Tanzania. *Journal of Experimental Agriculture International*, 35(4), 1-15.

Abstract

A study was conducted to evaluate maize response to leguminous biomass composted with phosphate rocks (PRs) in a split plot design. Field experiments were conducted at Wang'waray Farmers Training Center (F.T.C) located in Babati District of Manyara region in the Northern zone of Tanzania between December 2013 and June 2015. Three leguminous (*Crotalaria juncea*, *Lablab purpureus* and *Mucuna pruriens*) strips were cultivated in 2013/14 to produce a biomass which was harvested at flowering to early podding stage and air dried. Air-dry biomass was composted with PRs from Minjingu (medium reactive PR) and Panda Hill (low reactive PR). Maize response to different treatments was evaluated across the field

strips in 2014/15 season. The strips previously used to produce leguminous biomass were used as main plots and each strip was divided into seven subplots receiving different treatments at random. A medium-term maize variety SC. 627 was used as a test crop. Average maize grain yields obtained from *Crotalaria*, *Lablab* and *Mucuna* strips reached 5.3, 4.5 and 4.0 t ha⁻¹, respectively and were statistically different (P=.05). Application of Minjingu or Panda Hill PR alone didn't increase maize grain yield above the control while Minjingu PR applied with urea or composted with biomass increased maize grain yield by 2.40 and 1.58 t ha⁻¹, respectively above the control. Application of Panda Hill PR with urea or composted with biomass increased grain yield by 1.20 and 1.06 t ha⁻¹, respectively above the control. The observed differences (0.82 and 0.14 t ha⁻¹) were not statistically significant indicating that biomass composted with PR was as effective as the PR applied with urea.

Keywords: lablab; mucuna; rock phosphate; composts; maize; yields

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DOI: <https://doi.org/10.9734/jeai/2019/v35i430209>

Motivations for the use of sustainable intensification practices among smallholder farmers in Tanzania and Malawi {Journal article}

Citation

Jambo, I.J., Groot, J.C.J., Descheemaeker, K., Bekunda, M., and Tittonell, P. 2019. Motivations for the use of sustainable intensification practices among smallholder farmers in Tanzania and Malawi. *NJAS-Wageningen Journal of Life Sciences*, 1-10.

Abstract

Agricultural techniques and technologies that could foster sustainable intensification of farming (hereafter: SI practices) can originate from existing farm practices, from the adoption of externally suggested new practices, or from an adaptation of existing or new practices. The rate at which farmers use SI practices is often low and influenced by on-farm biophysical and socio-economic conditions. There is a narrow understanding of the role of motivations and the balance between external incentives and intrinsic motivations for use of SI practices. We analysed the role of intrinsic and extrinsic motivations among 246 sampled households alongside the perceived benefits and constraints from SI practices in five districts of Malawi and Tanzania.

Our results showed that farmer decisions were not exclusively dependent on external incentives, but also on intrinsic values which farmers attach to their production resources and farming practices. Despite various benefits perceived, farmers highlighted the lack of financial resources as a major constraint to the use of externally proposed SI practices. While we hypothesized that intrinsic motivation would be much stronger than extrinsic in influencing decisions to use SI practices, our results demonstrated equal importance of intrinsic and extrinsic motivations in influencing the number of SI practices which smallholder farmers used. We suggest explicitly addressing both intrinsic and extrinsic motivations in further research in combination with socio-economic and biophysical variables to give a better reflection of what drives farmers' decisions to use more sustainable farming practices. We argue that the design of SI research programs should support motivations of diversified farmers to participate in such programs.

Emphasising farmers' autonomy, a key to intrinsic motivation, can stimulate ownership of SI projects and smoothen the process of adoption, adaptation, and use of SI practices by farmers, and is expected to reduce the mismatch between proposed practices and farmers' expectations.

Keywords: Self-determination theory, Farming systems, Sustainable development, Technology adoption, External drivers, Farming constraints

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DOI: <https://doi.org/10.1016/j.njas.2019.100306>

Multipurpose legumes for smallholders in sub-Saharan Africa: Identification of promising 'scale out' options {Journal article}

Citation

Snapp, S.S., Cox, C.M. and Peter, B.G., 2019. Multipurpose legumes for smallholders in sub-Saharan Africa: Identification of promising 'scale out' options. *Global Food Security*, 23, pp.22-32.

Abstract

Legumes are often cited as essential components for sustainable agriculture development in Africa, yet investment in germplasm improvement and in understanding adoption of these important crops has been modest. In this review, we present promising legume options by farming system niche, thus providing an ecological as well as socio-economic lens for better policy decision making. We focus on multipurpose legumes with complementary growth habits that can be grown in conjunction for enhanced agriculture sustainability. We also show the region's spatially explicit distribution of chickpea, common bean, cowpea, groundnut, and pigeonpea, and define the climate niche for expansion of these crops through Google Earth Engine. Multipurpose legumes provide 'scale out' opportunities for smallholder farmers in sub-Saharan Africa, but not without considerable investment.

Keywords: Multipurpose legume, Farming system niche, Sustainable intensification, Doubled-up legume, Scaling, Gender

DOI: <http://dx.doi.org/10.1016/j.gfs.2019.03.002>

New insights on efficiency and productivity analysis: Evidence from vegetable-poultry integration in rural Tanzania {Journal article}

Citation

Habiyaremye, N., Tabe-Ojong, M.P., Ochieng, J. and Chagamoka, T. 2019. New insights on efficiency and productivity analysis: Evidence from vegetable-poultry integration in rural Tanzania. *Scientific African* 6:e00190.

Abstract

Despite its dependence on agriculture, food production does not seem to match the population increase in Tanzania. Exacerbating the situation, poverty in the light of per capita income keeps increasing making it one of the poorest economies in the world. Recent policy debates have been geared at probing into the situation and seeking ways of reversing this troublesome and disturbing trend. Increasing productivity and improving production

efficiency are steps in the right direction of augmenting food production. We collected data from 250 vegetable farmers in the Babati district of Tanzania and assess the efficiency and productivity level of the integration of poultry systems into their vegetable activity.

Specifying the Cobb-Douglas functional form in the stochastic production frontier, we find evidence of the direct impact of farm size, fertilizer quantity, labour cost and seed cost on productivity. While younger farmers are observed with the greatest level of efficiency, male farmers are more technically efficient than their female counterparts. Though surprising (because of the historical attribution of women to vegetables), this is somewhat expected as males are better connected in society and have higher access to improved and novel farming technologies and techniques which are relevant in increasing efficiency. The mean technical efficiency of this production system is 0.44 which is sharply below most studies on vegetables. This re-affirms and re-echoes to policy the need for effective policy developments that underscore the use of improved farming technologies.

Keywords: crops; poultry; intensification; farming systems; gender

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DOI: <https://doi.org/10.1016/j.sciaf.2019.e00190>

Perennial grains for Africa: possibility or pipedream? {Journal article}

Citation

Snapp, S., Roge, P., Okori, P., Chikowo, R., Peter, B. and Messina, J., 2019. Perennial grains for Africa: Possibility or pipedream? *Experimental Agriculture*, 55(2), pp.251-272

Abstract

Perennial grain crops have been proposed as a transformative approach to agriculture. Replacing annual staple crops with perennialized growth types of the same crops could provide environmental services, improve labour efficiency and weather resilience, reduce seed costs and produce livestock fodder or fuelwood production. Yet, the technologies and science for agricultural development in Africa have focused almost exclusively on annuals. In this paper, we review the literature to explore what has been potentially overlooked, including missed opportunities as well as the disadvantages associated with perennial grains. The case studies of pigeon pea and sorghum are considered, as an analogue for perennial grain crops in Africa. We find that a substantial number of farmers persist in 'perennializing' pigeon pea systems through ratoon management, and that sorghum ratoons are widely practiced in some regions. In contrast, many crop scientists are not interested in perennial traits or ratoon management, citing the potential of perennials to harbour disease, and modest yield potential. Indeed, an overriding prioritization of high grain yield response to fertilizer, and not including accessory products such as fodder or soil fertility, has led to multipurpose, perennial life forms being overlooked. Agronomists are encouraged to consider a wide range of indicators of performance for a sustainable approach to agriculture, one that includes management for diversity in crop growth habits.

Link: <https://doi.org/10.1017/S0014479718000066>

Physical quality of maize grain harvested and stored by smallholder farmers in the Northern highlands of Tanzania: Effects of harvesting and pre-storage handling practices in two marginally contrasting agro-locations {Journal article}

Citation

Mutungi, C., Muthoni, F., Bekunda, M., Gaspar, A., Kabula, E., and Abass. A. 2019. Physical quality of maize grain harvested and stored by smallholder farmers in the Northern highlands of Tanzania: Effects of harvesting and pre-storage handling practices in two marginally contrasting agro-locations. *Journal of Stored Products Research*. Vol. 84:101517-.

Abstract

On-farm trials were conducted to investigate the effects of maize harvesting and handling practices of smallholder farmers on the quality of the produce before, and during storage in two contrasting agro-locations. Farmers harvested and prepared the crop according to local practices, and stored it in ordinary woven polypropylene bags for 30 weeks. Grain moisture, insect populations, insect-damage, moldy/diseased/discolored grain, rodent-damage, shriveled grain, broken grains, non-consumable grains, impurities, and overall losses were monitored. Moisture of the pre-stored grain ranged between 11.0 and 23.7% while the overall physical damage was $16.9 \pm 6.2\%$. Late harvesting increased moldy/diseased/discolored grain two-fold while de-husking and drying practices increased the levels in early-harvested grain by factor of 2–3. Insect populations were >10 times higher in the cooler agro-location, and handling practices increased them by factor of 2–10.

The interaction of agro-location, harvesting time and drying influenced the amount of grain that was unfit for human consumption. Pre-storage losses of 3.6–11.2% were determined, mainly as grade-outs. With storage, the quality of early-and late-harvested maize did not differ. However, the majority of examined parameters were distinct by agro-location. Moreover, secondary pests and the levels of shriveled and broken grain levels were also distinct by drying method, while moldy/diseased/discolored grain, non-consumable grain, and overall losses were distinct depending on whether the harvested cobs were de-husked or not de-husked before drying. The high levels of grade-outs at the pre-storage stage suggest that sorting should be emphasized for quality improvement at the farm gate not only for the market but also household nutrition. Cultivation of varieties with superior maturing and post-harvest traits would lower the sorting losses. Agro-location and farmer practices influenced grain quality and magnitude of losses during storage. These findings should inform choice of intervention steps right from the pre-storage stage.

Keywords: Agro-climatic conditions, post-harvest operations, Farmer practices, Quality Losses

Link: <https://www.sciencedirect.com/science/article/pii/S0022474X19301377>

DOI: [10.1016/j.jspr.2019.101517](https://doi.org/10.1016/j.jspr.2019.101517)

Reducing Child Undernutrition through Dietary Diversification, Reduced Aflatoxin Exposure, and Improved Hygiene Practices: The Immediate Impacts in Central Tanzania {Journal article}

Citation

Seetha, A., Muzanila, Y., Tsusaka, W.T., Kachulu, L., Kumwenda, N., Musoke, M., Swai, E., Shija, J., Siambi, M., Monyo, E.S., Bekunda, M., and Okori, P. 2019. Reducing Child Undernutrition through Dietary Diversification, Reduced Aflatoxin Exposure, and Improved Hygiene Practices: The Immediate Impacts in Central Tanzania, *Ecology of Food and Nutrition*

Abstract

The study aimed to quantify the immediate effects of dietary diversification, food safety, and hygiene interventions on child undernutrition in four rural villages in Kongwa district of central Tanzania. One hundred mothers with their children of less than 24 months old were recruited for this study. The difference-in-difference (DID) method was used to assess the effects of intensive intervention through a learning-by-doing process on the topic of aflatoxin free diversified food utilization and improved hygiene practices. Periodic anthropometric measurements were conducted on the 0th, 7th, 14th, and 21st days, and DID estimator showed the significant and positive average marginal effects of the intervention on Z-Scores being 0.459, 0.252, and 0.493 for wasting, stunting, and underweight, respectively. Notably, at the end of the study, the mean aflatoxin M1 level in urine samples decreased by 64% in the intervention group, while it decreased by 11% in the control group. The study provides quantitative evidence on intensive 21-day training for mothers incorporating integrated technologies yielded positive impacts on their children's nutritional outcomes

Keywords: Undernutrition, complementary food, aflatoxin exposure, difference in difference

Link: <https://doi.org/10.1080/03670244.2019.1691000>

DOI: 10.1080/03670244.2019.1691000

Smallholder farmers' adoption of vegetable production technologies in Babati District, Tanzania {Journal article}

Citation

Ochieng, J., Afari-Sefa, V., Lukumay, P.J., Dominick, I. and Muthoni, F. 2019. Smallholder farmers' adoption of vegetable production technologies in Babati District, Tanzania. *Acta Horticulturae* 1255:31.

Abstract

Agricultural technologies have boosted crop yield increases and household incomes, particularly, during the Green Revolution in Asia and some parts of Sub-Sahara Africa. However, adoption of yield enhancing technologies in the vegetable subsector is still low, particularly within smallholder farms. The Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) has tested and promoted the adoption of external low-input strategies such as 1) using good elite seeds and healthy vegetable seedlings; 2) inorganic fertilizers; 3) good agronomic practices – GAP (i.e., mulching, timely weeding, timely planting, organic manure application, intercropping, crop rotation, etc.); 4) integrated pest management – IPM (cultural, chemical control and biological-using trap crops). Based

on a sampled survey of 310 farm households from five villages, we used both qualitative and quantitative methods to describe the dynamics of farmers' adoption of vegetable technologies and analyse factors influencing technology choice in Babati District located in the Manyara region, Tanzania. Findings show that farmers adopt technologies that are convenient to them and the decision to apply them is influenced by various socio-economic factors. We therefore provide policy-related recommendations that current and future technology scaling programs may consider to increase the adoption and sustainable use of vegetable production technologies among smallholder farmers to address food and nutrition insecurity challenges in developing countries.

Keywords: adoption, yields, multivariate probit, smallholders, Tanzania

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Tillage and crop rotations enhance populations of earthworms, termites, dung beetles and centipedes: Evidence from a long-term trial in Zambia {Journal article}

Citation

Muoni, T., Mhlanga, B., Forkman, J., Sitali, M. and Thierfelder, C. 2019. Tillage and crop rotations enhance populations of earthworms, termites, dung beetles and centipedes: Evidence from a long-term trial in Zambia. *Journal of Agricultural Science* 157(6): 504-514

Abstract

Macro-organisms contribute significantly to soil fertility improvement. The influence of conservation agriculture (CA) in southern Africa on their populations has not yet been fully understood. Thus, the objective of the current study was to evaluate the effects of CA and conventional tillage on below ground biological activity in a CA long-term trial in Monze, Zambia from 2011 to 2013. The study had ten treatments which differed by tillage systems (conventional ploughing, planting basins and direct seeding) and crop diversification intensity (sole cropping, 2- or 3-year crop rotations) involving maize, cotton, and sunn hemp. These factors were combined to create rotation-tillage (RotTill) treatments. Sampling of macrofauna was done once per year using a metal frame measuring 0.25 m², hand-sorted to 30-cm depth. RotTill treatments had a significant effect on earthworms (*Lumbricus terrestris*), termites (*Coptotermes formosanus*), dung beetles (*Scarabaeus viettei*) and centipedes (*Lithobius forficatus*). Earthworms and termites were more abundant in CA treatments than in conventionally ploughed (CP) treatments. Biota diversity was generally higher in CA treatments than in CP controls. Conventional mouldboard ploughing generally reduced macrofauna, thus affecting biological soil fertility and the beneficial effect of the interactions of these organisms with the soil. CA treatments had the highest maize grain yields throughout the study period. Based on the results, reduced tillage systems and crop rotations increase biological activity shown by increased densities of termites and earthworms.

Keywords: biodiversity; crop rotation; conservation agriculture; soil biology; intensification

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DOI: <https://doi.org/10.1017/S002185961900073X>

Understanding the multidimensionality of climate-smartness: Examples from agroforestry in Tanzania {Book chapter}

Citation

Kimaro, A., Sererya, O., Matata, P., Uckert, G., Hafner, J., Graef, F., Sieber, S. and Rosenstock, T. 2019. Understanding the multidimensionality of climate-smartness: Examples from agroforestry in Tanzania. IN: Rosenstock T., Nowak A., Girvetz E. (eds.), The Climate-Smart Agriculture Papers. Cham, Switzerland: Springer: 153-162.

Abstract

Climate-smart agriculture (CSA) has three goals—productivity, resilience and mitigation. Rarely are these accounted for in CSA programming or the scientific evidence that supports it. Here, we evaluate the climate smartness of CSA-based agroforestry practices in Tabora and Dodoma, Tanzania using unpublished data from earlier studies. Firstly, a study of on-farm wood production and its use with the improved cook stove (ICS) was used to ascertain the productivity and mitigation effects of CSA. Next, intercropping experiments of maize or cassava with pigeonpea and/or *G. sepium* provided information on the production and resilience benefits of CSA. It was found that agroforestry practices (shelterbelt, trees on contours and intercropping) supplied up eight tons per hectare ($t\ ha^{-1}$) of wood—enough to support a five-member family for up to 6 years when using ICS. Employing ICS also reduced the time spent in cooking (20%) and fuelwood collection (32%), and reduced gas emissions by 62%. Generally, intercropping pigeonpea or *G. sepium* enhanced farm production (as noted by a land equivalent ratio greater than 1) and agroecosystem resilience through crop diversification by using suitable intercropping arrangements and including a drought-resistant crop. Using the latter two in semi-arid Dodoma enhanced crop production across seasons and sites. Our analysis shows that adopting CSA-based agroforestry and intercropping practices is beneficial. However, these benefits are not universal. It also illustrates other key principles for understanding multidimensionality of CSA objectives, including the need to: select appropriate indicators, ensure designs are robust for heterogeneity, examine trade-offs, and conduct participatory evaluation of CSA.

Keywords: participatory approaches; agroforestry; intensification; climate; farming systems

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Year 2018

A framework for priority-setting in climate smart agriculture research {Journal article}

Citation

Thornton, P.K., Whitbread, A., Baedeker T., Cairns, J., Claessens, L., Baethgen, W., Bunn, C., Friedmann, M., Giller, K.E., Herrero, M., Howden, M., Kilcline, K., Nangia, V., Ramirez-Villegas, J., Kumar, S., West, P.C., and Keating, B. 2018. A framework for priority-setting in climate smart agriculture research. *Agricultural Systems* 167:161-175.

Abstract

Climate-smart agriculture (CSA) is widely promoted as an approach for reorienting agricultural development under the realities of climate change. Prioritising research-for-development activities is crucial, given the need to utilise scarce resources as effectively as possible. However, no framework exists for assessing and comparing different CSA research investments. Several aspects make it challenging to prioritise CSA research, including its multi-dimensional nature (productivity, adaptation, and mitigation), the uncertainty surrounding many climate impacts, and the scale and temporal dependencies that may affect the benefits and costs of CSA adoption. Here we propose a framework for prioritising agricultural research investments across scales and review different approaches to setting priorities among agricultural research projects. Many priority-setting case studies address the short- to medium-term and at relatively local scales. We suggest that a mix of actions that span spatial and temporal time scales is needed to be adaptive to a changing climate, address immediate problems and create enabling conditions for enduring change.

