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Impact of Conservation Agriculture Techniques on Community Livelihoods in the Central Dryzone of Myanmar

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Abstract

Within the context of Myanmar, extensive research has been undertaken to examine various facets of agricultural sector advancement, encompassing economic, social, environmental, and diverse viewpoints. However, limited attention has been directed towards investigating the domain of conservation agriculture (CA), indicating a gap in the existing knowledge. The exploration of indigenous wisdom and methodologies related to CA is of utmost significance. This research employs a combination of descriptive and inferential analyses, supplemented by regression analysis. The research cohort comprises 130 agricultural households actively engaged in diverse CA methodologies within the central dryland area of Myanmar. The results of this study reveal a dual-sided influence of CA practices on local livelihoods, contingent upon the nature of the specific practice as well as the livelihood dimensions under consideration. Notably, CA practices yield advantageous outcomes in terms of both economic prosperity and environmental preservation. However, it is noteworthy that these practices tend to exert unfavorable effects on the social dimensions of livelihoods.

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1. Introduction

The significance of bolstering agricultural productivity growth to safeguard economic stability and adopt climate change threats for food security. To address this challenge, governmental bodies and development partners are actively promoting the implementation of Climate Smart Agricultural technologies, with Conservation Agriculture (CA) being a prominent example. Beyond its role in providing sustenance, smallholder agriculture emerges as a pivotal catalyst for economic advancement, especially benefiting the vast rural population constituting 75 percent of the global impoverished demographic. Nonetheless, the strain on natural resources due to agricultural activities underscores the imperative of enhancing productivity to meet the demands of a burgeoning global population (FAO, IFAD, UNICEF, 2022). The current trajectory is further exacerbated by the adverse effects of climate change, which have already led to substantial production declines across various regions (Lobell and Wolfram Schlenker, 2014).

Conservation Agriculture (CA) emerges as a notable strategy that amalgamates three fundamental principles: minimum tillage, the conservation of permanent organic soil layer, and the yield diversification implementation through techniques like rotations. This integrated approach stands as a sustainable means to enhance farm productivity, bolster profits, and fortify food security (Andjela B, 2021; Arslan et al., 2014). CA presents a resilient framework of farming options that effectively addresses an array of challenges encountered in agriculture. These encompass issues such as inadequate crop yields, the susceptibility of smallholder farmers to drought, limited ownership of draft power, and the escalating soil erosion levels and fertility loss (Gomiero, 2016). Among its merits, CA facilitates improvements in crop yields, the augmentation of soil organic material, the enhancement of water use efficiency, and the generation of net revenue (Cárceles Rodríguez et al., 2022). Moreover, CA extends promising advantages to smallholder farmers, particularly those with restricted access to draft animal power. The approach enables early planting, streamlining land preparation and rendering it feasible before the onset of the initial substantial rains (Dhanaraju et al., 2022).

Addressing a plethora of challenges, the global matter of food system sustainability necessitates adaptive approaches. CSA encapsulates areas encompassing food and nutrition security, climate change adaptation and mitigation. Top of Form

This all-encompassing framework encompasses the realms of agriculture, livestock, forestry, and fisheries. Currently, conservation agriculture (CA) covers an estimated 205 million hectares (15 percent) of global cropland. A discernible and ascending trajectory has been evident since the mid-1990s (Kassam et al., 2022), and the pace of its adoption is poised for rapid acceleration in the coming years. This surge is a strategic response to achieving the SDGs (Chaudhari et al., 2021), as well as in pursuit of the mandate set forth by the 8th World Congress on Conservation Agriculture, aiming to elevate the global CA expanse to encompass 50 percent of the total global cropland by the year 2050 (Lomborg and Debroy, 2022).