Keywords: climate change; agriculture; food security; adaptation; climate-smart agriculture; agricultura climáticamente inteligente; climate change mitigation

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DOI: <https://doi.org/10.1016/j.agsy.2018.09.009>

A Multiscalar Approach to Mapping Marginal Agricultural Land: Smallholder Agriculture in Malawi {Journal article}

Citation

Peter, B.G., Messina, J.P. and Snapp, S.S., 2018. A multiscalar approach to mapping marginal agricultural land: smallholder agriculture in Malawi. *Annals of the American Association of Geographers*, 108(4), pp.989-1005.

Abstract

Marginal agricultural lands are defined here by suboptimal biophysical conditions and historically variable or low agricultural production. We characterize these areas using remotely sensed information to disentangle the biophysical and possible social factors driving marginality. Considering both the modifiable areal unit problem and the ecological fallacy problem, the heuristic we propose is generalizable across geographies and scales and provides information at multiple decision-making levels through a multiscalar interannual variability model. We present results from our study of Malawi, where the landscape is densely cultivated and smallholder farmers frequently occupy marginal lands, to illustrate the potential of a multiscalar analysis in a place where food insecurity alleviation is needed and where remote sensing can provide necessary information.

Our framework for identifying marginal agricultural lands consists of (1) locating long-term agricultural land, (2) measuring interannual productivity of long-term farmed locations, and (3) assessing marginal biophysical land characteristics and the fundamental climate niche for the dominant crop (in this case maize). Productivity and marginality in Malawi are spatially organized, and an assessment of productivity at multiple scales highlights the importance of presenting both global and local spatiotemporal variability for managing agroecological variance. By disaggregating broad classes of historically marginal production and the underlying drivers of marginality, different intervention efforts can intelligently target areas most likely to receive maximum benefit. These methodologies can be applied by both policymakers and scholars to identify and target marginal agricultural areas for improved productivity and for the support of smallholder farmer livelihoods.

Keywords: agriculture, development, marginal land, multiscalar, remote sensing

DOI: <https://doi.org/10.1080/24694452.2017.1403877>

Capturing farm diversity with hypothesis-based typologies: An innovative methodological framework for farming system typology development {Journal article}

Citation

Alvarez, S., Timler, C.J., Michalscheck, M., Paas, W., Descheemaeker, K., Tittonell, P., Andersson, J.A. and Groot, J.C.J. 2018. Capturing farm diversity with hypothesis-based typologies: An innovative methodological framework for farming system typology development. Plos one

Abstract

Creating typologies is a way to summarize the large heterogeneity of smallholder farming systems into a few farm types. Various methods exist, commonly using statistical analysis, to create these typologies. We demonstrate that the methodological decisions on data collection, variable selection, data-reduction and clustering techniques can bear a large impact on the typology results. We illustrate the effects of analysing the diversity from different angles, using different typology objectives and different hypotheses, on typology creation by using an example from Zambia's Eastern Province.

Five separate typologies were created with principal component analysis (PCA) and hierarchical clustering analysis (HCA), based on three different expert-informed hypotheses. The greatest overlap between typologies was observed for the larger, wealthier farm types but for the remainder of the farms there were no clear overlaps between typologies. Based on these results, we argue that the typology development should be guided by a hypothesis on the local agriculture features and the drivers and mechanisms of differentiation among farming systems, such as biophysical and socio-economic conditions. That hypothesis is based both on the typology objective and on prior expert knowledge and theories of the farm diversity in the study area. We present a methodological framework that aims to integrate participatory and statistical methods for hypothesis-based typology construction. This is an iterative process whereby the results of the statistical analysis are compared with the reality of the target population as hypothesized by the local experts.

Using a well-defined hypothesis and the presented methodological framework, which consolidates the hypothesis through local expert knowledge for the creation of typologies,

warrants development of less subjective and more contextualized quantitative farm typologies.

Keywords: crops; livestock; farming systems; intensification

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DOI: <https://doi.org/10.1371/journal.pone.0194757>

Complementary practices supporting conservation agriculture in southern Africa: A review {Journal Article}

Citation

Thierfelder, C., Baudron, F., Setimela, P., Nyagumbo, I., Mupangwa, W., Mhlanga, B., Lee, N. and Gérard, B. 2018. Complementary practices supporting conservation agriculture in southern Africa: A review. *Agronomy for Sustainable Development* 38:16.

Abstract

Conservation agriculture (CA)—the simultaneous application of minimum soil disturbance, crop residue retention, and crop diversification—is a key approach to address declining soil fertility and the adverse effects of climate change in southern Africa. Applying the three defining principles of CA alone, however, is often not enough, and complementary practices and enablers are required to make CA systems more functional for smallholder farmers in the short and longer term. Here, we review 11 complementary practices and enablers grouped under six topical areas to highlight their critical need for functional CA systems, namely: (1) appropriate nutrient management to increase productivity and biomass; (2) improved stress-tolerant varieties to overcome biotic and abiotic stresses; (3) judicious use of crop chemicals to surmount pest, diseases, and weed pressure; (4) enhanced groundcover with alternative organic resources or diversification with green manures and agroforestry; (5) increased efficiency of planting and mechanization to reduce labor, facilitate timely planting, and to provide farm power for seeding; and (6) an enabling political environment and more harmonized and innovative extension approaches to streamline and foster CA promotional efforts.

We found that (1) all 11 complementary practices and enablers substantially enhance the functioning of CA systems and some (e.g., appropriate nutrient management) are critically needed to close yield gaps; (2) practices and enablers must be tailored to the local farmer contexts; and (3) CA systems should either be implemented in a sequential approach, or initially at a small scale and grow from there, in order to increase feasibility for smallholder farmers. This review provides a comprehensive overview of practices and enablers that are required to improve the productivity, profitability, and feasibility of CA systems. Addressing these in southern Africa is expected to stimulate the adoption of CA by smallholders, with positive outcomes for soil health and resilience to climate change.

Keywords: climate change; farming systems; intensification; soil; agriculture

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DOI: <https://doi.org/10.1007/s13593-018-0492-8>

Effect of nutrition education and milk processing on nutritional status of under-five children among dairy farming households in Dedza district of Malawi {Journal article}

Citation

Mhango, K. 2018. Effect of nutrition education and milk processing on nutritional status of under-five children among dairy farming households in Dedza district of Malawi. MSc Thesis in Human Nutrition. Lilongwe University of Agriculture and Natural Resources. Lilongwe. Malawi

Abstract

Despite the role dairy production can play in mitigating impacts of under nutrition, milk consumption among dairy farming households in Malawi is poor and so is stunting status of under-five children. This study therefore determined the effect of incorporating nutrition education and milk processing on child nutritional status among dairy farming households.

A quasi-experimental study was conducted with 61 dairy farming households and 79 under-five children in two milk bulking groups (intervention vs control) in Dedza district from April to December 2016. Nutrition education and milk products processing interventions were provided concurrently four times at two months intervals. Analysis was done using SPSS and Stata. Chi square tests were done for proportions and t-test for means. P-value < 0.05 was considered statistically significant.

The dairy farming households were 88.5% male headed with 2.28 ± 0.61 lactating and 1.49 ± 0.72 cows on dry. Household milk products processing and consumption of homemade dairy products by under-five children improved at the intervention and differences were statistically significant with control. Stunting dropped from 34.2% to 20.5% and increased from 31.6% to 35.1% at end-line for intervention and control respectively but not significant. Mean height difference increased from 0.6 to 1.5 cm in favour of intervention group. Within group analysis results using baseline and end-line showed significant height and weight gains in intervention group.

Nutrition education and milk product processing training promoted household product processing, milk and milk products consumption by under-five children which contributed to improved nutritional status. Therefore, integrated programming should be promoted in dairy production nutrition interventions.

Keywords:

Link: <http://41.70.124.12:8080/xmlui/handle/123456789/1501>

Efficacy of tips approach and partial processing on household utilization of legumes: a case study of Ntcheu and Dedza districts {Thesis}

Citation

Mwafulirwa, S.P. 2018. Efficacy of TIPs approach and partial processing on household utilization of legumes: a case study of Ntcheu and Dedza districts. MSc Thesis in Human Nutrition. Lilongwe University of Agriculture and Natural Resources. Lilongwe. Malawi

Abstract

Legumes are the major source of proteins in the rural households in Malawi which cannot afford animal protein. However, farmers prioritise selling their legumes immediately after harvest. The study was conducted to assess the efficacy of training, Trials of Improved Practices (TIPs) approach and primary processing on increasing household consumption of legumes. Results show that respondents did not produce and store enough legumes to meet their annual legume budget requirements of 30kg per person per year. Respondents were not aware of the recommended annual legume budget reserve. About 50% of the legumes produced were sold soon after harvest. The stored legumes were used as a cash bank. Though 60% of respondents reported buying legumes to supplement the amount produced at household, the amount bought (less than 5kg) was too small to sustain consumption demand at household level. Processing and storage were not achieved since the respondents reported not have the legume to process store or budget, and limited knowledge on legume budgeting, processing, and storage. There were prospects that TIPs would have worked if processing and storage of legumes would have been achieved if there would be enough legume storage shown by the extent to which processing was done at second visit on the legumes available. Processing and storage seemed viable because protein quality is maintained when legumes were stored over a period of three months. Though there is loss of ash and fibre, these can be accessed through dietary diversification. The study has shown that TIPs approach would be a viable approach to increase legume consumption through budgeting, processing, and storage. Adopting the traditional processing method to process groundnuts, cowpeas, and soybean for the use as dietary protein source for the households is also viable.

Gender and mechanization: Exploring the sustainability of mechanized forage chopping in Tanzania {Journal article}

Citation

Fischer, G., Wittich, S., Malima, G., Sikumba, G., Lukuyu, B., Ngunga, D., and Rugalabam, J. 2018. Gender and mechanization: Exploring the sustainability of mechanized forage chopping in Tanzania. *Journal of Rural Studies*, Volume 64,2018, Pages,112-122, ISSN 0743-0167.

Abstract

Mechanization is currently experiencing a revival in agricultural research and development, with a new emphasis on equity and sustainability. This study evaluates the introduction of forage chopper machines in seven villages in northern Tanzania from a farmer's perspective. Data collected through focus group discussions and a survey are used for a gender analysis of this technology within a broader sustainable intensification indicator framework. The results not only draw attention to unabated challenges to smallholder mechanization (such as high operational costs or weak supporting infrastructures), but also show how the technology's sustainability is contingent upon equity dynamics on the household and community levels. The evaluation framework proved suitable for a holistic assessment. A broader approach to gender issues would strengthen its interdisciplinary claim. Suggestions for promoting the chopper's sustainability include gender-sensitive training and the establishment of group models for machine operation based on agreed and fair regulations.

Keywords: Agricultural, mechanization, Gender, Sustainability, Livestock, Tanzania.

Link: [012https://www.sciencedirect.com/science/article/pii/S0743016718304340](https://www.sciencedirect.com/science/article/pii/S0743016718304340)

DOI: <https://doi.org/10.1016/j.jrurstud.2018.09>.

Global assessment of agricultural system redesign for sustainable intensification {Journal article}

Citation

Pretty, J., Benton, T.G., Bharucha, Z.P., Dicks, L.V., Flora, C.B., Godfray, H.C.J., Goulson, D.G., Hartley, S., Lampkin, N., Morris, C., Pierzynski, G., Prasad, P.V., Reganold, J., Rockström, J., Smith, P., Thorne, P. and Wratten, S. 2018. Global assessment of agricultural system redesign for sustainable intensification. *Nature Sustainability* 1:441–446.

Abstract

The sustainable intensification of agricultural systems offers synergistic opportunities for the co-production of agricultural and natural capital outcomes. Efficiency and substitution are steps towards sustainable intensification, but system redesign is essential to deliver optimum outcomes as ecological and economic conditions change. We show global progress towards sustainable intensification by farms and hectares, using seven sustainable intensification sub-types: integrated pest management, conservation agriculture, integrated crop and biodiversity, pasture and forage, trees, irrigation management and small or patch systems. From 47 sustainable intensification initiatives at scale (each >104 farms or hectares), we estimate 163 million farms (29% of all worldwide) have crossed a redesign threshold, practising forms of sustainable intensification on 453 Mha of agricultural land (9% of worldwide total). Key challenges include investment to integrate more forms of sustainable intensification in farming systems, creating agricultural knowledge economies, and establishing policy measures to scale sustainable intensification further. We conclude that sustainable intensification may be approaching a tipping point where it could be transformative.

Keywords: agriculture; intensification

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Long-term spatial-temporal trends and variability of rainfall over Eastern and Southern Africa {Journal article}

Citation

Muthoni, F.K., Odongo, V.O., Ochieng, J., Mugalavai, E.M., Mourice, S.K., Mourice, I., Mwila, M. and Bekunda, M. 2018. Long-term spatial-temporal trends and variability of rainfall over Eastern and Southern Africa. *Theoretical and Applied Climatology*

Abstract

This study investigates the spatial-temporal trends and variability of rainfall within East and South Africa (ESA) region. The newly available Climate Hazards group Infrared Precipitation with Stations (CHIRPS-v2) gridded data spanning 37 years (1981 to 2017) was validated against gauge observations (N = 4243) and utilised to map zones experiencing significant monotonic rainfall trends. Standardised annual rainfall anomalies revealed the spatial-temporal distribution of below and above normal rains that are associated with droughts and floods respectively. Results showed that CHIRPS-v2 data had a satisfactory skill to estimate monthly rainfall with Kling-Gupta efficiency (KGE = 0.68 and a high temporal agreement ($r = 0.73$) while also preserving total amount ($\beta = 0.99$) and variability ($\gamma = 0.8$). Two contiguous zones with significant increase in annual rainfall (3–15 mm year⁻¹) occurred in Southwest Zambia and in Northern Lake Victoria Basin between Kenya and Uganda.

The most significant decrease in annual rainfall (-20 mm year^{-1}) was recorded at Mount Kilimanjaro in Tanzania. Other significant decreases in annual rainfall ranging between -4 and -10 mm year^{-1} were observed in Southwest Tanzania, Central-South Kenya, Central Uganda, and Western Rwanda. CHIRPS-v2 rainfall product provides reliable high spatial resolution information on amount of rainfall that can complement sparse rain gauge network in rain-fed agricultural systems in ESA region. The observed spatial-temporal trends and variability in rainfall are important basis for guiding targeting of appropriate adaptive measures across multiple sectors.

Keywords: farming systems; intensification; climate change; water

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DOI: <https://doi.org/10.1007/s00704-018-2712-1>

Maize yield and profitability tradeoffs with social, human, and environmental performance: is sustainable intensification feasible? (Journal article)

Citation

Snapp, S.S., Grabowski, P., Chikowo, R., Smith, A., Anders, E., Siringi, D., ... & Bekunda, M. 2018. Maize yield and profitability tradeoffs with social, human, and environmental performance: is sustainable intensification feasible? *Agricultural Systems*, 162, 77-88.

Abstract

Sustainable intensification (SI) has been regarded as the basis for environmentally sound and equitable agricultural development. Field based assessment of technologies needs to move beyond production and economic performance to include environment, social and human condition. In this study we systematically consider all five domains of SI based on participatory action research (PAR) initiated in 2012 at three Central Malawi sites that varied in agroecology from low to high potential. Fifteen SI indicators were assessed for four technologies: sole maize (*Zea mays* L.) with 0 and recommended fertilization (69 kg N ha^{-1} and 9 kg P ha^{-1}), pigeonpea (*Cajanus Cajun* (L.) Millsp.)-maize intercrop (half rate fertilizer), and doubled up legume rotation (DLR, a pigeonpea- groundnut intercrop) sequenced with maize at half rate fertilizer in that phase.

Through radar charts SI performance and tradeoffs were visualized, and causal loop analysis allowed identification of research gaps. SI indicator assessments included crop performance from on-farm trials, profitability, modeled probability of food sufficiency, risk of crop failure and ratings of technologies by women farmers who were engaged in evaluation of technologies through participatory research. The PAR included six mother trials, 236 baby trial farmers and a survey that was carried out with 324 farmers (baby trial farmers plus control farmers) to document socioeconomic factors and management practices on focal fields. Replicated mother trials further provided the basis for simulation modeling (APSIM) of weather-associated crop failure risk and slow processes such as soil carbon (C) accrual. Radar charts were used to visualize SI performance of the technologies. Environmental performance of the two pigeonpea-diversified technologies was variable, but generally high compared with sole maize systems, due to gains in vegetative biomass, duration of cover and biological nitrogen (N) fixation. Maize production and economic assessment varied by site, and with steeper tradeoffs for legume diversification in the mesic site, less so in the marginal site. The domains of social and human capacity building were superior for legume integration, notably in terms of diverse diet, food security and farmer preferences (notably,

female farmers generally favored legume crops). Performance varied by site with legume systems most beneficial at the most marginal site, including less risk of crop failure than unfertilized maize. Causal loop analyses identified regulators of SI that require further attention, notably: crop-livestock conflicts and opportunities, male-female control of legume crop production, and residue management. Overall, the SI indicators framework provided a systematic means to consider tradeoffs and opportunities associated with novel crop combinations and management practices.

Keywords: indicators; legumes; maize; crop production; malawi; sustainable intensification; causal loop; trade-offs; maize yield

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DOI: <https://doi.org/10.1016/j.agsy.2018.01.012>

On-farm comparison of different postharvest storage technologies in a maize farming system of Tanzania Central Corridor {Journal article}

Citation

Abass, A., Fischler, M., Schneider, K., Daudi, S., Gaspar, A., Rüst, J., ... & Msola, D. 2018. On-farm comparison of different postharvest storage technologies in a maize farming system of Tanzania Central Corridor. *Journal of Stored Products Research*, 77, 55-65.

Abstract

Seven methods for storing maize were tested and compared with traditional storage of maize in polypropylene bags. Twenty farmers managed the experiment under their prevailing conditions for 30 weeks. Stored grain was assessed for damage every six weeks. The dominant storage insect pests identified were the Maize weevil (*Sitophilus zeamais*) and the Red flour beetle (*Tribolium castaneum*). The moisture content of grain in hermetic conditions increased from $12.5 \pm 0.2\%$ at the start of storage to a range of 13.0 ± 0.2 – $13.5 \pm 0.2\%$ at 30 weeks. There was no significant difference ($F = 87.09$; $P < 0.0001$) regarding insect control and grain damage between hermetic storage and fumigation with insecticides. However, the insecticide treatment of polypropylene yarn (ZeroFly®) did not control the insect populations for the experimental period under farmers' management. Grain damage was significantly lower in hermetic storage and fumigated grain than ZeroFly® and polypropylene bags without fumigation. No significant difference in grain damage was found between airtight treatment alone and when combined with the use of insecticides. During storage, *S. zeamais* was predominant and could be of more economic importance than *T. castaneum* as far as maize damage is concerned. At 30 weeks, the germination rate of grain stored with insecticides or in hermetic storage ($68.5 \pm 3.6\%$ to $81.4 \pm 4.0\%$) had not significantly reduced from the rate before storage ($F = 15.55$; $P < 0.0001$) except in ZeroFly®, also in polypropylene bags without treatment. Even though such bags did not control storage pests, farmers still liked this cheap technology. Hermetic storage techniques can be recommended to farmers without the use of insecticides provided they are inexpensive, and the proper application of technologies is ensured.