According to (Tin Yi, Wai Myo Hla, 2016), the Dry Zone, which accommodates roughly 14.5 million individuals (constituting 34% of Myanmar's population), stands as the most water-stressed region in the country. This area grapples with acute water scarcity. Approximately 43% of households within this zone face impoverished conditions, rendering it one of Myanmar's most food-insecure areas (European Commission', 2023). In the context of arid conditions, recognizing the vulnerability of dryland environments and incorporating practices such as conservation agriculture tailored to these circumstances could open doors for enhancing livelihoods. Given the aforementioned perspectives, the primary objective of this article is to delve into the ramifications of eight distinct conservation agriculture practices. The study aims to assess the degree to which these practices contribute to the overall well-being of the residents. Moreover, article discusses policy options for promoting conservation agriculture in response to climate change.

2. Method

2.1. Geography

The Central Dry Land in Myanmar (CDL) constitutes a relatively flat expanse located in the middle part of Myanmar, encompassing an area of approximately 80,000 square kilometers. This territory make up 12% of the countrys' total land area.Positioned between latitude 19.5 degrees and 23.3 degrees N and longitude 94.3 degrees and 96.4 degrees E, the CDZ is enclosed by mountain to north, east, and west, while its southern boundary is defined by the Ayeyarwaddy River delta (see Figure1).

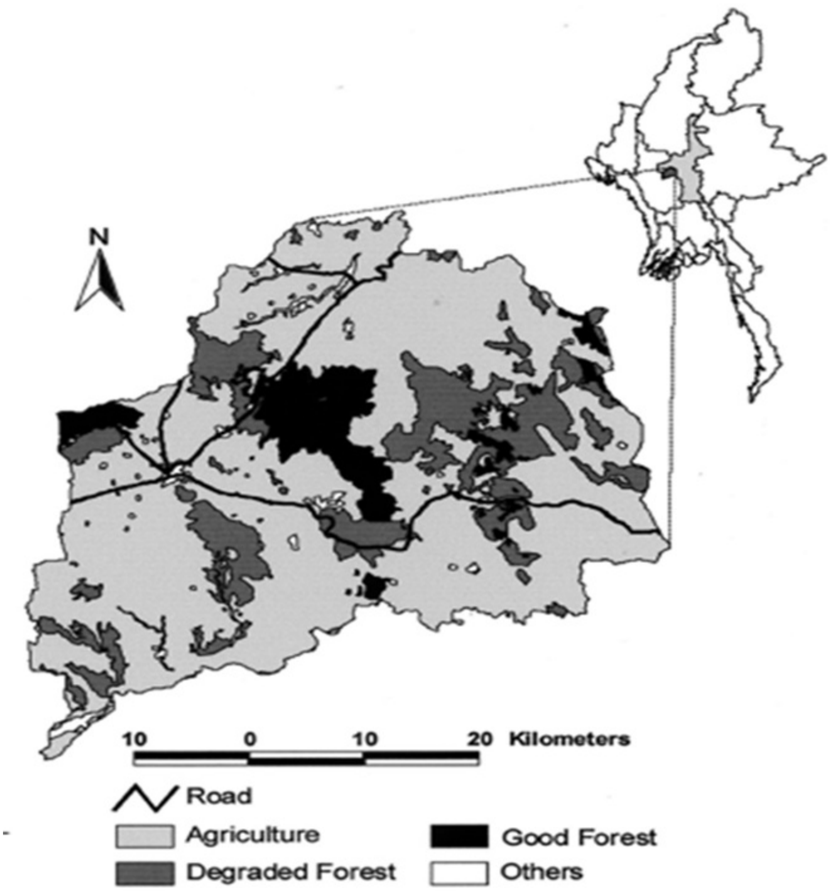

Figure 1. Location map

2.2. Demographics

Around 12 million individuals inhabit the CDL, constituting nearly 23 percent of total population of Myanmar. Ethnic diversity within the CDL is notably limited, as data extracted from the household survey by LIFT 2013 and reveals that most respondents are biggest ethnic group as Burmar (Herridge et al., 2019). Among the CDL's entire populace, roughly 80%, or 10 million people, are categorized as residing in rural areas (ADB, 2018; Tun Oo et al., 2023).

Normally, a village within the CDZ accommodates 170 households, each comprising 4.9 individuals. Approximately 60% of these households engage in farming activities (Herridge et al., 2019). Utilizing these statistics, it can be deduced that the CDZ is home to about 1.2 million farmers, while not everyone holds land ownership. The mean size of a farm ranges between 3 to 4 hectares, exhibiting considerable variation from under 1 hectare to over 20 hectares (FAO, 2022). Among CDZ households, groundnuts and pulses are more commonly thought of as cash crops than as family staples. 2013 LIFT survey shows primary income sources for CDZ households include pulses, groundnuts, labor-related earnings, coarse grains, and small business proceeds. Essential dietary items include rice, vegetables, and oil (Herridge et al., 2019).

Financial strain is prevalent among CDZ households, with an estimated 80% resorting to debt in last year (Herridge et al., 2019). Loans primarily focused on food and agricultural inputs. Notably, wealthier households tended to allocate a relatively higher portion of their resources to agricultural inputs as opposed to food, while the reverse was observed among less affluent households. Roughly one-third of households reported an increase in their debt burden (Herridge et al., 2019), a circumstance likely leaving limited capacity for investing in innovative approaches or experimenting with unproven technologies.

2.3. Climate and climate change

Despite being categorized as having a tropical monsoon climate, the CDZ climate experiences significantly diminished precipitation levels. The annual average stands at approximately 700 mm, with a range spanning from 500 to 1000 mm. This contrasts starkly with the 2000 to 5000 mm observed across the rest of the country (FAO, 2022). Precipitation in the CDZ is determined with a relatively short span of 5 to 6 months, typically initiating throughout second week of May and concluding from last week of October to second week of November (Herridge et al., 2019). The CDZ's cropping environment is characterized by its demanding nature due to the combined impact of the variable duration and quantity of monsoon rains, coupled with soils that generally exhibit a limited capacity for retaining water (Cárceles Rodríguez et al., 2022; Seleiman et al., 2021).

2.4. Cropping Systems

Within the study area, two prominent cropping systems prevail: the sesame-based system and the rice-based system. In the sesame-based approach, farmers engage in the practice of intercropping sesame and pigeon pea during the initial monsoon period. Following the sesame harvest, a sequence of groundnut, pulses, or sorghum cultivation typically takes place. On the other hand, the rice-based system involves while paddy plantation during the monsoon season, often followed by planting a sunflower or chickpea. Furthermore, farmers diversify their crop portfolio by cultivating cash crops like onions and chilies (Sarkar and Kundu, 2001).

2.5. Data Collection

In the Kyauk Padaung sub-district, particularly in the communities of Sin-Tat-Kyin, Bin-Ga, and Kyauk-Ta-Gar, which have faced substantial impacts from excessive weather event such as water scarcity, a comprehensive household-level survey was conducted. The main aim was to gain a holistic understanding of the prevailing livelihood conditions within these selected areas. This endeavor involved conducting interviews with a total of four agricultural extension officers and three specialists. Within each village, specific criteria were used to purposively select villages that were affected by drought, and those inhabited by landless, small, and marginal farmers. At the village level, respondents were then randomly chosen. In total, three villages were selected from the Kyauk Padaung sub-district.

Structured questionnaires were employed as the primary tool for interviewing farmers. The completion of each survey took approximately 45 minutes. The questionnaire was thoughtfully designed to encompass various dimensions including household characteristics, income sources, land use systems, seasonal schedules, livestock practices, forestry activities, agricultural inputs and costs, annual working days, wage rates of hired labor, fertilizer utilization, existing agricultural methods, prevailing soil and water conservation structures, practices related to Integrated Nutrient Management and Integrated Pest Management, causes behind crop failure, and management challenges. The questionnaire was complemented with a wide array of literature findings and information.