Keywords: maize; farmers; storage; grain; damage; postharvest technology; hermetic storage; grain damage; food loss; insect damage; farming systems

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DOI: <https://doi.org/10.1016/j.ispr.2018.03.002>

Scaling Agricultural Innovations: Pigeonpea in Malawi {Journal article}

Citation

Peter, B.G., Messina, J.P., Frake, A.N. and Snapp, S.S. 2018. Scaling agricultural innovations: pigeonpea in Malawi. *The Professional Geographer*, 70(2), pp.239-250.

Abstract

Successful scaling of agricultural development strategies is fundamental to increased production and yields, yet targeting efforts frequently fail to fully consider the underlying biophysical drivers of agricultural marginality, particularly at fine spatial resolutions. We present a heuristic for intelligent targeting, utilizing remotely sensed information to identify the intersection between marginal conditions for performance of a staple crop and the optimal niche for technologies that improve crop performance. Here, we explore the geographic potential of maize diversification with pigeonpea, a crop with soil productivity enhancing properties. Overall, 79 percent of agricultural land in Malawi exhibits climate conditions optimal for pigeonpea cultivation and, in total, approximately 51 percent of Malawian maize-based farming is expected to receive some benefit from pigeonpea integration, with 9 percent receiving predictable and substantial benefits. These findings illustrate the geographic scaling potential of pigeonpea in Malawi and provide direction for informed pigeonpea deployment and market development across the country.

Keywords: development, pigeon pea, remote sensing, scaling, targeting

Link: <https://doi.org/10.1080/00330124.2017.1347798>

Taking agricultural technologies to scale: experiences from a vegetable technology dissemination initiative in Tanzania {Journal article}

Citation

Gramzow, A., Sseguya, H., Afari-Sefa, V., Bekunda, M. & Lukumay, P.J. 2018. Taking agricultural technologies to scale: experiences from a vegetable technology dissemination initiative in Tanzania. *International Journal of Agricultural Sustainability*, 1-13.

Abstract

One of the widely suggested approaches to meet the increasing food demand of a substantially growing world population is sustainable intensification. We present a unique agricultural research and scaling programme in Tanzania, focusing on the key elements necessary for results related to: gender analysis; private sector engagement; social capital; improvement and adaptation; and programme performance monitoring and evaluation. Since 2014, more than 6000 farmers have benefited from either the adaptive research or the scaling component of the programme. Preliminary impact analysis results from six pilot locations indicate that programme participants realized significantly higher yields compared to non-participants. In addition to productivity improvements, introducing resistant and drought-tolerant elite vegetable varieties improved the resilience of the existing farming systems. Finally, considering the needs of both male and female participants had a positive impact on technology adoption rates and reach.

Keywords: sustainability; intensification; technology; vegetable crops; scale; gender

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DOI: <https://doi.org/10.1080/14735903.2018.1473103>

The productivity and management systems of free-range local chickens in rural areas of Babati District, Tanzania {Journal article}

Citation

Marwa, L.J., Mbagi, S.H., Mutayoba, S.K. and Lukuyu, B. 2018. The productivity and management systems of free-range local chickens in rural areas of Babati District, Tanzania. *Livestock Research for Rural Development* 30(8): Article #134.

Abstract

A study was conducted to assess productivity and management systems of local chickens in rural areas of Babati District, Tanzania. Four villages from four different wards were engaged in the study. Cross-sectional study was employed in gathering information whereby 140 households were interviewed. In addition, four focused group discussions each with an average of 18 farmers were done. The questionnaire and check list were designed to collect information on rural chicken production status, population structure, breeds/strains, feeding, housing, health management, mortality, and labour distribution in chicken management within the family. Data were analysed by using SPSS Statistics 21.0 program. The findings showed that 96.5% of the respondents in the study area kept local chickens, at an average of 17 birds per household. Most of the village households (53%) kept their chickens under scavenging mode of production with occasional supplementations. Other

systems used included semi-scavenging (44%) and full confinement (3%). Labour in chicken management was provided either by man, woman or children depending on the nature of activity. However, majority of routine managements were done by women and children. Moreover, men and children (boys) played major role in poultry house construction and marketing of chickens to far markets. The results suggest a need for innovative approaches that integrate improved nutrition, housing, and health management for the farmers to realize economic gains in raising chickens while taking into consideration gender responsibilities within the family.

Keywords: constraints, flock structure, labour, production performance, survey

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External link to download this item: <http://www.lrrd.org/lrrd30/8/leon30134.html>

Training transfer for sustainable agricultural intensification in Tanzania: critical considerations for scaling {Journal article}

Citation

Sseguya, H., Bekunda, M., Muthoni, F., Flavian, F. & Masigo, J. 2018. Training transfer for sustainable agricultural intensification in Tanzania: critical considerations for scaling-up. *Journal of Agricultural Science and Technology*, 20, 661-671.

Abstract

Sustainable Intensification (SI) in agriculture is fronted as a promising approach to increase agricultural production in Sub-Saharan Africa countries. Technologies that can lead to realization of the SI goal are available but one of the key challenges is the low reach among smallholder farmers due to, among others, ineffective training and co-learning. In this study, a survey methodology was used to obtain data from 145 trainees in a sustainable intensification intervention in Kongwa and Mvomero districts, Tanzania, to analyze the drivers of training transfer. Hierarchical linear regression revealed that motivation of trainees, training design and delivery, and work environment (peer, extension and local institutional support) had positive effects on transfer of the training. For successful transfer of training, recommendations given were a deliberate focus on selection of suitable trainees and ensuring their motivation to learn; use of appropriate documentation, extension and training methods; strengthening farmers' networks for peer learning; and strengthening collaborations with local institutions.

Keywords: agricultural development; learning; training; inputs; sustainable intensification; smallholders

Permanent link to cite or share this item: <https://hdl.handle.net/10568/93380>

When the going gets tough: Performance of stress tolerant maize during the 2015/16 (El Niño) and 2016/17 (La Niña) season in southern Africa {Journal article}

Citation

Setimela, P., Gasura, E., Thierfelder, C., Zaman-Allah, M., Cairns, J.E. and Boddupalli, P.M. 2018. When the going gets tough: Performance of stress tolerant maize during the 2015/16 (El Niño) and 2016/17 (La Niña) season in southern Africa. *Agriculture, Ecosystems and Environment* 268:79-89.

Abstract

The 2015/2016 El Niño was the most severe on record in southern Africa and was associated with drought and heat stress. To help farmers to cope with such extreme production constraints the International Maize and Wheat Improvement Centre (CIMMYT), has been developing maize varieties through a rapid-cycle breeding strategy to deliver a steady stream of incrementally improved varieties with tolerance to multiple stresses. Performance of stress tolerant maize germplasm in an El Niño year was evaluated using two types of trials. The first one comprised a regional on-farm trial with forty maize varieties (20 early intermediate and 20 intermediate-late varieties), planted across 30 locations in four countries in southern Africa. The second set comprised a multi-locational evaluation trial with six hybrids that were tested under conventional ridge tillage (CP) and conservation agriculture (CA) using a randomized block design with each farm as replicate in nine extension planning areas (EPA), across two years. In the regional on-farm trial, analysis of variance on grain yield showed significant differences ($P < 0.001$) in both early-intermediate and intermediate-late varieties. Stress tolerant varieties such as CZH142020 (5.6 t ha⁻¹) and CZH131008 (4.8 t ha⁻¹), had significantly higher yield advantage over commercial control varieties (<4.5 t ha⁻¹) in both maturity groups, respectively during the El Niño year. Furthermore, stress tolerant hybrids had larger grains and smaller ear uniformity index (EUI) (calculated as among plots ear size variance); compared non-stress tolerant varieties. In the CA/CP evaluation trial, varieties under CA yielded ≥ 0.7 t ha⁻¹ more grain compared to those under CP. Stress tolerant maize in combination with CA led to higher yield gains compared to non-stress tolerant maize planted under CP. Therefore, combinations of climate-smart agriculture technologies are required to mitigate negative effects of extreme events like El Niño and increase resilience of low-input farming systems.

Keywords: Climate-smart agriculture, Conservation agriculture, Drought tolerant maize, Heat tolerant maize

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DOI: <https://doi.org/10.1016/j.agee.2018.09.006>

Yield response and economic performance of participatory evaluated elite vegetable cultivars in intensive farming systems in Tanzania {Journal article}

Citation

Lukumay, P.J., Afari-Sefa, V., Ochieng, J., Dominick, I., Coyne, D. and Chagomoka, T. 2018. Yield response and economic performance of participatory evaluated elite vegetable cultivars in intensive farming systems in Tanzania. *Acta Horticulturae*, 1205, 75-86.

Abstract

Yield response and economic performance of farmer selected and preferred elite tomato (*Lycopersicon esculentum* 'Tengeru 2010'); African eggplant (*Solanum aethiopicum* 'Tengeru white') and amaranth (*Amaranthus cruentus* 'Madiira I') cultivars were undertaken in four communities located in Babati district, Tanzania, using the mother/baby field trial approach with a randomized complete block experimental layout. The trials were carried out over two annual production seasons to study the yield and profitability performance of elite vegetable cultivars grown under selected integrated management practices (IMPs), namely: healthy seedlings, good agronomic practices, and integrated pest management in comparison with standard farmer practices (SFPs). Input-output data from 16 plots showed that IMPs led to significant yield and profit increase ($p < 0.001$) of up to 64.40 t ha⁻¹ compared to 28.28 t ha⁻¹ with a benefit-cost ratio (BCR) of 8.5 for tomato, and 53.45 t ha⁻¹ compared to 23.04 t ha⁻¹ (BCR=4.50) for African eggplant. Good quality seeds of improved cultivars were found to add 50 t ha⁻¹ to tomato and African eggplant yields, with healthy seedlings adding a further 30 t ha⁻¹ to the total yield compared to the control. IMPs significantly reduced ($p < 0.005$) pest and disease incidence for tomato and African eggplant as well as reducing the frequency and quantity of chemical pesticides applied from 0.045 to 0.012 t ha⁻¹, a good sign of environmental compliance.

Keywords: field trials; African; amaranth; tomato; integrated management practices; benefit-cost ratio

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Year 2017

Accounting for correlation among environmental covariates improves delineation of extrapolation suitability index for agronomic technological packages {Journal article}

Citation

Muthoni, F.K., Baijukya, F., Bekunda, M., Sseguya, H., Kimaro, A., Alabi, T., ... and Hoeschle-Zeledon, I. 2017. Accounting for correlation among environmental covariates improves delineation of extrapolation suitability index for agronomic technological packages. *Geocarto International*, 1-23.

Abstract

This paper generates an extrapolation suitability index (ESI) to guide scaling-out of improved maize varieties and inorganic fertilizers. The best-bet technology packages were selected based on yield gap data from trial sites in Tanzania. A modified extrapolation detection algorithm was used to generate maps on two types of dissimilarities between environmental conditions at the reference sites and the outlying projection domain. The two dissimilarity maps were intersected to generate ESI. Accounting for correlation structure among covariates improved estimate of risk of extrapolating technologies. The covariate that highly limited the suitability of specific technology package in each pixel was identified. The impact based spatial targeting index (IBSTI) identified zones that should be prioritized to maximize the potential impacts of scaling-out technology packages. The proposed indices will guide extension agencies in targeting technology packages to suitable environments with high potential impact to increase probability of adoption and reduce risk of failure.

Keywords: maize; food security; sustainable agriculture; big data; novel correlation; priority setting; risk of failure; spatial targeting

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DOI: <https://doi.org/10.1080/10106049.2017.1404144>

Aflatoxin contamination of groundnut and maize in Zambia: observed and potential concentrations {Journal article}

Citation

Kachapulula, P.W., Akello, J., Bandyopadhyay, R., & Cotty, P.J. 2017. Aflatoxin contamination of groundnut and maize in Zambia: observed and potential concentrations. *Journal of Applied Microbiology*. 1-32

Abstract

Aims: The aims of the study were to quantify aflatoxins, the *potentcarcinogens* associated with stunting and immune suppression, in maize and groundnut across Zambia's three agroecologies and to determine the vulnerability to aflatoxin increases after purchase.
Methods and Results: Aflatoxin concentrations were determined for 334 maize and groundnut samples from 27 districts using lateral-flow immunochromatography. Seventeen per cent of crops from markets contained aflatoxin concentrations above allowable levels in Zambia (10 µg/kg). Proportions of crops unsafe for human consumption differed significantly ($P < 0.001$) among agroecologies with more contamination (38%) in the warmest (Agroecology I) and the least (8%) in cool, wet Agroecology III. Aflatoxin in groundnut (39 µg/kg) and maize

(16lgkg¹) differed (P=0.032). Poor storage (31°C, 100% RH, 1 week) increased aflatoxin in safe crops by over 1000-fold in both maize and groundnut. The L morphotype of *Aspergillus flavus* was negatively correlated with postharvest increases in groundnut.

Conclusions: Aflatoxins are common in Zambia's food staples with proportions of unsafe crops dependent on agroecology. Fungal community structure influences contamination suggesting Zambia would benefit from biocontrol with atoxigenic *A. flavus*. Significance and Impact of the Study: Aflatoxin contamination across the three agroecologies of Zambia is detailed and the case for aflatoxin management with atoxigenic biocontrol agents provided. The first method for evaluating the potential for aflatoxin increase after purchase is presented.

Keywords: maize; groundnuts; aflatoxins; agroecologies; *aspergillus section flavi*

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DOI: <https://doi.org/10.1111/jam.13448>

Analysis of good agricultural practices in an integrated maize-based farming system {Journal article}

Citation

Lazaro, V., Rajendran, S., Afari-Sefa, V. and Kazuzuru, B. 2017. Analysis of good agricultural practices in an integrated maize-based farming system. *International Journal of Vegetable Science*

Abstract

Profitability due to use of good agricultural practices (GAPs) is important for improving farmer return on investment. Although GAPs are theoretically expected to be profitable, actual returns accrued to farmers may not necessarily be realized due to shortfalls in profit to farmers after harvest. Farmers cultivate vegetables because of their high farmgate values and profitability per unit area compared to field crops. However, farmers sometimes experience reduced profits due to lack of awareness and technical know-how on improved technologies, lack of bargaining power at market, and lack of access to market information and high-value markets. The objective of the study was to measure gross margin of GAPs introduced to farmers using a financial cost–benefit analysis approach. In 2013, a field survey of 45 randomly selected farm households was administered to elicit enterprise data on production practices including Tomato (*Solanum lycopersicum* L.) and other crops before intervention of GAPs. A similar survey was carried out in the GAP intervention area in 2014 from 55 randomly selected farm households. Integrating GAPs within existing maize-based farming systems yielded an average gross margin of US\$1870·ha⁻¹ for vegetable producers who primarily produce tomato, African Eggplant (*S. aethiopicum* L.), cv. DB3, and Amaranth (*Amaranthus spinosus* L.), cv. Madiira 1, compared to standard farmer practices that yielded a gross margin of US\$1846·ha⁻¹ during the study. Profit from the introduced GAPs was not statistically different from traditional practices within the short time duration. Whether the introduced GAPs could enhance farmer net crop income and livelihood over the long term needs to be determined.

Keywords: farming systems; crops; intensification

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DOI: <https://doi.org/10.1080/19315260.2017.1341445>

Application of secondary nutrients and micronutrients increases crop yields in sub-Saharan Africa {Journal article}

Citation

Kihara, J., Sileshi, G. W., Nziguheba, G., Kinyua, M., Zingore, S., and Sommer, R. 2017. Application of secondary nutrients and micronutrients increases crop yields in sub-Saharan Africa. *Agronomy for Sustainable Development* 37:25.

Abstract

Secondary and micronutrients are important in enhancing crop productivity; yet, they are hardly studied in sub-Saharan Africa. In this region, the main focus has been on macronutrients but there is emerging though scattered evidence of crop productivity limitations by the secondary and micronutrients. Elsewhere, widespread deficiencies of these nutrients are associated with stagnation of yields. Here, we undertake a meta-analysis using 40 articles reporting crop response to secondary and micronutrients to (1) determine the productivity increase of crops and nutrient use efficiency associated with these nutrients, and (2) provide synthesis of responses to secondary nutrients and micronutrients in sub-Saharan Africa. This study used 757 yield data rows (530 from publications and 227 from Africa Soil Information Service) from field trials carried out in SSA between 1969 and 2013 in 14 countries. Data from publications constituted response to S (49.4%), Zn (23.0%), S and micronutrient combinations (11.5%), and <10% each for Cu, Mo, Fe, and B. Data from Africa Soil Information Service were all for S and micronutrient combinations. Of the two sources, most yield data are for maize (73.6%), followed by sorghum (6.7%) and wheat (6.1%) while rice, cowpea, faba bean, tef, and soybean each accounted for less than 5%. The major points are the following: (1) application of S and micronutrients increased maize yield by 0.84 t ha⁻¹ (i.e., 25%) over macronutrient only treatment and achieved agronomic efficiencies (kilograms of grain increase per kilogram of micronutrient added) between 38 and 432 and (2) response ratios were >1 for S and all micronutrients, i.e., the probability of response ratio exceeding 1 was 0.77 for S and 0.83 for Zn, 0.95 for Cu, and 0.92 for Fe, and indicates positive crop response for a majority of farmers. We conclude that S and micronutrients are holding back crop productivity especially on soils where response to macronutrients is low and that more research is needed to unravel conditions under which application of S and micronutrients may pose financial risks.

Keywords: Agronomic efficiency, Boundary analysis, Meta-analysis, Sulfur, Effect size , Response ratio

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DOI: <https://doi.org/10.1007/s13593-017-0431-0>

Automated cropland mapping of continental Africa using Google Earth Engine cloud computing {Journal article}

Citation

Jun Xiong, Thenkabail, P.S., Gumma, M.K., Teluguntla, P., Poehnelt, J., Congalton, R.G., Yadav, K. and Thau, D. 2017. Automated cropland mapping of continental Africa using Google Earth Engine cloud computing. *ISPRS Journal of Photogrammetry and Remote Sensing* 126:225–244.