During the survey process, the introduction of the author to the farmers was facilitated by an agricultural extension officer from the local Department of Agriculture. This personal introduction by a familiar figure played a pivotal role in encouraging active participation by the farmers. Ultimately, the author conducted interviews with a total of 130 farmers, comprising 44 from Sin-Tat-Kyin, 47 from Bin-Ga, and 39 from Kyauk-Ta-Gar village, all within the year 2019.

2.6. Data Analysis

Within this article, a combination of descriptive and Ordinary Least Squares (OLS) techniques occurred. The focal point of investigation was the CA adaptation practices, particularly among small and marginal farmers (S&M farmers), who are confronted with a binary choice between adopting CA practices or continuing without them within their farming activities. Notably, many S&M landholders in this study engaged in multiple cropping practices under the framework of CA, with none of them practicing minimum tillage.

The continuous variable under scrutiny pertains to agricultural income. The examination of significance revolved around discerning the connections between CA practices and various indicators encompassing social, economic, and environmental domains. To explore these relationships, the analysis utilized OLS regression methodology as delineated. The dependent variables include indicator of livelihoods, variables of independent include CA practices, schooling, fitness, accommodation, employment, quality of soil, livestock, infections, and wild plant proliferation.

$$y = \beta + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + e$$

Where,

- y = Outcome variables (e.g., time consumed by households on farming, primary occupation, soil quality of soil, soil erosion).
- X = Independent Variables (e.g., CA practices).
- β represents the gradient of the line.

- e residues error component that remains unaccounted for.

This study concentrated solely on certain independent variables, which include multiple cropping, mixed cropping, intercropping, crop rotation, cover cropping, agroforestry, and mulching. The corresponding dependent variables encompass income, debt levels, the amount of time households dedicate to farming in terms of hours and days, primary occupation, the primary source of clean water, perceived soil quality, perceived land degradation, and the frequency of disease occurrences. In addition, the table below shows the summary statistics on the profile of enumerated S&M farmers.

Table 1. Brief of Variables

	N	Minimum	Maximum	Mean	Std. Deviation
Total HHM	130	1	12	4.58	2.045
Age	130	18	85	55.04	12.915
Sex	130	1	2	1.40	.492
Edu	130	0	5	1.95	1.033
Fexperi	130	0	65	36.25	14.324
Type of H	130	0	4	1.98	.362
M Job	130	1	2	1.05	.211
Extra Job	83	0	3	1.42	1.117
SesArea	130	0	40	5.19	5.495
Livestock	130	0	18	.40	1.895
IncoAgri	130	0	6300000	761086.54	1180404.971
Hhspday	130	0	4	1.92	1.560
LabCost	130	0	3000	1407.69	1382.034
diseases	130	0	1	.61	.490
pests	130	0	1	.96	.193
weed	130	0	1	.96	.193
climate	130	0	1	.96	.193
misused	130	0	1	.04	.193
market	130	0	1	.35	.480

3. Results and Discussion

3.1. Correlation between difference agriculture practices

In relation to various agricultural practices, namely multiple cropping, intercropping, mixed cropping, cover cropping, agroforestry, and mulching, a total of seven types of correlations can be identified. Starting with multiple cropping, it exhibits a perfect positive relationship (r=+1) with the other practices. On the other hand, intercropping exhibits a slight positive correlation (r=+0.393) with the practice of multiple cropping. Likewise, mixed cropping shows a modest positive correlation (r=+0.319) with multiple cropping.

Crop rotation displays a minor positive correlation with multiple cropping practices. Cover cropping and mulching also exhibit slight positive correlations. Conversely, agroforestry shows a negative correlation with multiple cropping and intercropping practice. However, mulching and cover cropping demonstrate a moderate positive correlation.