Abstract

The automation of agricultural mapping using satellite-derived remotely sensed data remains a challenge in Africa because of the heterogeneous and fragmental landscape, complex crop cycles, and limited access to local knowledge. Currently, consistent, continent-wide routine cropland mapping of Africa does not exist, with most studies focused either on certain portions of the continent or at most a one-time effort at mapping the continent at coarse resolution remote sensing. In this research, we addressed these limitations by applying an automated cropland mapping algorithm (ACMA) that captures extensive knowledge on the croplands of Africa available through: (a) ground-based training samples, (b) very high (sub-meter to five-meter) resolution imagery (VHRI), and (c) local knowledge captured during field visits and/or sourced from country reports and literature. The study used 16-day time-series of Moderate Resolution Imaging Spectroradiometer (MODIS) normalized difference vegetation index (NDVI) composited data at 250-m resolution for the entire African continent. Based on these data, the study first produced accurate reference cropland layers or RCLs (cropland extent/areas, irrigation versus rainfed, cropping intensities, crop dominance, and croplands versus cropland fallows) for the year 2014 that provided an overall accuracy of around 90% for crop extent in different agro-ecological zones (AEZs). The RCLs for the year 2014 (RCL2014) were then used in the development of the ACMA algorithm to create ACMA-derived cropland layers for 2014 (ACL2014). ACL2014 when compared pixel-by-pixel with the RCL2014 had an overall similarity greater than 95%. Based on the ACL2014, the African continent had 296 Mha of net cropland areas (260 Mha cultivated plus 36 Mha fallows) and 330 Mha of gross cropland areas. Of the 260 Mha of net cropland areas cultivated during 2014, 90.6% (236 Mha) was rainfed and just 9.4% (24 Mha) was irrigated. Africa has about 15% of the world's population, but only about 6% of world's irrigation. Net cropland area distribution was 95 Mha during season 1, 117 Mha during season 2, and 84 Mha continuous. About 58% of the rainfed and 39% of the irrigated were single crops (net cropland area without cropland fallows) cropped during either season 1 (January-May) or season 2 (June-September). The ACMA algorithm was deployed on Google Earth Engine (GEE) cloud computing platform and applied on MODIS time-series data from 2003 through 2014 to obtain ACMA-derived cropland layers for these years (ACL2003 to ACL2014). The results indicated that over these twelve years, on average: (a) croplands increased by 1 Mha/yr, and (b) cropland fallows decreased by 1 Mha/year. Cropland areas computed from ACL2014 for the 55 African countries were largely underestimated when compared with an independent source of census-based cropland data, with a root-mean-square error (RMSE) of 3.5 Mha. ACMA demonstrated the ability to hind-cast (past years), now-cast (present year), and forecast (future years) cropland products using MODIS 250-m time-series data rapidly, but currently, insufficient reference data exist to rigorously report trends from these results.

Keywords: Cropland mapping, Classification, MODIS, Remote sensing products, Google Earth Engine, Africa, Automated cropland mapping algorithm

Link: <https://www.sciencedirect.com/science/article/pii/S0924271616301575>

Creating adaptive farm typologies using Naive Bayesian classification {Journal article}

Citation

Paas, W. and Groot, J.C.J. 2017. Creating adaptive farm typologies using Naive Bayesian classification. *Information Processing in Agriculture* 4(3): 220-227.

Abstract

The applicability of statistical typologies that capture farming systems diversity in innovation and development projects would increase if their adaptability would be enhanced, so that newly encountered farms can be classified and used to update the typology. In this paper we propose Naïve Bayesian (NB) classification as a method to allocate farms to types by using only a few variables, thus allowing the addition of new entries to a typology. We show for two example datasets that the performance of NB classification is already acceptable when 50% of the original survey dataset to construct the typology is used for training the NB classifier. For our datasets, the performance of Naïve Bayesian classification was improved when probabilities for observations to belong to multiple types were used, requiring a sample size of 30% of the survey dataset. Based on the results in this paper, we argue that NB classification is a powerful and promising statistical approach to increase the adaptability and usability of farm typologies.

Keywords: Farming systems, Data distributions, Clustering, Diversity

DOI: <https://doi.org/10.1016/j.inpa.2017.05.005>

Distribution of maize lethal necrosis disease, its causal viruses and alternative hosts in the north central regions of Tanzania {Thesis and Dissertation}

Citation

Mariki, A. 2017. Distribution of maize lethal necrosis disease, its causal viruses and alternative hosts in the north central regions of Tanzania. MSc thesis in Crop Science. Kampala, Uganda: Makerere University.

Abstract

Maize is an important income generating food crop in Tanzania. However, yields remain low due to several limiting factors including among other diseases caused by fungi and viruses. The threat caused by several biotic factors in the country was further worsened with an outbreak of maize lethal necrosis (MLN) disease in 2012 in Arusha and Mwanza regions. Maize lethal necrosis is a disease caused by the synergistic interaction between Maize chlorotic mottle virus (MCMV) and Sugarcane mosaic virus (SCMV). Of these two, MCMV is a new virus in the African continent, first recognized in an MLN outbreak in Kenya, whereas SCMV is known to be endemic in Africa. This study focused on understanding the extent of MLN spread in north-central regions of Tanzania by conducting surveys between February and June 2015. A total of 163 farmers' fields were sampled, in 14 districts in Arusha, Dodoma and Manyara regions. Incidence and severity were estimated based on MLN symptoms such as chlorosis, mottling and necrosis. The Enzyme – linked immunosorbent assays (ELISA) and reverse transcription-polymerase chain reaction (RT-PCR) methods were used for the detection of MCMV and SCMV in field samples. Disease severity assessed on a 1 to 5 rating scale varied from 2 to 3.6, with an overall mean incidence of 16.1%. Thirty nine percent of the samples tested positive to MCMV, 22% for SCMV and 5.5% for both MCMV and SCMV. A

total of 254 non-maize crops and weeds tested for MCMV and SCMV, revealed SCMV in 7 samples (2.8%) in sugarcane (*Saccharum officinarum*), finger millet (*Eleusine coracana*), sorghum (*Sorghum bicolor*) and bristly foxtail (*Setaria verticillata*). The nucleotide sequence of the coat protein region of MCMV showed very high levels of homology (99%) between MCMV from Tanzania and those from Kenya and other countries. However, the SCMV nucleotide sequence of the coat protein region was divergent by up to 11%, compared to other isolates. This study confirmed the occurrence of MLN in 13/14 districts surveyed and also showed that SCMV occurs in maize as well as other cereal hosts. Further study of pathogen diversity and factors contributing towards disease occurrence is recommended as interventions for disease management are developed and deployed at various levels.

Keywords: maize; intensification

Link: <https://hdl.handle.net/10568/81213>

Does crop diversity contribute to dietary diversity? evidence from integration of vegetables into maize-based farming systems {Journal article}

Citation

Rajendran, S., Afari-Sefa, V., Shee, A., Bocher, T., Bekunda, M., Dominick, I. & Lukumay, P.J. (2017). Does crop diversity contribute to dietary diversity? evidence from integration of vegetables into maize-based farming systems. *Agriculture & Food Security*, 6(50), 1-13.

Abstract

Background Maize is the most important staple crop for food security and livelihood of smallholder farmers in many parts of sub-Saharan Africa, but it alone cannot ensure food security. Cropping patterns must be diversified to ensure an adequate supply and economic access to greater variety of foods for smallholder farm households. This study measured the effect of crop diversification on household dietary diversity in a selected study locale using a survey of 300 randomly stratified farm households in 10 villages located in the Babati, Kongwa and Kiteto districts of Tanzania.

Results Based on multiple regression analysis, the study found that simply increasing Simpson's Index does not influence dietary diversity of farm households due to the presence of interaction effect between Simpson's Index and crop income. It is much more critical and significant to increase the revenue generated from diversified crops along with other socioeconomic endowment and behavioral characteristics of farm households. This is particularly applicable to poorer smallholder farmers who receive crop income less than US\$85 per sales transaction and per season. Particularly, marginal and smallholders might be exposed to the effects of crop diversification and crop income toward increasing in their household dietary diversity score.

Conclusion under average crop income scenarios, households that diversify their crop production tend to increase their dietary diversity from their existing dietary diversity score at a decreasing rate. However, under below average crop income threshold scenarios, farmers tend to increase their dietary diversity score from their existing score at an increasing rate when they diversify into high-value crops that attract relatively high farm gate values and accrue higher net revenues from the market. Monthly food expenditure also tends to positively influence household dietary diversity, indicating that farm households that spend more on market-purchased food have consistent increases in their dietary

diversity scores at the household level. This study concludes that improving economic access to variety of foods at the smallholder household level by diversifying diets through increased crop diversification should be encouraged within maize-based farming systems of the study locale, through integration of micronutrient-rich foods such as vegetables.

Keywords: Agriculture & Food Security

Link: DOI: 10.1186/s40066-017-0127-3

Economic cost evaluation of selected vegetable post-harvest losses in Babati District Tanzania {Thesis and Dissertation}

Citation

Mtui, M.A. 2017. Economic cost evaluation of selected vegetable post-harvest losses in Babati District Tanzania. MSc thesis in Agricultural Economics. Nakuru, Kenya: Egerton University.

Abstract

Vegetables remain an important source of nutrients in many parts of the world as they contain essential micronutrients, vitamins, antioxidants, and other health-related phytochemicals. They complement staple-based diets. Economically, vegetable production and marketing has a potential of high profit, employment, income generation and increasing commercialisation of the rural areas. However, vegetables are highly perishable and as such most actors in the vegetable value chain incur high post-harvest losses. In Tanzania, research on vegetable post-harvest losses is limited, yet post-harvest loss reduction may substantially contribute to higher returns leading to improving quality of lives of farmers and other actors in the supply chain. The study quantified the economic post-harvest losses of African eggplant, amaranth and tomatoes along the supply chain, determined the principal causal factors contributing to selected vegetable postharvest losses and the factors influencing the choice of post-harvest handling practices and techniques. A multi-stage sampling design was adopted for the ultimate selection of 200 vegetable farmers, 50 retailers and 50 wholesalers in Babati district. Descriptive statistics was used to determine the economic post-harvest losses of African eggplant, Amaranth, and Tomato. The log-linear regression model was used to determine the principal causal factors contributing to vegetables post-harvest losses and multivariate probit model was used to determine factors that influence farmers' choice of post-harvest handling techniques and practices. Results showed that farm level vegetable post-harvest losses were higher compared to retail and wholesale market levels. This study found that economic postharvest losses incurred per individual per season for Eggplant were TZS 408,800, TZS 111, 650 and TZS 255,000; Amaranth TZS 181,500, TZS 23,650 and TZS 16,800 and Tomatoes TZS 918,500, TZS 237,000 and TZS 182,100 for farmers, retailers and wholesalers respectively. Field pests and diseases, delays in harvesting or selling and poor storage conditions were the principal causal factors contributing to vegetable postharvest losses along the supply chain. Lastly quantity harvested, education level and access to extension services had significant ($p < 0.1$) positive influence on choice of post-harvest handling techniques while household income and farm-size had significant ($p < 0.1$) negative influence. As a result, there is a need for equipped storage facilities, training on vegetable postharvest handling and marketing, and promotion of simple and cost-effective postharvest technologies among the supply chain actors.

Keywords: crops; farming systems; intensification; livestock; poultry

Link: <https://hdl.handle.net/10568/106354>

Engaging smallholder-farmers in model-based identification of alternative options, trade-offs, and synergies for sustainable intensification in North-Tanzania {Thesis and Dissertation}

Citation

Kirimbo, G.E. 2017. Engaging smallholder-farmers in model-based identification of alternative options, trade-offs, and synergies for sustainable intensification in North-Tanzania. MSc thesis. Wageningen, The Netherlands: Wageningen University and Research Centre.

Abstract

Crop-livestock farming systems in Babati are under severe pressure from a fast-growing human population. Continuing soil fertility degradation and the extinction of communal resources are linked to low crop yields and high poverty rates among the smallholder farmers. Alternative intensification options such as the use of improved seeds, phosphorus-based fertilizers and manure in maize-pigeon pea intercrop and tomato as a new crop have been proposed by the Africa RISING project to improve farm productivity. The feasibility of these field level options needs to be assessed at farm-scale to give insight into the interactions between crops, soils, animals, and the household. We used the farm-scale model, Farm DESIGN, to explore alternative options for differently resource endowed farms to enhance their farm performances in terms of economic, environmental, and social indicators by combining the current farm resources with the AR interventions.

Two sample farms of each farm type were selected. In addition, the study attempted to engage smallholder farmers and extension workers. Data for the current farms were obtained from a previous study while data for the novel interventions were gathered from literature reviews and ongoing research experiments. The windows of opportunities and the preferred innovations depended on available land sizes, current cropping systems and livestock ownership. The High Resource Endowed farms showed widest ranges of potential improvements in terms of operating profit followed by the Medium Resource Endowed farms while the Low Resource Endowed farms showed modest improvements. Improvements in terms of operating profit and soil organic matter were possible by reducing area under the currently grown crops and adopting the Africa RISING interventions. However, often strong trade-offs with household leisure time were evident due to the high labour demand of these inventions. Cultivation of the high value tomato crop with its characteristic low soil organic matter inputs created strong trade-offs between operating profit and organic matter balance.

Adopting the new practices of maize-pigeon pea intercrop, maintaining or slightly increase animal numbers as well as incorporating a portion of the crop residues into the soil played a key role in increasing organic matter balances on all farm types. The interactions with farmers allowed virtual experiential learning to take place and provided evidence that the farmers found the simulation outcomes credible and meaningful. We conclude that the model is an effective tool in exploring windows of opportunity within smallholder farming systems and promotes the discussion of future farm development options between smallholder farmers and extension workers.

Keywords: mixed farming; farming systems; intensification; crops; livestock

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Ex-ante welfare impacts of adopting maize-soybean rotation in eastern Zambia {Journal article}

Citation

Manda, J., Alene, A.D., Mukuma, C. and Chikoye, D. 2017. Ex-ante welfare impacts of adopting maize-soybean rotation in eastern Zambia. *Agriculture, Ecosystems & Environment* 249:22-30

Abstract

This paper estimates the welfare impacts of adoption of maize-soybean rotation in eastern Zambia using data from on-farm trials and household survey data collected from over 800 households. The on-farm trials were conducted from 2012 to 2015 while the household survey was conducted in 2012. The study evaluated maize-soybean rotation where soybean was grown with and without inoculants and inorganic fertilizer, whereas continuous maize cropping was used as a control. The paper estimated household level income changes and poverty reduction due to adoption of maize-soybean rotation using market level economic surplus as well as household level analyses to allocate economic surplus changes to individual households. The results showed that several factors influence the adoption of maize-soybean rotation, including land ownership, education, and age of the household head. Results also showed that adoption of maize-soybean rotation reduced per-unit production costs by between 26 and 32% compared to continuous maize. Ex-ante welfare impact analysis showed significant potential income gains and poverty reduction following adoption of maize-legume rotation in eastern Zambia. The paper concludes with implications for policy to promote wider adoption of soil fertility management practices such as maize-soybean rotation for increased maize productivity in Zambia.

Keywords: farming systems; crops; intensification; maize; legumes

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DOI: <https://doi.org/10.1016/j.agee.2017.07.030>

Exploring options for sustainable intensification through legume integration in different farm types in eastern Zambia {Book chapter}

Citation

Timler, C., Michalscheck, M., Alvarez, S., Descheemaeker, K. and Groot, J.C.J. 2017. Exploring options for sustainable intensification through legume integration in different farm types in eastern Zambia. IN: Oborn, I. et al. (eds), *Sustainable Intensification in Smallholder Agriculture: An Integrated Systems Research Approach*. UK: Routledge: 196-209

Abstract

This chapter aims to perform an ex-ante evaluation of farm-type specific interventions for sustainable intensification and innovation at the farm level. In eastern Zambia, the livelihoods of small-scale farmers depend largely on maize-legume mixed systems characterised by low productivity, extreme poverty and environmental degradation. A baseline survey was conducted in 2011/2012 in Eastern Zambia to obtain an initial description of the local farming systems and their diversity, and to derive a statistical farm typology. The information derived from the modelling is important in guiding discussions between farmers and stakeholders towards the selection of farm designs that are likely to be adopted by target farmers. In FarmDESIGN, the windows of opportunities are defined using

fixed assumptions on the achievable yields and market prices. However, in real conditions, farmers have to make decisions early in the cropping season under uncertainties on the future production and market situations.

Permanent link to cite or share this item: <https://hdl.handle.net/10568/89048>

External link to download this item: <https://books.google.com/books?id=nislDwAAQBAJ>;
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DOI: <https://doi.org/10.4324/9781315618791>

Gender dynamics in smallholder vegetable production: insights from Tanzania {Thesis and Dissertation}

Citation

Patt, N. 2017. Gender dynamics in smallholder vegetable production: insights from Tanzania. MSc thesis in Geographical Development Studies. Berlin, Germany: Freie Universität Berlin.

Abstract

The presented study investigates gender dynamics in vegetable producer's households as related to labor, income, and expenditure allocation – as field that has not yet been sufficiently covered by research. It is conducted in cooperation with the “Africa Research in Sustainable Intensification for the Next Generation” (Africa RISING) project funded by the United States Agency for International Development (USAID) and led by the International Institute of Tropical Agriculture (IITA). The study focuses on farmers in Babati, Kiteto and Kongwa districts in northern and central Tanzania. Quantitative data was collected during a survey with 403 male and female farmers in nine villages. Later on, we conducted focus group discussions with sex-separated farmer groups and expert interviews with male and female extension officers. Thus, we validated the quantitative data, investigated on underlying causes for gender inequalities and identified entry points for additional research and development interventions. The survey results show that men and women have different perceptions of labor, income, and expenditure allocation within the households. Following this, the qualitative research revealed that both men and women keep information on their individual income confidential in order to strengthen their position in intra-household negotiations. Moreover, both complain about their partner's lack of contribution to the household economy and production activities. Nevertheless, both qualitative and quantitative data indicate that men have higher income and are in power when it comes to moneyrelated decisions, while women remain economically dependent. Women explain their dependence with men's control of access to land, financial capital, knowledge, and markets. Men on the other hand named women's physical limitations and poor money management skills as reasons that prevent them from progressing economically through vegetable farming. Both stated that domestic labor prevents women from getting more involved in farming activities. The analysis shows that distrust and low cooperation within the households constitute obstacles for food security, poverty alleviation and women empowerment. Therefore, we emphasize the necessity of including men in gender transformative approaches in agricultural research and development.

Keywords: agriculture; gender; vegetables; smallholder agriculture; income security; women's empowerment

Link: <https://hdl.handle.net/10568/90680>

Geospatial approach for delineating extrapolation domains for sustainable agricultural intensification technologies

{Journal article}

Citation

Muthoni, F.K., Baijukya, F., Sseguya, H., Bekunda, M., Hoeschle-Zeledon, I., Ouko, E. and Mubea, K. 2017. Geospatial approach for delineating extrapolation domains for sustainable agricultural intensification technologies. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XLII-3/W2:145-149.

Abstract

Sustainable intensification (SI) is a viable pathway to increase agricultural production and improve ecosystem health. Scaling SI technologies in locations with similar biophysical conditions enhance adoption. This paper employs novel extrapolation detection (ExeDet) algorithm and gridded bioclimatic layers to delineate extrapolation domains for improved maize variety (SC719) and inorganic fertilizers (YaraMila-CEREAL® and YaraBela-Sulfan®) in Tanzania. Suitability was based on grain yields recorded in on-farm trials. The ExeDet algorithm generated three maps: (1) the dissimilarity between bioclimatic conditions in the reference trial sites and the target extrapolation domain (Novelty type-1), (2) the magnitude of novel correlations between covariates in extrapolation domain (Novelty type-2) and (3) the most limiting covariate.