To summarize, in a broader context, the seven agricultural practices tend to share positive relationships with one another, except for agroforestry, which stands as an exception. Statement

Table 2. Relationship between CA practices

CA practices	Status	multiple cropping	inter cropping	mix cropping	crop rotation	cover cropping	agro forestry	mul-ching
multiple cropping	Relation	**1**	**.393****	**.319****	**.248****	**.164**	**-.009**	**.040**
	P value	**-**	**.000**	**.000**	**.005**	**.063**	**.921**	**.648**
inter cropping	Relation	.393**	1	.123	.069	.124	-.099	.048
	P value	.000		.162	.438	.161	.263	.584
mix cropping	Relation	.319**	.123	1	-.049	.170	.083	.109
	P value	.000	.162		.579	.053	.349	.218
crop rotation	Relation	.248**	.069	-.049	1	.088	.000	-.030
	P value	.005	.438	.579		.318	1.000	.738
cover cropping	Relation	.164	.124	.170	.088	1	.071	.176*
	P value	.063	.161	.053	.318		.423	.045
agro forestry	Relation	-.009	-.099	.083	.000	.071	1	.167
	P value	.921	.263	.349	1.000	.423		.058
mul-ching	Relation	.040	.048	.109	-.030	.176*	.167	1
	P value	.648	.584	.218	.738	.045	.058	

N=130

3.2. Impact of CA practices on agricultural income

The objective of this examination remained to ascertain where exists a distinction among various CA practices, encompassing multiple-cropping, inter-cropping, mixed-cropping, rotation of crop, cover-cropping, protecting, and agro-forestry, in terms of their impact on the economic indicator of agricultural income (as shown in Table 3). Upon examining Table 3, it becomes evident that multiple cropping demonstrates a notably optimistic, and statistically a notable impact ($P<0.01$) annual agricultural income. The study findings indicate that farmers who implement a multiple cropping system, involving the cultivation of more than two crops, experience an increment revenue by 1,150,446 kyat (1150US$) per year. Conversely, mixed-cropping exhibits a significant but negative result ($P<0.05$) on agricultural revenue per year. The research indicates that farmers who engage in growing two crops simultaneously during the same growing season face a reduction in income by 1,521,617 kyat(1521 US$) per year.

Table 3. Impact of CA practices on agricultural income

Variable	Coefficients	P value
Multiple cropping	1150446.153	.007***
Inter-cropping	784500.545	.444
Mix-cropping	-1521617.543	.028**
Crop-rotation	-703986.442	.298
Cover-cropping	126021.639	.911
Agro-forestry	-544954.820	.611
mulching	-154716.620	.953

N=130

4. Conclusion

This study was conducted with the purpose of evaluating the prevailing practices and adoption levels of seven distinct conservation agriculture (CA) techniques. The primary focus centered on understanding their influence on livelihood outcomes, particularly with regards to the impact on income derived from agricultural practices. Through this research, several insightful conclusions have emerged, shedding light on potential pathways for augmenting the adoption of CA farming practices among small and marginal (S&M) farmers within the study area, thus bolstering agricultural income.

First and foremost, the findings underscore the significance of accounting for various socioeconomic factors such as the farmer's age, primary career, and off-farm employment status while promoting CA farming practices like multiple cropping and mixed cropping for adoption among S&M farmers. Neglecting these critical aspects could yield suboptimal results when striving to elevate the rates of CA farming practices within the study region. For instance, recognizing the importance of extension services and their potential to positively influence CA adoption becomes essential. Furthermore, distributing seeds to farmers through governmental or non-governmental organizations and revitalizing reliable water sources are additional strategies capable of fostering greater adoption of CA farming practices.

In conclusion, for CA practices to genuinely enhance the livelihoods of farmers inhabiting vulnerable production areas in Myanmar, this study puts forth recommendations that emphasize the necessity of accurately targeting conservation agriculture initiatives to suitably resourced farming groups. Additionally, empowering economically disadvantaged farmers warrants consideration, ensuring that policies are designed to uplift their circumstances in tandem with the broader objectives of CA adoption.

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