The novelty type1 and 2 maps were intersected and reclassified into five suitability classes. These classes were cross tabulated to generate extrapolation suitability index (ESI) for the candidate technology package. An impact based spatial targeting index (IBSTI) was used to identify areas within the zones earmarked as suitable using ESI where the potential impacts for out scaling interventions can be maximized. Application of ESI and IBSTI is expected to guide extension and development agencies to prioritize scaling intervention based on both biophysical suitability and potential impact of particular technology package. Annual precipitation was most limiting factor in largest area of the extrapolation domain. Identification of the spatial distribution of the limiting factor is useful for recommending remedial measures to address the limiting factor that hinder a technology to achieve its full potential. The method outlined in this paper is replicable to other technologies that require extrapolation provided that representative reference trial data and appropriate biophysical grids are available.

Key words: Extrapolation Suitability Index, correlation structure, inorganic fertilizers, GIS, improved maize varieties, scaling out, spatial targeting, Tanzania

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DOI: <https://doi.org/10.5194/isprs-archives-XLII-3-W2-145-2017>

Influence of farmer organizations as a market information system on market access and income of smallholder vegetable farmers in Babati District, Tanzania {Thesis and Dissertation}

Citation

Aku, A.O. 2017. Influence of farmer organizations as a market information system on market access and income of smallholder vegetable farmers in Babati District, Tanzania. MSc thesis in Agricultural Economics. Nakuru, Kenya: Egerton University.

Abstract

Vegetable production is of great importance in terms of nutrition improvement, income generation and food security. Africa Research in Sustainable Intensification for the Next Generation (Africa RISNG) action research project actively integrates vegetable farming and marketing practices in order to reduce the vulnerability of indigenous populations of Babati district located in the Manyara region of Tanzania. In Tanzania smallholder vegetable farmers receive asymmetrical and incomplete market information which is costly. Mobilizing farmers into groups so as to access viable market information while enhancing their bargaining power is one way to overcome this challenge. However, the extent to which this has been achieved has not yet been evaluated.

This study sought to evaluate the influence of farmer organizations towards improving smallholder income in Babati. Objectives of the study were: to determine types of market information accessed by smallholder vegetable farmers through farmer organizations, determine factors influencing information seeking behaviour of vegetable farmers and determine effect of access to market provided by farmer organizations on smallholder vegetable farmer's income. The target population was smallholder farmers who grow vegetables within maize based farming systems. Multi-stage sampling technique was employed where by 250 smallholders' vegetable farmers were interviewed using structured questionnaire. The results showed that the type of market (29%) is the most type of market information accessed by vegetable farmer through farmer organization. From the Poisson model the results show that distance to the market information source point has a negative influence on farmer's information seeking behaviour. In contrast, gender, education, income and group membership had a significant positive relationship with farmers' information seeking behaviour.

In estimating the effect of access to market provided by farmer organizations on smallholder vegetable farmer's income, Propensity Score Matching (PSM) was used. The results indicate that farmers who had access to the market provided by farmer organization have more income (501691.413 TZS) than non-member (405471.429 TZS). From the results, it is recommended that an enabling policy environment that establishes and strengthens farmer organizations be supported. This will assist in transforming smallholder farming as viable business ventures through increased productivity and increased household incomes while reducing rural poverty.

Keywords: farming systems; vegetables; markets

Link: <https://hdl.handle.net/10568/90677>

Insect antagonistic bio-inoculants for natural control of leaf-mining insect pests of French beans {Journal article}

Citation

Akello, J., Chabi-Olaye, A. and Sikora, R. 2017. Insect antagonistic bio-inoculants for natural control of leaf-mining insect pests of French beans. *African Crop Science Journal* 25(2):237–251.

Abstract

Fungal endophytes, specifically, *Trichoderma asperellum*, *Beauveria bassiana* and *Metarhizium anisopliae*; strains M2RT4, S4SU1 and S4ST7, respectively, are known to deter aphid infestation and damage to leguminous crops, but no research exists on their biochemical profiles and effects on French bean (*Phaseolus vulgaris*) leaf miners. The objective of this study was to assess the ability of these endophytic bio-inoculants to produce extracellular enzymes, as well as determine their impact on French beans seedling emergence and growth, and leaf miner fecundity and pupation. Laboratory and greenhouse experiments were conducted at the International Centre of Insect Physiology and Ecology (ICIPE, Nairobi), and the University of Bonn (Germany). Bio-priming French bean seeds by soaking in fungal suspension containing 10⁸ conidia/ml for 4 hr positively impacted on seedling vigour. Six weeks after germination, all bio-inoculant treatments improved nodulation by 1.5-1.7 folds, while S4SU1 and M2TR4 improved shoot biomass by ~ 2g. In vitro, spore suspensions of these isolates were highly toxic to leaf miner larvae, often resulting in high mortalities and a suppression of pupation by over 70%. All tested isolates exhibited protease (Index=1.22), lipase (Index=1.32) and cellulase (Index=1.06) activities; with *M. anisopliae* being the best enzyme secretor when cultured under dark conditions on enzyme-specific substrate for 7-14 days. In vivo *B. bassiana*-primed seedlings deterred larval feeding and development, resulting in reduced number of larvae, pupae and adults, by 65.3, 43.2 and 54.0%, respectively. For the first time, this study showed that bio-priming French bean seeds with bio-inoculants can boost *P. vulgaris* growth and nodulation, consequently altering its interaction and response to leaf miner infestation, feeding and damage to treated seedlings. These bioinoculants, thus, hold great potential as crop protection agents and could be safely used for priming seeds prior to planting, if leaf mining damages and associated yield losses in French beans are to be minimised in an environmentally sound manner. Further studies should be undertaken to elucidate the mechanisms involved in plant growth promotion, nodulation and insect feeding deterrence.

Keywords: crops, beans, pests of plants

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DOI: <https://doi.org/10.4314/acsj.v25i2.8>

Maize-legume intercropping in central Malawi: Determinants of practice {Journal article}

Citation

Silberg, T.R., Richardson, R.B., Hockett, M. and Snapp, S.S. 2017. Maize-legume intercropping in central Malawi: Determinants of practice. *International Journal of Agricultural Sustainability*

Abstract

In Malawi, population growth has reduced opportunities for farmers to expand and cultivate new land. The country's primary farming population is comprised of smallholders, many who cultivate monocultures of maize (*Zea mays*). To reduce negative outcomes from this practice, intercropping maize with legumes has been promoted. The sustainable intensification (SI) practice was once widely used but has declined in recent decades. Little is known about the determinants of intercropping or its role in agricultural development. The objective of this study was to examine the drivers of intercropping among smallholders. We used multiple logistic regression analysis to estimate the determinants of intercropping based on a survey of 324 households. Smallholders who sold legumes were more likely to intercrop, contrary to literature positing intercropping as a practice primarily intended to enhance food security. In addition, complementary SI practices such as fertilizer, manure and compost application were more likely to have occurred on intercropped fields relative to sole maize fields. Furthermore, smallholder farmers appeared to apply more fertilizer to their intercropped fields relative to their sole maize fields. The study highlights the value of including field-level characteristics and household socioeconomic survey data to understand farming practices as a means to inform agricultural policy.

Keywords: farming systems; intensification; crops; legumes; food security

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DOI: <https://doi.org/10.1080/14735903.2017.1375070>

mapping land suitability for agriculture in Malawi {Journal article}

Citation

Li, G., Messina, J.P., Peter, B.G. and Snapp, S.S., 2017. Mapping land suitability for agriculture in Malawi. *Land degradation & development*, 28(7), pp.2001-2016.

Abstract

Population growth, climate sensitivity, and edaphic properties are important factors that influence decision-making and risk mitigation for agricultural production. Within the agricultural sector in Malawi, continuous cropping without the use of long-term sustainable strategies and frequent cultivation on marginal lands have resulted in continually declining soil fertility. Improving soil quality of marginal lands using innovative technologies is imperative for increasing agricultural productivity and improving food security. Here, we propose an ensemble approach to map agricultural land suitability and identify the distribution of marginal land in Malawi. Quantitative data available for eight soil and terrain factors were rated individually, and five distinct models were applied to generate a spatial distribution map of land suitability. The results indicate that highly suitable, moderately suitable, marginally suitable, and unsuitable agricultural areas account for 8.2%, 24.1%, 28.0%, and 39.7% of the total land area, respectively. The majority of suitable lands are

currently used for agriculture, but more than half (57.4%) of Malawi's total cropland exists on marginally suitable or unsuitable land categories and is likely a candidate for rehabilitation through sustainable agricultural practices. The methods and products herein will be valuable resources for effectively managing and improving Malawi's agricultural lands for increasing food security. Copyright © 2017 John Wiley & Sons, Ltd.

Keywords: land suitability; spatial models; sustainable agriculture; soil rehabilitation; Malawi
Link: <https://doi.org/10.1002/ldr.2723>

Measuring sustainable intensification in smallholder agroecosystems: A review {Journal article}

Citation

Smith, A., Snapp, S., Chikowo, R., Thorne, P., Bekunda, M. and Glover, J. 2017. Measuring sustainable intensification in smallholder agroecosystems: a review. *Global Food Security* 12:127–138.

Abstract

Sustainable intensification (SI) is at the forefront of food security discussions as a means to meet the growing demand for agricultural production while conserving land and other resources. A broader definition of SI is emerging that takes into account the human condition, nutrition, and social equity. Next steps require identification of indicators and associated metrics, to track progress, assess tradeoffs and identify synergies. Through a systematic, qualitative review of the literature we identified SI indicators, with a primary focus on African smallholder farming systems. We assessed indicators and metrics for which there is consensus, and those that remain contested. We conclude that, while numerous metrics for evaluating SI systems exist, many often-cited indicators lack strong sets of associated metrics.

Keywords: sustainability; indicators; agricultural development; food security; smallholders
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DOI: <https://doi.org/10.1016/j.gfs.2016.11.002>

Nature-based agricultural solutions: Scaling perennial grains across Africa {Journal article}

Citation

Peter, B.G., Mungai, L.M., Messina, J.P. and Snapp, S.S., 2017. Nature-based agricultural solutions: scaling perennial grains across Africa. *Environmental Research*, 159, pp.283-290.

Abstract

Modern plant breeding tends to focus on maximizing yield, with one of the most ubiquitous implementations being shorter-duration crop varieties. It is indisputable that these breeding efforts have resulted in greater yields in ideal circumstances; however, many farmed locations across Africa suffer from one or more conditions that limit the efficacy of modern short-duration hybrids. In view of global change and increased necessity for intensification, perennial grains and long-duration varieties offer a nature-based solution for improving farm productivity and smallholder livelihoods in suboptimal agricultural areas. Specific conditions where perennial grains should be considered include locations where biophysical and social

constraints reduce agricultural system efficiency, and where conditions are optimal for crop growth. Using a time-series of remotely sensed data, we locate the marginal agricultural lands of Africa, identifying suboptimal temperature and precipitation conditions for the dominant crop, i.e., maize, as well as optimal climate conditions for two perennial grains, pigeonpea and sorghum. We propose that perennial grains offer a lower impact, sustainable nature-based solution to this subset of climatic drivers of marginality. Using spatial analytic methods and satellite-derived climate information, we demonstrate the scalability of perennial pigeonpea and sorghum across Africa. As a nature-based solution, we argue that perennial grains offer smallholder farmers of marginal lands a sustainable solution for enhancing resilience and minimizing risk in confronting global change, while mitigating social and edaphic drivers of low and variable production.

Keywords: Nature-based solutions, Crop suitability, Scaling Perennial grains, Remote sensing
Link: <https://doi.org/10.1016/j.envres.2017.08.011>

Occurrence of aflatoxins and its management in diverse cropping systems of central Tanzania {Journal article}

Citation

Seetha, A., Munthali, W., Msere, H.W., Swai, E., Muzanila, Y., Sichone, E., Tsusaka, T.W., Rathore, A. and Okori, P. 2017. Occurrence of aflatoxins and its management in diverse cropping systems of central Tanzania. *Mycotoxin Research* 33(4):323–331.

Abstract

The staple crops, maize, sorghum, bambara nut, groundnut, and sunflower common in semi-arid agro-pastoral farming systems of central Tanzania are prone to aflatoxin contamination. Consumption of such crop produce, contaminated with high levels of aflatoxin B1 (AFB1), affects growth and health. In this paper, aflatoxin contamination in freshly harvested and stored crop produce from central Tanzania was examined, including the efficacy of aflatoxin mitigation technologies on grain/kernal quality.

A total of 312 farmers were recruited, trained on aflatoxin mitigation technologies, and allowed to deploy the technologies for 2 years. After 2 years, 188 of the 312 farmers were tracked to determine whether they had adopted and complied with the mitigation practices. Aflatoxigenic *Aspergillus flavus* and aflatoxin B1 contamination in freshly harvested and stored grains/kernels were assessed. *A. flavus* frequency and aflatoxin production by fungi were assayed by examining culture characteristics and thin-layer chromatography respectively. AFB1 was assayed by enzyme-linked immunosorbent assay. The average aflatoxin contamination in freshly harvested samples was 18.8 µg/kg, which is above the acceptable standard of 10 µg/kg. Contamination increased during storage to an average of 57.2 µg/kg, indicating a high exposure risk. Grains and oilseeds from maize, sorghum, and sunflower produced in aboveground reproductive structures had relatively low aflatoxin contamination compared to those produced in geocarpic structures of groundnut and bambara nut.

Farmers who adopted recommended post-harvest management practices had considerably lower aflatoxin contamination in their stored kernels/grains. Furthermore, the effects of these factors were quantified by multivariate statistical analyses. Training and behavioral changes by farmers in their post-harvest practice minimize aflatoxin contamination and

improve food safety. Moreover, if non-trained farmers receive mitigation training, aflatoxin concentration is predicted to decrease by 28.9 µg/kg on average.

Keywords: food safety; aflatoxins; health

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DOI: <https://doi.org/10.1007/s12550-017-0286-x>

Patterns and determinants of vegetable intake in Babati District, Tanzania {Thesis and Dissertation}

Citation

Jape, V.W. 2017. Patterns and determinants of vegetable intake in Babati District, Tanzania. MSc thesis in Agricultural Economics. Copenhagen, Denmark: University of Copenhagen.

Abstract

The vegetable has potential to expand the diversity of rural and urban diets thereby improve human nutrition and health. The World Health Organization (WHO) recommends an intake of a minimum of 240 grams of vegetable per person per day in order to supply the body with the required micronutrients that are necessary to improve human health and reduces the risk of developing chronic diseases and disorders such as obesity and malnutrition. Despite the nutritional benefits, consumption levels, particularly in developing countries, are generally reported to be below the recommended level. This study presents the current consumption status and analyses the factors influencing household vegetable intake in Babati District, Tanzania. The study used cross-sectional data from 257 farm households and applied a binary logistic regression model to estimate determinants of vegetable intake. Results show that the mean daily intake of vegetable per person is 205.9 grams. Thirty-two percent of the sampled households had mean daily intake per person below the minimum recommended level. Education level, income, household size, having vegetable home garden, gender of the head and perception of the safety of vegetables sold in the market were found to significantly contribute to the vegetable consumption. The policy implication of the findings is that strategies that encourage households to grow vegetables at home, improve access to education and knowledge about healthy eating and build the capacity of women in making food-related decisions are likely to foster more consumption of vegetables.

Keywords: intensification; farming systems; vegetables

Link: <https://hdl.handle.net/10568/82977>

Productivity and profitability of manual and mechanized conservation agriculture (CA) systems in eastern Zambia

{Journal article}

Citation

Mupangwa, W., Mutenje, M., Thierfelder, C., Mwila, M., Malumo, H., Mujeyi, A. and Setimela, P. 2017. Productivity and profitability of manual and mechanized conservation agriculture (CA) systems in eastern Zambia. *Renewable Agriculture and Food Systems*

Abstract

Climate variability and declining soil fertility pose a major threat to sustainable agronomic and economic growth in Zambia. The objective of this study was to assess crop yield, land and labor productivity of conservation agriculture (CA) technologies in Eastern Zambia. On-farm trials were run from 2012–2015 and farmers were replicates of a randomized complete block design. The trials compared three CA systems against a conventional practice. Yield and net return ha⁻¹ were determined for maize and legume yield (kg ha⁻¹) produced by ridge and furrow tillage, CA dibble stick planting, CA animal traction ripping and direct seeding. The dibble stick, rippline and direct seeding CA systems had 6–18, 12–28 and 8–9% greater maize yield relative to the conventional tillage system, respectively. Rotation of maize with cowpea and soybean significantly increased maize yields in all CA systems. Intercropping maize with cowpea increased land productivity (e.g., the land equivalent ratio for four seasons was 2.01) compared with full rotations under CA. Maize/cowpea intercropping in dibble stick CA produced the greatest net returns (US\$312-767 ha⁻¹) compared with dibble stick maize-cowpea rotation (US\$204-657), dibble stick maize monoculture (US\$108-584) and the conventional practice (US\$64-516). The net-return for the animal traction CA systems showed that maize-soybean rotations using the ripper were more profitable than the direct seeder or conventional ridge and furrow systems. Agronomic and economic benefits of CA-based cropping systems highlight the good potential for improved food security and agricultural productivity for smallholder farmers.

Keywords: climate; soil; intensification

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DOI: <https://doi.org/10.1017/S1742170517000606>

Re-evaluating the Malawian Farm Input Subsidy Programme

{Journal article}

Citation

Messina, J.P., Peter, B.G. and Snapp, S.S., 2017. Re-evaluating the Malawian farm input subsidy programme. *Nature plants*, 3(4), pp.1-9.

Abstract

The Malawian Farm Input Subsidy Programme (FISP) has received praise as a proactive policy that has transformed the nation's food security, yet irreconcilable differences exist between maize production estimates distributed by the Food and Agriculture Organization of the United Nations (FAO), the Malawi Ministry of Agriculture and Food Security (MoAFS) and the National Statistical Office (NSO) of Malawi. These differences illuminate yield-reporting deficiencies, and the value that alternative, politically unbiased yield estimates could play in understanding policy impacts. We use net photosynthesis (PsnNet) as an objective source of evidence to evaluate production history and production potential under a fertilizer input

scenario. Even with the most generous harvest index (HI) and area manipulation to match a reported error, we are unable to replicate post-FISP production gains. In addition, we show that the spatial delivery of FISP may have contributed to popular perception of widespread maize improvement. These triangulated lines of evidence suggest that FISP may not have been the success it was thought to be. Lastly, we assert that fertilizer subsidies may not be sufficient or sustainable strategies for production gains in Malawi.

DOI: <http://dx.doi.org/10.1038/nplants.2017.13>

Sustainable recommendation domains for scaling agricultural technologies in Tanzania {Journal article}

Citation

Muthoni, Fr K., Guo, Z., Bekunda, M., Sseguya, H., Kizito, F., Baijukya, F., and Hoeschle-Zeledon, I. 2017. Sustainable recommendation domains for scaling agricultural technologies in Tanzania. *Land Use Policy* 66: 34-48.

Abstract

Low adoption of sustainable intensification technologies hinders achievement of their potential impacts on increasing agricultural productivity. Proper targeting of locations to scale-out particular technologies is a key determinant of the rate of adoption. Targeting locations with similar biophysical and socio-economic characteristics significantly increases the probability of adoption. Areas with similar biophysical and socio-economic characteristics are referred to as recommendation domains (RDs). This study used geospatial analysis to delineate sustainable recommendation domains (SRDs) for scaling improved crop varieties and good agronomic practices in Tanzania. The study uses K-means clustering to identify relatively similar clusters from grid raster's representing biophysical and socio-economic environments. Critical ecosystems are masked-out from the clusters to generate the SRDs. The potential impacts of scaling technologies in the generated SRDs were assessed and a spatial targeting index developed. Results identify 20 SRDs and the bio-socio-economic gradients that delineate them. This study proposes an Impact Based Spatial Targeting Index (IBSTI) as an objective tool for priority setting when scaling agricultural technologies. IBSTI identified priority areas within each SRD that should be targeted to maximize potential impacts of a scaling intervention. The data-driven clustering method is recommended for regions with limited technology trials. Results demonstrate the potential of geospatial tools in generating evidence-based policies on scaling of sustainable intensification technologies.

Keywords: Critical ecosystems, Impact based spatial targeting index (IBSTI)K-means clustering, GIS, Priority setting, Sustainable intensification

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Year 2016

Aflatoxins and fumonisin contamination of marketed maize, maize bran and maize used as animal feed in northern Tanzania {Journal article}

Citation

Nyangi, C., Mugula, J.K., Beed, F., Boni, S., Koyano, E. and Sulyok, M. 2016. Aflatoxins and fumonisin contamination of marketed maize, maize bran and maize used as animal feed in northern Tanzania. *African Journal of Food Agriculture, Nutrition and Development* 16(3):11054-11065.

Abstract

The objective of this study was to investigate the occurrence of total aflatoxin and total fumonisin in maize and maize-based products in Babati, northern Tanzania. A total of 160 samples were collected in 2013-14. Quantification for total aflatoxin and fumonisin was done using enzyme-linked immunosorbent assay (Reveal AccuScan® Neogen, USA) and the results were confirmed using Liquid Chromatography Tandem Mass Spectrometer. Aflatoxin was detected in 32% of maize samples (mean 3.4 ± 0.3 µg/kg; range 2.1–16.2 µg/kg) and fumonisin in 39% of samples (mean 5.6 ± 1.40 mg/kg; range 0.4–62.0 mg/kg). Among marketed products, maize bran (used for animal feed) was the most contaminated (2.4 µg/kg aflatoxin and 1 mg/kg fumonisin), followed by whole maize in market stalls (1.9 µg/kg aflatoxin and 0.4 mg/kg fumonisin) and then maize flour (1.4 µg/kg aflatoxin and 0.3 mg/kg fumonisin). Un-marketed maize sorted out by farmers as “bad” and intended for animal feeding was the most contaminated (overall mean aflatoxin and fumonisin levels of 1.7 µg/kg and 7.4 mg/kg, respectively). The results indicate that levels of aflatoxin and fumonisin contamination in marketed maize were within tolerable limits.

Keywords: aflatoxins; animal feeding; maize; markets

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DOI: <https://doi.org/10.18697/ajfand.75.ILRI07>

Are conservation agriculture (CA) systems productive and profitable options for smallholder farmers in different agro-ecoregions of Zimbabwe? {Journal article}

Citation

Mupangwa, W., Mutenje, M., Thierfelder, C. and Nyagumbo, I. 2016. Are conservation agriculture (CA) systems productive and profitable options for smallholder farmers in different agro-ecoregions of Zimbabwe? *Renewable Agriculture and Food Systems*

Abstract

Continuous conventional tillage coupled with unsystematic cereal/legume rotations has promoted low crop productivity on smallholder farms. A multi-locational study was established in three agro-ecoregions (AEs) of Zimbabwe. The aim of the study was to determine the effect of four tillage systems (conventional plowing, planting basins, rip-line and animal traction direct seeding systems) on maize (*Zea mays* L.), cowpea [*Vigna unguiculata* (L.) Walp] and soybean [*Glycine max* (L.) Merrill] yields and evaluate the economic performance of the conservation agriculture (CA) systems relative to conventional

plowing. Each farmer was a replicate of the trial over the three cropping seasons. In the high (750–1000 mm per annum) and low (450–650 mm) rainfall AEs, conventional practice and CA systems gave similar maize grain yield. Under medium rainfall conditions (500–800 mm) planting basins, rip-line and direct seeding systems gave 547, 548 and 1690 kg ha⁻¹ more maize yield than the conventional practice. In the high and low rainfall AEs, conventional practice and planting basins had the lowest maize production risk. Cowpea yield was 35 and 45% higher in the rip-line and direct seeding than conventional practice. Soybean yield was higher in rip-line (36%) and direct seeding (51%) systems than conventional practice. Direct seeding system gave the highest net benefits in all AEs. A combination of long-term biophysical and socio-economic assessments of the different cropping systems tested in our study is critical to fully understand their performance under different AEs of Zimbabwe.

Keywords: agriculture; cowpeas; smallholders; crops

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DOI: <https://doi.org/10.1017/S1742170516000041>

Assessment of maize yield gap and major determinant factors between smallholder farmers in the Dedza district of Malawi

{Journal article}

Citation

Tamene, L., Mponela, P., Ndengu, G., and Kihara, J. 2016. Assessment of maize yield gap and major determinant factors between smallholder farmers in the Dedza district of Malawi. *Nutrient Cycling in Agroecosystems* 105(3): 291–308

Abstract

This study explored the effect of soil nutrient status, agronomic practices and socio-economic factors on maize yield attained by smallholder farmers in the Dedza District of Malawi. Results show that maize yield ranged between 0.4 and 12 t ha⁻¹ with a mean value of 4.1 t ha⁻¹. Observed high yields (>8.0 t ha⁻¹) were associated with households using improved varieties combined with improved management practices such as NPK, urea and animal manure. With regards to soil factors, boron (B) and nitrogen (N) which are critically deficient in the area were significantly ($\beta = 21.1$, $p < 0.01$) associated with maize yield increase. From agronomic factors, weeds, seed spacing, plant density and fertilizer application played significant role in maize yield. Weed rating inversely impacted yield ($\beta = -0.5$; $p < 0.001$) where fields with the lowest weed rating had the highest yield (4.6 t ha⁻¹) than those with the highest rating (2.3 t ha⁻¹). Socio-economic factors such as household wealth, household members with off-farm employment, number of years the household head has been involved in farming decision making, access to agricultural advice and group membership also influenced agronomic practices and resulted in yield gap. Household wealth and off-farm employment contributed to increased yield while household head experience in farming had negative impact. Extension service impacted yield negatively which can be attributed to the low extension worker to farmer ratio. The study demonstrated that closing yield gap in maize mixed farming systems requires integrated approach to addressing agronomic, biophysical, and socio-economic constraints.

Keywords: Maize yield gap, Farmers' management practices, Agronomic practices Household typology, Dedza district, Malawi

Link: Permanent link to cite or share this item: <https://hdl.handle.net/10568/66111>

DOI: <https://doi.org/10.1007/s10705-015-9692-7>

Assessment of pre-harvest aflatoxin and fumonisin contamination of maize in Babati District, Tanzania {Journal article}

Citation

Nyangi, C., Beed, F., Mugula, J.K., Boni, S., Koyano, E., Mahuku, G., Sulyok, M. and Bekunda, M. 2016. Assessment of pre-harvest aflatoxin and fumonisin contamination of maize in Babati District, Tanzania. *African Journal of Food Agriculture, Nutrition and Development* 16(3):11039-11053.

Abstract

A survey was conducted in 2013 to establish total aflatoxin and total fumonisin in maize, as well as farmers' practices relating to maize cultivation and awareness of mycotoxins, in three villages of Babati District, northern Tanzania. Quantification of total aflatoxin and fumonisin was done using enzyme-linked immunosorbent assay (Reveal AccuScan® Neogen, USA) and the results were confirmed using Liquid Chromatography Tandem Mass Spectrometer. The mean aflatoxin was 2.94 µg/kg and all samples (n=440) were within the East African Community (EAC) standard of 10 µg/kg for total aflatoxin, but the mean fumonisin was 5.15 mg/kg, more than double the EAC standard of 2 mg/kg, and 35% of samples exceeded this standard. Maize samples obtained from farmers in the village in the mid altitude, dry zone had significantly higher mean aflatoxin (3.32 µg/kg) and significantly lower mean fumonisin (3.17 mg/kg) than maize from the other two villages (in the high and mid altitude, high rainfall zones). Most farmers (n=442) were male (72%), educated to primary school level (77%) and aware of mycotoxins (62%). As well as participating in a development program, Africa Research in Sustainable Intensification for the Next Generation, most (86%) farmers had experience of working with other development programs. All farmers used flat planting, most used improved seeds (98%), ox ploughing (78%), insecticides (78%) and early planting (36%). Practices associated with mycotoxins were planting time, tillage methods, previous season planted crops, and use of insecticides. Awareness of mycotoxins and climatic conditions were also associated with mycotoxin prevalence. In conclusion, good practices are associated with acceptable aflatoxin levels and should be continued. However, the high level of fumonisins warrants further investigation.

Keywords: aflatoxins; maize; food safety

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DOI: <https://doi.org/10.18697/ajfand.75.ILRI06>

Determinants of integrated soil fertility management technologies adoption by smallholder farmers in the Chinyanja Triangle of Southern Africa {Journal article}

Citation

Mponela, P., Desta, L.T., Ndengu, G., Magreta, R., Kihara, J., and Mango, N. 2016. Determinants of integrated soil fertility management technologies adoption by smallholder farmers in the Chinyanja Triangle of Southern Africa. *Land Use Policy* 59: 38-48.

Abstract

Integrated Soil Fertility Management (ISFM) technologies have proven to be viable options for improving land productivity and increasing yield. However, adoption of the set of complementary technologies that are required in ISFM is quite variable and studies tend to focus on single technologies. In this study we used cluster analysis to group technologies and ordered probit to determine the probability of multiple technology adoption. The result show that usage of ISFM in the Chinyanja Triangle (Southern Africa) is grouped into 3 technological sets based on complementarities. The set of nutrient dense technologies of inorganic fertiliser, compost, and animal manure (ISFMset3) indicates that they are used by farmers who face similar opportunities of having land that require minimal input, sell produce at farm gate as opposed to market, have more transport and communication facilities, and recover from livestock loss. Loss of crops, however, deter adoption of this set. The technological set comprising of fallow, rotation, and grain legumes (ISFMset2) which enhances biomass accumulation and nitrogen fixation with complementary effects in cereal dominated farming system, is more likely adopted by households with land that require more inputs, are more educated, own more bicycles and have higher financial capital. Other four technologies (ISFMset1 including mulch, lime, compost, and agroforestry) are used by a few individuals to address specific constraints in nutrient and water retention, and acidity. The result also indicated variations in usage of ISFMset3 between sites. These results are instrumental in identifying factors that influence adoption of a set of ISFM technologies in the Chinyanja Triangle and could be of use in targeting research and development initiatives.

Keywords: soil fertility; innovation adoption; smallholders; farmers; households; livestock; farming systems; malawi; fertilidad del suelo; adopción de innovaciones; agricultores; ganado; hogares; sistemas de explotación

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DOI: <https://doi.org/10.1016/j.landusepol.2016.08.029>

Doubled-up legume rotations improve soil fertility and maintain productivity under variable conditions in maize-based cropping systems in Malawi {Journal article}

Citation

Smith, A., Snapp, S., Dimes, J., Gwenambira, C. and Chikowo, R. 2016. Doubled-up legume rotations improve soil fertility and maintain productivity under variable conditions in maize-based cropping systems in Malawi. *Agricultural Systems* 145:139–149.

Abstract

Smallholder farmers in Malawi must cope with small farm size, low soil fertility and production risks associated with rainfed agriculture. Integration of legumes into maize-based cropping systems is advocated as a means to increase production of diverse nutrient-dense grains and improve soil fertility. It is difficult to achieve both aims simultaneously, however. Short-duration grain legumes rarely produce enough biomass to appreciatively improve soils, and long duration pigeonpea, commonly grown in Malawi as a dual-purpose crop, produces little or no edible grain as a consequence of grain-filling into the dry season. A novel technology is the doubled-up legume rotation (DLR) system in which two legumes with complementary phenology are intercropped and grown in rotation with maize. Initial performance from on-farm research is favorable; however, it is crucial to understand competition for resources in mixed cropping systems under variable soil and climate conditions. We used soil and crop yield data from farmer participatory trials to parameterize the Agricultural Production Systems Simulator (APSIM) and evaluate its performance in simulating observed treatments at three locations in central Malawi.

We used the calibrated APSIM model to investigate the performance of DLR and other maize-based systems across 26 growing seasons (1979–2005) in the three agroecologies. We simulated two DLR systems (maize rotated with a groundnut/pigeonpea or soybean/pigeonpea intercrop), maize rotated with groundnut or soybean, maize intercropped with pigeonpea, and continuous maize under a range of N fertilizer inputs. We extended findings to the household level by determining calorie and protein yields of these systems and calculating the chance that an average household could meet their food requirements by dedicating all available farmland to a given system. Simulated maize grain yields in DLR and maize-grain legume rotations were essentially equivalent and exceeded yields in maize/pigeonpea intercrop and sole cropped maize receiving comparable fertility inputs. All rotation systems were more likely to meet household calorie and protein needs than other systems receiving equivalent inputs. DLR systems accumulated higher total soil C and N over time than traditional rotation systems in areas where pigeonpea performed well. However, the effects of improved soil fertility on maize yields were counterbalanced by factors including N immobilization and water availability. We conclude that where growing conditions allow, DLR can harness the complementary phenology of pigeon pea to build soil quality for the future without reducing maize yields or compromising household food production in the immediate term.

Keywords: intensification; forage; soil; legumes

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DOI: <https://doi.org/10.1016/j.agsy.2016.03.008>

Evaluating manual conservation agriculture systems in southern Africa {Journal article}

Citation

Thierfelder C, Matemba-Mutasa R, Bunderson WT, Mutenje M, Nyagumbo I, Mupangwa W. 2016. Evaluating manual conservation agriculture systems in southern Africa. *Agriculture, Ecosystems & Environment* 222:112-124.

Abstract

Future threats of climate variability and change and accelerated soil degradation in southern Africa have increased the need for more sustainable and “climate-smart” agriculture practices. Manual systems of conservation agriculture (CA) based on seeding into planting basins or direct seeding techniques have received increased attention over the last decade. However, a critical review of the pros and cons of the different manual seeding systems under different agro-ecologies has been lacking. This paper aims at analysing different manual seeding systems in areas extending from central Mozambique to central Malawi. Results show that CA systems perform differently in contrasting agro-ecological environments. Direct seeded treatments had greater maize yields than conventional tillage practices by an average of 12–27% and outperformed the conventional practice in nine out of fourteen yield comparisons. Basin planted treatments performed well only in Sofala and Manica (15%) with yield penalties of –9% in Tete. The strongest factor influencing maize grain yields in the more variable areas of Manica and Sofala was the quality of season and the location, whereas tillage treatment and location were more important in the higher rainfall areas of Tete. Direct seeding systems out-yielded other treatments in areas of higher rainfall and responded better to a favourable environment than conventional tillage practices. CA systems, especially direct seeding in Malawi, Manica and Sofala, showed greater financial returns to investments and labour productivity due to reduced labour costs and higher yields. Labour savings of up to 43 labour days ha⁻¹ could be achieved with direct seeded treatments in Malawi. The results of this research clearly highlight the need for site-specific recommendations and adaptation of CA systems to different agro-ecological environments. Blanket recommendations of one CA system across many agro-ecologies, as has often been done in the past, will only lead to underperformance of CA in some areas and rejection by smallholder farmers if yield benefits are not achieved.

Keywords: climate change; agriculture; food security; climate-smart agriculture

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DOI: <https://doi.org/10.1016/j.agee.2016.02.009>

Examining the drivers of agricultural experimentation among smallholder farmers in Malawi {Journal article}

Citation

Hockett, M. and Richardson, R.B. 2016. Examining the drivers of agricultural experimentation among smallholder farmers in Malawi. *Experimental Agriculture*

Abstract/Description

Smallholder farmers in Malawi are faced with the challenge of managing complex and dynamic farming systems while also adapting to change within volatile agroecological conditions. Moreover, management decisions are influenced by a combination of local knowledge, expert recommendations, and on-farm experimentation. Although many

smallholder farmers actively experiment with new crops and technologies, little is known about the prevalence of experimentation, or the types of experiments farmers conduct. This study examined the decision-making processes of experimenting farmers to explore the drivers of on-farm experimentation. Using a mixed-methods design that incorporated field observations, survey data and in-depth interviews, we identified numerous examples of experiments with new crops, varieties and techniques that had been executed either independently or through participation in an agricultural development project. Results of quantitative and qualitative analysis reveal that smallholder farmers in Malawi across a range of socioeconomic characteristics are inclined to experiment, and gender roles in agricultural experimentation vary widely. While experimental methods differ between farmers, there are commonalities in the drivers of experimentation, including adapting to climate change, improving soil health, improving nutrition and generating income. Smallholders have a great capacity for experimentation, and their knowledge, experience, preferences, and priorities – if properly understood and incorporated – could ultimately benefit both future agricultural development projects and their participants.

Keywords: Intensification; food security; agriculture; crops

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DOI: <https://doi.org/10.1017/S0014479716000673>

Phosphorus use efficiency and productivity of pigeonpea (*Cajanus cajan* (L.) millsp.) and soybean (*Glycine max* (L.) merrill) on smallholder farms in different agro-ecological zones of central Malawi {Thesis and Dissertation}

Citation

Mzumara. E.L. 2016. Phosphorus use efficiency and productivity of pigeonpea [*Cajanus cajan* (L.) millsp.] and soybean [*Glycine max* (L.) merrill] on smallholder farms in different agro-ecological zones of central Malawi. MSc Thesis in Agronomy. Lilongwe University of Agriculture and Natural Resources. Lilongwe. Malawi

Abstract

Low soil fertility especially nitrogen (N) is one of the major constraints to increased maize productivity on smallholder farms in Malawi. Integration of grain legumes in maize-based systems is one of the strategies to improve soil fertility and yields as legumes fix atmospheric nitrogen through a symbiotic relationship with *Rhizobium* bacteria. A study was conducted in the 2013/2014 growing season in Linthipe and Golomoti Extension Planning Areas (EPAs) in Dedza district, and Nsipe EPA in Ntcheu district. The objectives of the study were to evaluate the grain yields and biological nitrogen fixation (BNF) of the sole and intercropped pigeonpea and soybean under two levels of inorganic P fertilizer (0 and 14 kg P ha⁻¹) and to determine the Phosphorus use efficiency (PUE). BNF was assessed using the N difference method. The experiment was laid out in a randomized complete block design. Soils were sandy clay loams, loamy sand and sandy loams to sandy clay loams for Linthipe, Golomoti and Nsipe respectively. Soil pH was moderately acidic to acidic, pH 4.9 to 5.8 in the three sites. Available soil P (Mehlich-3) averaged 44, 84 and 39mg kg⁻¹; and the mean soil organic matter (OM) were 2.55, 1.63 and 2.39% for Linthipe, Golomoti and Nsipe EPAs, respectively. Soybean grain yields were not affected by cropping system. However, intercropping significantly reduced pigeonpea grain yield by 47%. Similarly, BNF of soybean was not affected by cropping system while that of pigeonpea was reduced by 41% on per crop basis, with intercropping. Overall, intercropping of pigeonpea and soybean was efficient

in resource utilization than sole cropping with land equivalent ratio (LER) of 1.44. On area basis, total BNF of the soybean+pigeonpea intercrop system was 90 kg ha⁻¹ which was 67 and 38% higher than the BNF of the sole crops of soybean and pigeonpea, respectively. Site and P fertilizer interaction effects were significant on grain yield and N fixed by soybean. P fertilization increased grain yields of both the sole and intercropped soybean in the mid altitude areas of Linthipe (p=0.002) and Nsipe (p=0.037). Similarly, P fertilizer increased BNF in both sole and intercropped stands of soybean in Linthipe, p=0.039 and Nsipe, p=0.002 over unfertilized. However, P fertilization had no significant effect on soybean grain yields and BNF in the low altitude area, Golomoti. Pigeonpea grain yield and BNF were not affected by P fertilizer at Nsipe and Golomoti EPAs. The PUE values for soybean were 56.9, 25.7 and 41.6 for Linthipe, Golomoti and Nsipe EPAs, respectively and those for pigeonpea were 20.1 and 23 for Golomoti and Nsipe EPAs, respectively. This study showed that intercropping of soybean with pigeonpea and application of inorganic P in mid altitude areas, offer good option for increasing grain yields of the legumes and improves soil fertility through biological nitrogen fixation that consequently lower smallholder farmers' cost of production.

Keywords: biological nitrogen fixation, soybean, pigeon pea, doubled up legumes, phosphorus use efficiency

Preferences for legume attributes in maize-legume cropping systems in Malawi {Journal article}

Citation

Waldman, K.B., Ortega, D.L., Richardson, R.B., Clay, D.C. and Snapp, S. 2016. Preferences for legume attributes in maize-legume cropping systems in Malawi. *Food Security* 8(6):1087-1099.

Abstract

Adoption rates of leguminous crops remain low in sub-Saharan Africa despite their potential role in improving nutrition, soil health, and food security. In this study we explored Malawian farmers' perceptions of various legume attributes and assessed how these perceptions affected allocation of land to legume crops using a logit link model. We found high regional variation in both consumption- and production-related preferences, but relatively consistent preferences across samples. While scientific understanding and farmer perceptions were aligned on some topics and for some legumes, there were discrepancies elsewhere, particularly in terms of soil fertility and nutrition. Understanding why these discrepancies exist and where there were potential biases are critical in explaining the extent of adoption. In many cases perceptions of legume attributes may be influenced by the cultural role of the crop in the household, particularly in terms of food security or market-orientation. The findings also suggest that researchers need to look beyond both the agronomic properties and farmers' preferences to fully understand the extent of adoption. Socioeconomic factors, biases, and marketing concerns may also influence integration of legumes into maize-based cropping systems.

Keywords: legumes; crops; farming systems; intensification; mixed farming; livestock

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DOI: <https://doi.org/10.1007/s12571-016-0616-4>

Ratooning and perennial staple crops in Malawi. A review {Journal article}

Citation

Rogé, P., Snapp, S., Kakwera, M.N., Mungai, L., Jambo, I. and Peter, B., 2016. Ratooning and perennial staple crops in Malawi. A review. *Agronomy for Sustainable Development*, 36(3), pp.1-18.

Abstract

The management of staple crops as perennials is a historic legacy and a present-day strategy in some regions of Sub-Saharan Africa, yet perenniality is rarely an agronomic subject. Farmers in Malawi cut annual crops, such as pigeonpea and sorghum, to extend production for more than one growing season. Cassava, a perennial food crop, has a proven track record of abating hunger. Here we review ratooning, as well as the historic role of perennial staple crops in Malawi. Ratooning is a method of harvesting a crop which leaves the roots and the lower parts of the plant uncut to give the ratoon or the stubble crop. This review is completed with interviews with Malawian farmers. The major points follow. The management of staple crops as perennials is underserved by research. Indeed, we retrieved only 86 references on ratooning sorghum and pigeonpea. Of these, 9 % and 19 % respectively were from the African continent. The literature and interviews indicate that pigeonpea and sorghum have high productive potential when well managed in ratoon systems. Thirty-five percent of interviewee responses that supported ratooning mentioned saving seed. Other primary reasons to ratoon include stimulating regrowth (30 %) and saving labor (20 %). However, 31 % of responses that were against ratooning cited increased disease potential, as well as excessive vegetative regrowth (18 %).

Keywords: Africa, Agroecology, Malawi, Perennial staple crops, Ratooning

Link: <https://doi.org/10.1007/s13593-016-0384-8>

Smallholder farms and the potential for sustainable intensification {Journal article}

Citation

Mungai, L.M., Snapp, S., Messina, J.P., Chikowo, R., Smith, A., Anders, E., Richardson, R.B. and Li, G. 2016. Smallholder farms and the potential for sustainable intensification. *Frontiers in Plant Science* 7:1720.

Abstract

The sustainable intensification of African agriculture is gaining momentum with the compelling need to increase food and agricultural production. In Southern Africa, smallholder farming systems are predominately maize-based and subject to erratic climatic conditions. Farmer crop and soil management decisions are influenced by a plethora of complex factors such as market access resource availability, social relations, environment, and various messages on sustainable farming practices. Such factors pose barriers to increasing sustainable intensification in Africa. This paper characterizes smallholder farming practices in Central Malawi, at Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) project sites. We present findings from a survey of 324 farmers, located within four Africa RISING sites selected in a stratified random manner to represent (1) low agricultural potential (high evapotranspiration, variable rainfall), (2) medium agricultural potential (two sites), and (3) high agricultural potential (well-distributed rainfall).

Soil fertility was low overall, and certain farming practices appeared to limit the sustainability of agricultural production. Nearly half of farmers did not value legume residues as a high nutrient value resource for soil amelioration, as legume residues were removed (17.9%) or burned (21.4%). Conversely, maize residues were rarely removed (4.5%) or burned (10.4%). We found that farmers do not allocate soil amendment resources to legume fields (zero instances of mineral fertilizer or manure application to legumes compared to 88 and 22% of maize systems, respectively). Policy makers in Malawi have led initiatives to intensify agricultural systems through subsidizing farmer access to mineral fertilizer as well as maize hybrid seed, and only rarely to improved legume seed. In this survey, farmers allocate mineral fertilizer to maize systems and not legume systems. There is urgent need to invest in education on sustainable reinvestment in natural resources through complementary practices, such as maximization of biological nitrogen fixation through improved legume agronomy and better organic resource and crop residue management. Recent efforts by Malawi agricultural services to promote doubled-up legumes as a sustainable intensification technology are encouraging, but benefits will not accrue unless equal attention is given to an extension campaign on management of organic resources such as crop residues.

Keywords: sustainable intensification, agriculture, Malawi, smallholder farmer, integrated management

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DOI: <https://doi.org/10.3389/fpls.2016.01720>

Spatial variation in tree density and estimated aboveground carbon stocks in Southern Africa {Journal article}

Citation

Desta, L.T., Mponela, P., Sileshi, G. W., Chen, J., and Tondoh, J. E. 2016. Spatial variation in tree density and estimated aboveground carbon stocks in Southern Africa. *Forest* 7(3): 57.

Abstract

Variability in woody plant species, vegetation assemblages and anthropogenic activities derails the efforts to have common approaches for estimating biomass and carbon stocks in Africa. In order to suggest management options, it is important to understand the vegetation dynamics and the major drivers governing the observed conditions. This study uses data from 29 sentinel landscapes (4640 plots) across the southern Africa. We used T-Square distance method to sample trees. Allometric models were used to estimate aboveground tree biomass from which aboveground biomass carbon stock (AGBCS) was derived for each site. Results show average tree density of 502 trees•ha⁻¹ with semi-arid areas having the highest (682 trees•ha⁻¹) and arid regions the lowest (393 trees•ha⁻¹). The overall AGBCS was 56.4 Mg•ha⁻¹. However, significant site to site variability existed across the region. Over 60-fold differences were noted between the lowest AGBCS (2.2 Mg•ha⁻¹) in the Musungwa plains of Zambia and the highest (138.1 Mg•ha⁻¹) in the scrublands of Kenilworth in Zimbabwe. Semi-arid and humid sites had higher carbon stocks than sites in sub-humid and arid regions. Anthropogenic activities also influenced the observed carbon stocks. Repeated measurements would reveal future trends in tree cover and carbon stocks across different systems.

Keywords: biomass; allometry; anthropogenic factors; landscape; carbon stock; biomassa; alometría; factores antropogénicos; paisaje; existencias de carbono; África meridional

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Sustainable intensification and farmer preferences for crop system attributes: Evidence from Malawi' s central and southern regions {Journal article}

Citation

Ortega, D.L., Waldman, K.B., Richardson, R.B., Clay, D.C. and Snapp, S. 2016. Sustainable intensification and farmer preferences for crop system attributes: Evidence from Malawi's central and southern regions. *World Development* 87:139–151.

Abstract

Low soil fertility is a limiting factor to farm productivity, household nutrition, and economic development in many parts of Africa due to the continuous cultivation of maize over centuries. Diversifying maize monocrop with legumes has been proposed as one solution to declining soil fertility. Adoption of legumes in Africa remains low despite the much-needed soil fertility and nutrition benefits provided by the crops. We employ choice experiments to examine farmers' preferences for groundnut, soybean, and pigeon pea intercropped with maize and explore barriers and drivers to adoption in Central and Southern Malawi. Overall, farmers significantly discount legume yields in favor of maize yields despite the additional benefits provided by legumes. Labor constraints and market access are potentially more important barriers to legume adoption than previously thought. Results identified three

types of farmers with varying preferences for grain yields, the largest group (48%) associated with strongly positive preference for both legume and maize grain yield, a medium-sized group (35%) that values only maize yield, and the smallest group (17%) having preferences only for legume yield. The medium group may be growing legumes for other benefits such as enhanced maize productivity, and the smallest group may be primarily subsistence producers. These findings suggest that uptake of legume maize intercrop systems might be improved if practitioners focus on legumes that have lower labor requirements and better marketability.

Keywords: Africa, Malawi, farmer preferences, legumes, maize

Link: <https://doi.org/10.1016/j.worlddev.2016.06.007>

Targeting, bias, and expected impact of complex innovations on developing-country agriculture: Evidence from Malawi {Journal article}

Citation

Haile, B., Azzarri, C., Roberts, C. and Spielman, D.J. 2016. Targeting, bias, and expected impact of complex innovations on developing-country agriculture: Evidence from Malawi. *Agricultural Economics* 48:1-10

Abstract

Agronomic analyses of new technologies are often conducted under carefully controlled research station programs or trials managed by self-selected farmers. Oftentimes, the technologies are then scaled up with minimal evaluation under real-world conditions. Yet, the interim step between agronomic trials and large-scale promotion is crucial to generate evidence on the social and economic impact of technologies that is both internally valid and generalizable. The article focuses on a participatory action research program in Malawi designed to test and identify scalable technology options to intensify the smallholder sector and contribute to poverty reduction and food and nutrition security. We examine the socioeconomic characteristics of farmers testing technologies and find evidence of systematic targeting of better-endowed farmers. After controlling for observable differences using matching and a doubly robust estimator, we find evidence of early positive effects on maize yield and harvest value, although placebo tests suggest possible selection on unobservables. We note that attention should be given to program design and household characterization to better define and improve targeting criteria, technology selection, and external validity.

Keywords: agriculture; innovation; research; intensification; policies

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The role of forages in sustainable intensification of crop-livestock agro-ecosystems in the face of climate change: The case for landscapes in Babati, northern Tanzania {Book chapter}

Citation

Kizito, F., Lukuyu, B., Sikumba, G., Kihara, J., Bekunda, M., Bossio, D., Nganga, A. Kimaro, K.W., Sseguya, H., Jumbo, B. and Okori, P. 2016. The role of forages in sustainable intensification of crop-livestock agro-ecosystems in the face of climate change: The case for landscapes in Babati, northern Tanzania. IN: Rattan Lal, David Kraybill, David O. Hansen, Bal Ram Singh, Theodosy Mosogoya and Lars Olav Eik (eds.), Climate change and multi-dimensional sustainability in African agriculture. Cham (ZG): Switzerland: 411-430.

Abstract

Agro-ecosystem productivity is highly dependent on soil moisture fluxes yet climate change induces unpredictable dynamic interactions on water and nutrient resources. This study assessed on-farm seasonal productivity, runoff and soil moisture storage estimates within forage grass and forage legume intercrops at the Long site in Babati District of Northern Tanzania and how these would be impacted by climate change. The WaterWorld model was used to ascertain the impact of climate change on temperature and moisture fluxes at landscape level within these agro-ecosystems. Study results revealed a steady increase in temperature and a projected increase in rainfall over the next 40 years to the 2050s with an average future precipitation of 1300 mm yr⁻¹ compared to the current baseline of 960 mm yr⁻¹. On-farm seasonal water balance estimates within forage grass–forage legume intercrops revealed that with the 645 mm of rainfall received in the 2014 rainy season, evapotranspiration (ET) was the predominant factor accounting for about 75 % of the fluxes. We demonstrate that compared to the control trials, runoff levels were significantly lower in areas with forage grass–legume intercrops which translated to 20 % lower runoff levels; there was higher soil moisture storage with an average of about 25 mm (30 % higher) in areas with forage grass–forage legume intercrops than the bare plot control areas. The Napier-Desmodium and Napier-Lablab combinations had about 15 % higher soil moisture storage and 30 % higher water productivity compared to the sole Napier accessions. The sole forage grasses depicted about 15–50 % higher runoff levels compared to the Napier-Desmodium and Napier-Lablab combinations. In doing so, a combination of perennial forages (grasses and legumes) improves the sustainability of farming systems through erosion control and soil moisture retention beyond serving as feed resources. Using both qualitative and quantitative metrics from this study, we draw on the sustainable intensification indicators framework to illustrate explicit linkages on synergies and tradeoffs associated with forage interventions within smallholder farming systems. Sustainable intensification within these landscapes will thus require more innovative solutions that incorporate establishing different types of alternative forage grass–forage legume combinations coupled with other improved agronomic practices into a compendium package of interventions that allows for sustainable land use to cope with climate change and variability.

Keywords: Sustainable intensification, Climate change, Adaptation, Farmer options, Innovative solutions

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Year 2015

Approaches to reinforce crop productivity under rain-fed conditions in sub-humid environments in Sub-Saharan Africa
{Book chapter}

Citation

Chikowo, R., Zingore, S., Nyamangara, J., Bekunda, M., Messina, J. and Snapp, S. 2015. Approaches to reinforce crop productivity under rain-fed conditions in sub-humid environments in Sub-Saharan Africa. In L. Rattan, S. Bal Ram, L.M. Dismas, K. David, O.H. David & E. Lars Olav, Sustainable intensification to advance food security and enhance climate resilience in Africa (235-253). Switzerland: Springer International Publishing.

Abstract

Smallholder farming in much of Sub-Saharan Africa is rain-fed and thus exposed to rainfall variability. Among the climate variables, rainfall is projected to decline and have an overriding effect on crop productivity. With little opportunity for supplementary irrigation for the majority of farmers, a plausible strategy to maintain crop production under water-limited conditions includes balanced nutrient management for enhancing efficiency of use of limited soil water. Co-application of judicious rates of organic and mineral nutrient resources, particularly including the use of phosphorus (P) on P-limited soils, will facilitate development of an extensive crop rooting system for efficient exploration and capture of soil water, especially at a depth >0.8 m. This chapter explores case studies across Eastern and Southern Africa where various soil water conservation and nutrient management approaches have been used to gain 'extra miles' with limited available soil water.

Firstly, an approach is described that varies nitrogen (N) fertilizer application across growing seasons, by adjusting N application rates to match current season rainfall trends. The approach offers opportunities for farmers to increase crop productivity to >6 t ha⁻¹ in high agro-potential areas, compared to a ceiling of 4.5 t ha⁻¹ for the fixed fertilization model, while minimizing economic losses due to investments in N fertilizer during drought years. Secondly, we deal with the subject of fertilization across nutrient gradients, where a poor agronomic N use efficiency of <18 kg grain kg⁻¹ of applied N is demonstrated for soils with <0.4 % organic carbon, compared with >35 kg grain kg⁻¹ of N applied when soil organic carbon >0.5 %. Thirdly, the conservation agriculture (CA)-nutrient management nexus is examined, where maize yields in farmers' fields with CA alone were barely 0.5 t ha⁻¹ compared to an average of 2.5 t ha⁻¹ for CA combined with fertilizers. Fourthly, a novel system that involves intercropping two legumes with contrasting phenology for enhanced cropping system functioning is described. Finally, an approach that can be used for co-learning with farmers on soil fertility management principles for risk management is presented.

The data lead to the conclusion that the 'doubled-up' legumes system results in reduced fertilizer requirements for cereal crops grown in sequence, which benefits yield stability over time. Variable use of N fertilizer according to season quality and more tailored targeting of nutrients are vital for profitable investments in fertilizers in Africa. The Africa RISING project in Eastern and Southern Africa is currently harnessing some of these principles as vehicles for intensification of smallholder farming systems.

Keywords: Droughts, Nutrient use efficiency, Soil nutrients, Water productivity and Maize

Evaluation of nutritive value of browse tree fodder species in semi-arid Kiteto and Kongwa districts of Tanzania {Journal article}

Citation

Nassoro, Z., Rubanza, C.D.K. and Kimaro, A.A. 2015. Evaluation of nutritive value of browse tree fodder species in semi-arid Kiteto and Kongwa districts of Tanzania. Food, Agriculture and Environment 13 (3&4): 113-120.

Abstract

The use of browse tree fodder as supplements to ruminant feeding in the tropics is limited by lack of information on their nutritive potential. A study was carried out based on objectives: (1) to determine chemical composition and concentration of minerals and (2) to assess in vitro digestibility potential of five foliage species of *Acacia* (*A. mellifera*, *A. senegal*, *A. tortilis* and *A. xanthophloea*); and *Boscia* spp. indigenous to Kongwa and Kiteto districts, compared to *Gliricidia sepium*, *Leucaena pallida* and *Melia azedarach* that are established in farmlands in the two districts aiming to fill the existing feed gap for ruminants and soil improvement purposes. Data on chemical and mineral composition were analysed for ANOVA by using SAS software. The browse tree species had high levels of crude protein (CP) that varied ($P < 0.05$) among the species from 130 to 230 g/kg DM for *A. xanthophloea* and *G. sepium*, respectively. The species had moderate to low ($P < 0.05$) contents of fibers which varied among the species. The NDF ranged from 342 (*A. xanthophloea*) to 644 g/kg DM (*Boscia* spp.), ADF from 184 g/kg DM (*L. pallida*) to 577 g/kg DM (*M. azedarach*) and ADL from 38 to 175 g/kg DM. The browse species had adequate levels of macro minerals ranging 2.2 - 12.6, 1.8 - 7.1, 1.4 - 6.4 and 1.5 - 3.1 g/kg DM for Ca, P, Mg and S, respectively. Concentrations of micro minerals were moderate to high ($P < 0.05$) (4.3 - 53, 155 - 300, 13.1 - 80.9 and 15.2 - 46 mg/kg DM for Cu, Fe, Mn and Zn, respectively). The species had high ($P < 0.05$) in vitro digestibility potential 320 - 671 and 325 - 658 g/kg DM for IVOMD and IVDMD, respectively. Browse tree fodder species with enough foliage biomasses such as *A. tortilis* (pods), *G. sepium*, *L. pallida* and *M. azedarach* and in the current study could be utilized as protein supplements to ruminant livestock fed on low quality feeds including hays, stovers and crop residues due to their high levels of crude protein and minerals, low fibre contents as well as high digestibility potential.

Keywords: *Acacia*, browse fodder, chemical composition, minerals, in vitro digestibility, ruminants

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External link to download this item: <http://world-food.net/evaluation-of-nutritive-value-of-browse-tree-fodder-species-in-semi-arid-kiteto-and-kongwa-districts-of-tanzania/>

Filling the maize basket supports crop diversity and quality of household diet in Malawi {Journal article}

Citation

Snapp, S. and Fisher, M. 2015. Filling the maize basket supports crop diversity and quality of household diet in Malawi. *Food Security* 7(1):83-96.

Abstract

Food security and dietary quality are broadly supported development goals, yet few studies have addressed how agricultural subsidy policies and promotion of modern crop varieties impact smallholder farm production and household diet. Crop intensification through subsidies could have indirect impacts through gains/losses in income and purchasing power, as well as direct influences on local availability. An integrated household survey conducted multiple times in Malawi provided evidence-based insights into the complex interactions between agriculture and nutrition. The nationally representative dataset indicated that agricultural input subsidies did not preclude crop or dietary diversity. Two pathways of subsidy impact appeared to be operating: an association with diversified cropping for a direct influence on available food quality; and an association with adoption of modern maize varieties for an indirect influence through commercialization and income that supports diverse food purchases. Although crop diversity was positively associated with dietary diversity, we found that education, income, market access, and availability of improved storage technologies had higher influence on dietary diversity. Finally, we provide evidence supporting the need for complementary investments in both education and employment creation, particularly for female heads of households.

Keywords: Subsidies, Mixed cropping, Diet quality, Agro-diversity, Intensification

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DOI: <https://doi.org/10.1007/s12571-014-0410-0>

Newly introduced AVRDC vegetable technologies in reduction of income poverty: Babati District, Tanzania {Thesis and Dissertation}

Citation

Pallangyo, V.L. 2015. Newly introduced AVRDC vegetable technologies in reduction of income poverty: Babati District, Tanzania. MA thesis in Art in Rural Development. Morogoro, Tanzania: Sokoine University of Agriculture.

Abstract

The use of traditional technologies is one of the reasons for the poor income generation in Tanzania for vegetable growers: The Tanzanian Government has prioritized agriculture sector as a major means to fight poverty, but little emphasis has been put on the cultivation of vegetables. Hence no technological advancement in vegetables, this situation leads to small amount of yield and consequently low supply of the product hence low-income generation. However, the government has done less, but some nongovernmental organizations such as AVRDC, TAHA and others have helped to innovate, facilitate, and also monitor vegetable activities (introduction of new technologies). Although, non-governmental organizations have tried to introduce new technologies to farmers the problem remained cost effectiveness of technology towards income poverty reduction. The

present study was conducted in Babati District, Manyara Region, Tanzania; specifically, the study was designed to assess the profitability of the newly introduced technologies towards income poverty reduction. A total of 77 farmers were investigated by interview method, purposive sampling technique was applied and Paired sample T-test was used to assess the effectiveness of technologies and the results of the study revealed that newly introduced technologies were significant at p-value = 0.028 and 0.028 for cost and revenue, respectively. In conclusion, the study findings show that, newly introduced technologies can be adopted by vegetable producers because profit gained by using newly introduced technologies can dramatically reduce income poverty of vegetable producers.

Keywords: vegetables; crops; poverty

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Resolving the Gender Empowerment Equation in agricultural research: A systems approach {Journal article}

Citation

Tegbaru, A., FitzSimons, J., Kirscht, H. and Hillbur, P. 2015. Resolving the Gender Empowerment Equation in agricultural research: A systems approach. *Journal of Food, Agriculture and Environment* 13(3&4):131-139.

Abstract

The aim of this paper was to bridge the socio-technical divide in agricultural systems research by providing an approach that addresses marginalized groups, particularly rural women, and their access to and ownership of agricultural intensification processes. By revisiting social systems theory and the evolution of gender approaches in the CGIAR, the paper provides socio-spatial perspectives on gender supported by a landscape approach to innovation, agency and empowerment. A systems approach to empowerment is critical to make agricultural research-for-development gender transformative. The paper explores a more inclusive CGIAR systems research in the light of the ambitions to alleviate poverty, improve nutrition and income without compromising the long-term productivity of the natural environment. The empowering dimension of systems research is distinct from that of commodity focused value chain approaches and other traditional gender approaches within agriculture which have separated gender and development from systems thinking.

Keywords: agriculture; women; gender

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External link to download this item: <http://world-food.net/resolving-the-gender-empowerment-equation-in-agricultural-research-a-systems-approach/>

Response of maize to phosphorus in sole maize and maize-pigeonpea cropping system in semi-arid areas of Tanzania {Thesis and Dissertation}

Citation

Mkoma, A. 2015. Response of maize to phosphorus in sole maize and maize-pigeonpea cropping system in semi-arid areas of Tanzania. MSc thesis in Soil Science and Land Management. Morogoro, Tanzania: Sokoine University of Agriculture.

Abstract

Estimating crop response to fertilizer application and identification of effective fertilizer materials is important for plant nutrient management and in sustaining soil fertility. Unlike other agro-ecological zones, no fertilizer recommendations have been established for the semi-arid zones in Tanzania. This could be due to the fact that semi-arid areas are regarded as marginal land for agricultural production. To address this gap, field experiments were carried out to establish phosphorus (P) fertilizer rates and identify the effective P source for semi-arid areas of Kongwa and Kiteto districts in a sole maize and maize-pigeonpea cropping system. Assessment of soil fertility status on experimental sites was carried out. Triple Super Phosphate (TSP) fertilizer was used to test various application rates: 0, 7.5, 15, 30, 45 and 60 kg P ha⁻¹. For P-source trial, Minjingu Mazao, Minjingu hyper phosphate and TSP were tested at 0 and 30 kg P ha⁻¹ for each fertilizer material. Sole maize or intercropped with pigeonpea was used as the test crop in two fertilizer trials. The treatments were arranged in a Randomized Complete Block Design (RCBD) with three replications. Soils in the study sites were deficient of P, N and Ca; and had very low organic matter contents. Compared to the control, the fertilizer treatments had higher yield across sites and cropping system. The 15 kg P ha⁻¹ fertilizer rate increased the grain yield by 38 to 49% in sole maize and 55 to 60% in maize-pigeonpea intercropping system at Njoro and 51 to 54% in sole maize and 44 to 46% in maize pigeonpea intercropping system in Moletí. Maize yield obtained with 15 kg P ha⁻¹ was equivalent to the maximum yield obtained under 30 kg P ha⁻¹ fertilizer rate. Maize yield obtained after 30 kg P ha⁻¹ fertilizer rate declined slightly possibly reflecting sufficiency level of P. These results suggest that 15 kg P ha⁻¹ P is the agronomic P fertilizer rate for maize production under sole maize and maize-pigeon pea intercropping system in semi-arid areas of Kongwa and Kiteto districts, Therefore, application of this particular rate in maize and maize-pigeon pea cropping system may be an option for the marginal farmers in the region as farmers may reduce the application rate by 50% without losing yield significantly. Maize grain yield obtained with Minjingu Mazao fertilizer treatment was similar to the yield obtained with TSP fertilizer in Moletí site (3.6 vs. 3.7 t ha⁻¹) and Njoro site (3.9 vs. 4.2 t ha⁻¹). High response of maize to Minjingu mazao is attributed to slightly acidic soil condition, starter N, calcium and fortified micronutrients in this fertilizer material. Thus farmer may use Minjingu mazao or TSP as they are equally suitable P sources in maize production in semi-arid areas of Kongwa and Kiteto districts.

Keywords: crops; farming systems; maize

Link: <https://hdl.handle.net/10568/80686>

Year 2014

Agronomic survey to assess crop yield, controlling factors and management implications: a case-study of Babati in northern Tanzania {Journal Article}

Citation

Kihara, J., Tamene, L., Massawe, P., and Bekunda, M. 2014. Agronomic survey to assess crop yield, controlling factors and management implications: a case-study of Babati in northern Tanzania. *Nutrient Cycling in Agroecosystems* 102(1): 5-16.

Abstract

Improved agronomic management is important to reduce yield gaps and enhance food security in sub-Saharan Africa. This study was undertaken to understand contributing factors to observed yield gaps for maize in farmer fields and to demonstrate appropriate agronomic survey methods. The study aimed to (1) demonstrate an approach for farm-level agronomic survey, (2) identify key crop production constraints and (3) define the nutrient input and output balances of different fields. Agronomic survey was conducted in 117 farmer fields randomly distributed in a 10 km by 10 km block in Babati, northern Tanzania. A semi-structured questionnaire and production measurements were used to collect data which were analyzed with regression classification and mixed effect models. The exploitable maize yield gap at farm-level reaches up to 7.4 t ha⁻¹, and only <5 % of fields achieve maize grain yield of 5 t ha⁻¹. Slope, plant density, distance from homestead, crop variety, timing of planting and period since conversion significantly influenced maize yields. For example, fields on flat land had up to 1.6 t ha⁻¹ more maize grain yield than those on steep slopes while fields with plant density >24,000 plants ha⁻¹ had 900 kg ha⁻¹ more yield than those with less density. At least 52 % of the fields had negative nutrient balances. We conclude that cropping systems used in Babati should be preferentially supplemented with mineral fertilizers while optimizing plant density, increasing manure application and appropriate varietal choice to reduce the yield gaps.

Keywords: Agronomic survey, Plant density, Yield gap, Regression tree, Nutrient balances

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Does crop diversity contribute to dietary diversity? Evidence from integration of vegetables into maize-based farming systems in Tanzania {Journal article}

Citation

Rajendran, S., Afari-Sefa, V., Bekunda, M., Dominick, I., and Lukumay, P.J. 2014. "Does crop diversity contribute to dietary diversity? Evidence from integration of vegetables into maize-based farming systems in Tanzania," 88th Annual Conference, April 9-11, 2014, AgroParisTech, Paris, France 170542, Agricultural Economics Society.

Abstract

Maize is one of the most important staple foods that is critical to food security and livelihoods of farmers in sub-Saharan Africa. Although maize is important staple crop for ensuring food security, it cannot ensure nutritional security. To provide and ensure an adequate supply and greater variety of nutritional foods within a farm household, cropping

patterns and farming systems must be diversified to include micronutrient-rich vegetables and fruit crops, particularly traditional African species. Vegetables provide nutritional benefits and increase household incomes for smallholders and are thus an excellent complement to staple crops for addressing food and nutritional security. The objective of this study is to ascertain if an increased diversity of crops in farmers' fields leads to increased diversified diets or otherwise. This underlying objective is analysed with a multiple linear regression model from a primary survey of 300 farm households selected from 10 villages in the Babati, Kongwa and Kiteto districts of Tanzania. Results show that farm diversity does not have a positive and significant effect on dietary diversity after controlling for other covariates. However, variables such as households' size, level of education, monthly expenditure on food, irrigated area, proportion of vegetables consumed from own household production and control of household income by female decision makers were found to have strong association with dietary diversity.

Keywords: Maize-based Farming Systems, Household Dietary Diversity Score (HDDS) Crop Income, Monthly Food Expenditure, Farm Households

Link: <https://agricultureandfoodsecurity.biomedcentral.com/articles/10.1186/s40066-017-0127-3>

Evaluation of nutritive value of browse tree fodder species indigenous to Kiteto and Kongwa Districts {Thesis and Dissertation}

Citation

Nassoro, Z. 2014. Evaluation of nutritive value of browse tree fodder species indigenous to Kiteto and Kongwa Districts. MSc thesis in Biodiversity Conservation. Dodoma, Tanzania: University Of Dodoma.

Abstract

The use of browse tree fodder as supplements to ruminant feeding in the tropics is limited by lack of information on their nutritive potential. A study was carried out to screen eight browse species in Kongwa and Kiteto districts (*Acacia mellifera*, *Acacia senegal*, *Acacia xanthophloea*, *Acacia tortilis*, *Boscia* spp., *Gliricidia sepium*, *Leucaena pallida* and *Melia azedarach*) for potential chemical composition, concentration of minerals, and in vitro digestibility potential using chemical assays. Data analysis was done by using SAS (9.1.3) software. Results reveal that the browse tree species had high levels of crude protein (CP) that varied ($P < 0.05$) among the species from 130-230 g/kg DM for *A. xanthophloea* and *G. sepium* respectively. The species had moderate to low ($P < 0.05$) contents of fibers which varied among the species. NDF ranged from 342 (*Acacia xanthophloea*) to 644 g/kg DM (*Boscia* spp.), ADF 184 g/kg DM (*L. pallida*) to 577 g/kg DM (*M. azedarach*) and ADL ranged from 38-175 g/kg DM. The browse species had sufficient contents of macro minerals which varied ($P < 0.05$) among the species from (2.2-12.6, 1.8-7.1, 1.4-6.4 and 1.5-3.1) g/kg DM for Ca, P, Mg and S respectively.

Concentrations of micro minerals among the species were moderate to high ($P < 0.05$) which varied from (4.3-53, 155-300, 13.1-80.9 and 15.2-46) mg/kg DM for Cu, Fe, Mn and Zn, respectively. The species had high ($P < 0.05$) in vitro digestibility potential that varied from 320-671 g/kg DM and 325-658 g/kg DM for IVOMD and IVDMD, respectively. The browse tree fodder species in the current study could be utilized as protein supplements to ruminant livestock fed on low quality feeds including hays, stovers and crop residues due to

their high levels of crude protein and minerals, low fiber contents as well as high digestibility potential.

Keywords: animal feeding; mixed farming; forage

Link: <https://hdl.handle.net/10568/80691>

Post-harvest food losses in a maize-based farming system of semi-arid savannah area of Tanzania {Journal article}

Citation

Abass, A., Ndunguru, G., Mamiro, P., Alenkhe, B., Mlingi, N. and Bekunda, M. 2014. Post-harvest food losses in a maize-based farming system of semi-arid savannah area of Tanzania. *Journal of Stored Products Research* 57:49–57.

Abstract

An assessment of post-harvest handling practices and food losses in a maize-based farming system in semi-arid areas of Central and Northern Tanzania was carried out in 2012. Seventeen crops were mostly cultivated by the farmers in the surveyed areas; maize (32%), sunflower (16%) and pigeon peas (12%) were the most cultivated while maize was the most stored. There are at least 7 months between two harvest seasons of each crop; while farmers sold the crops soon after harvest to cater for household expenditure (54%) and school fees (38%), the market prices increased significantly ($P < 0.05$) within six months of storage. Most processing activities (winnowing, dehulling, drying, sorting, and shelling) were carried out manually, almost entirely by women, but mechanized processing for maize, sunflower, millet, and sorghum were commonly practiced. Quantitative post-harvest losses of economic importance occur in the field (15%); during processing (13e20%), and during storage (15e25%). The main storage pests responsible for the losses are larger grain borers (*Prostephanus truncatus*), grain weevils (*Sitophilus granarius*) and the lesser grain borer (*Rhyzopertha dominica*). Most of the farmers considered changes in weather (40%), field damage (33%), and storage pests (16%) as the three most important factors causing poor crop yields and aggravating food losses. However, survey results suggest that the farmers' poor knowledge and skills on post-harvest management are largely responsible for the food losses. 77% of the surveyed farmers reported inadequate household foods and 41% received food aid during the previous year. Increasing farmers' technical know-how on adaptation of the farming systems to climate variability, and training on post-harvest management could reduce food losses and improve poverty and household food security.

Keywords: food security; farming systems

Link: <https://doi.org/10.1016/j.jspr.2013.12.004>

Year 2013

Modeling and participatory farmer-led approaches to food security in a changing world: A case study from Malawi
{Journal Article}

Citation

Snapp, S., Kerr, R.B., Smith, A., Ollenburger, M.H., Mhango, W., Shumba, L., Gondwe, T. and Kanyama-Phiri, G.Y. 2013. Modeling and participatory farmer-led approaches to food security in a changing world: A case study from Malawi. *Sécheresse* 24(4):350–358.

Abstract

Crop diversification has a long history in Africa, as a foundation for more resilient and sustainable farming systems. However, success has often been mixed. Variable weather and changing climate requires a focus on supporting farmer capacity to adapt and innovate. Participatory research and simulation modeling are uniquely suited to this goal. Here we present a case study from Northern Malawi where crop modeling in conjunction with participatory approaches were used to evaluate the performance of the promising mixed cropping systems, involving maize and pigeon pea. Using historical rainfall records, simulated yield (Agricultural Production Systems Simulator, APSIM) from maize and pigeon pea-maize intercrop and rotation systems was compared to food requirements for 12 households selected to represent a range of wealth status. We found that pigeon pea-maize intercrops were highly likely to produce sufficient calories for smallholder households across variable rainfall patterns, from 73 to 100% of the years simulated, for 10 out of 12 case study households. This stands in contrast to monoculture maize, where sufficient calories were consistently produced for only half of the case study households. Survey data from this case study documented adoption patterns that reflected strong interest in legume mixtures, and gains in farmer capacity. Farmers shared agronomic information and seeds of pigeon pea and other improved legumes. Overall, we found that farmers were highly motivated to experiment with and adopt legumes that produced food and other valued combinations of traits, whereas green manures met with limited interest. Notably, farmers prioritized species that were reliable at producing food under variable rainfall. Support for farmer-to-farmer learning was critical to the success of the project, and a co-learning approach provided valuable insights to researchers regarding which technologies were more adaptable, and ultimately, adoptable by smallholders living in a highly variable environment.

Keywords: crops; food security

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