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Impact of crop diversification on dietary diversity and calorie intake of farm households in Yamethin District, Central Dry Zone, Myanmar

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Abstract

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Farm households in Myanmar are practicing diversification of crops as a strategy to reduce the likelihood of crop failure and meet their household's dietary and calorie needs. This study aims to evaluate how crop diversification affects the dietary diversity and calorie intake of farm households in Myanmar. The farm household survey was carried out with 282 farm households in Yamethin District, utilizing structured questionnaires that included crop production, food group items, and food intake of farm households. Crop diversification level was determined using *Simpson's diversification index,* and the difference in dietary diversity intakes of farm households was measured using the *Household Dietary Diversity Score (HDDS) method,* which is based on seven food groups. Pearson's correlation analysis was also used to measure the association between the level of crop diversification, and dietary diversity as well as calorie intake of farm households. The study revealed that crop diversification has a positive relationship with own production ratio, HDDS, and calorie intake of farm households. The findings indicate that farm households in Yamethin District should emphasize utilizing improved crop varieties in addition to varying their cropping patterns in order to meet their dietary and calorie needs. Additionally, this study emphasizes the necessity for the distribution of resistant crop varieties and provision of extension services by the government of Myanmar.

Keywords: crop diversification; food security; dietary diversity; Dry Zone; Simpson's index

Introduction

Agriculture not only provides food for people but is also one of the most powerful instruments for eradicating severe poverty and boosting economies. Agriculture produces the majority of food worldwide, and thus changes in agricultural productivity could have a significant impact on human diets (FAO, 2024). Particularly in developing countries, a significant share of agricultural households continues to experience insufficient access to food and calories due to the increasing impacts of climate change on agriculture and food production (Hawkes and Ruel, 2006; Pinstrup-Andersen, 2007). Agricultural crop production is critical for the income and livelihoods of the majority of farm households residing in rural areas of developing countries, where crop production has a strong relationship with daily dietary needs and food consumption (Pinstrup-Andersen, 2007; Abdulai and Aubert, 2004). Moreover, crop diversification is becoming a strategy for farm households to lower the production risk, while maintaining crop yields and promoting access to foods (Haddad, 2000).

Agriculture is the backbone of Myanmar's economy, accounting for 23% of its GDP (Cho et al., 2016). Crops are

produced in a range of agro-climatic zones, with the coastal zone producing paddy, the hilly and mountainous regions producing intense fruits and horticulture crops, and the dry zone producing a wide variety of crops by the Ministry of Agriculture, Livestock and Irrigation (MOALI, 2017). Many researchers have found a positive relationship between crop diversity and dietary diversity of farm households (Abdulai and Aubert, 2004; Haddad, 2000; Herforth, 2010; Oyarzun et al., 2013; Torheim et al., 2004; Jones et al., 2014; Gibson and Rozelle, 2000). Few studies have examined the relationship between crop diversification and dietary diversity of farm households (MOALI, 2017; Oyarzun et al., 2013; Babatunde et al., 2010), and changes in food group consumption (Herforth, 2010). Therefore, it is relevant to study the relationship between the level of crop diversification of farm households and the changes in dietary diversity as well as calorie intake.

Crop diversification is becoming an important farming strategy for farm households to enhance dietary diversity, which is crucial for ensuring that households obtain essential nutrients. According to Jones et al. (2014), consuming a wide variety of crops results in a more varied diet, which is essential for satisfying household members' nutritional needs. Crop diversification can help reduce the risks of food insecurity, especially in areas that are experiencing climate change, and Altieri et al. (2012) highlighted that diversified farming systems are more resilient to environmental stresses, thus ensuring a more stable food supply and contributing to nutritional well-being. Furthermore, evidence suggests that households engaged in crop diversification tend to have higher caloric intake (Torheim et al., 2004; Jones et al., 2014). Cho et al. (2016) also found that farms growing various crops, such as legumes, grains, and vegetables, resulted in increased availability of food resources, which directly influenced the caloric intake of farm households. Similarly, Kant (2004) also investigated consumption of a variety of foods or food groups is associated with greater calorie and nutrient intakes of households.

Currently, assessment methods for crop diversification and dietary intake analysis have evolved, with a variety of qualitative and quantitative tools (Raneri et al., 2023). Conventional approaches often rely on crop diversification indices, such as Simpson's Index, to quantify agricultural practice diversity, while dietary assessment commonly employs measures like the Household Dietary Diversity Score (HDDS) and food frequency questionnaires to gauge nutritional diversity (Cho et al., 2016; Torheim et al., 2004). Jones et al. (2014) determined the relationship between farm production diversity and households' diets by using two analyses: namely Simpson's crop diversification index and area evenness and Household Dietary Diversity Score (HDDS). Although these tools have been widely used independently, limited studies have explored their integrated application to understand how agricultural diversification directly influences dietary quality and calorie consumption at the household level (Swindale and Bilinsky, 2006a). Recent advances include the use of detailed food intake records and nutrient analysis, which provide a more comprehensive understanding but are often resource-intensive and not feasible in all settings. This study is crucial in bridging this gap by simultaneously examining crop diversification (using Simpson's Index), household own production ratio (OPR), dietary diversity (HDDS), and calorie intake within the same framework. By doing so, our research offers a holistic view that links agricultural practices with nutritional outcomes, providing valuable evidence for policymakers aiming to promote sustainable and nutritious farming systems in the dry zone of Myanmar.

Crop diversification has become a vital farming strategy to enhance food security and nutritional well-being, especially amid growing environmental challenges. By cultivating a variety of crops, farmers can diversify their food sources, reduce dependency on a single commodity, and mitigate risks posed by climate variability (FAO, 2020). Evidence indicates that diversified farming systems contribute not only to greater dietary variety, but also to increased caloric intake, supporting household nutritional needs. In Myanmar's dry zone, where water scarcity and climatic stresses are prevalent, crop diversification can serve as a resilient approach to sustain food production and improve dietary outcomes (Cho et al., 2016). Despite this potential, there is a noticeable research gap in understanding the direct linkages among crop diversification levels, household production ratios, dietary diversity scores, and calorie intake. Our study aimed to fill this gap by empirically analyzing these interconnected factors, thereby generating comprehensive insights that can inform targeted interventions and policies to improve both agricultural productivity and nutritional intake of farm households in the dry zone of Myanmar.

Materials and Methods

Study areas

The dry zone region of Myanmar comprises the Mandalay, Magway, and lower Sagaing Regions. This study was conducted in Yamethin district. Mandalay region and Yamethin district are situated at 20° 15′ N latitude and 96° 15′ E longitude and have two townships (Yamethin and Pyawbwe) (MOALI, 2017). Pyawbwe Township were selected (Fig.1). These villages are Se Htate, Aing To, Ingyin Kan, Thein Kone, Se Gyi, Hta Naung Kone, Bwet, Kuaar Myaw villages

from Yamethin Township and Kyu Taw Wa, Taw Twin Hla, Nyaung Shwe, Chaung Ma Gyi, Sa Bal Kone, and Chaung Nar villages from Pyawbwe Township. Yamethin' climate is mostly dry, and temperatures typically range from 16°C to 38°C. In summer months, the temperature often goes up to over 40°C and water scarcity is a typical phenomenon in these areas (Oo et al., 2017). In monsoon season, the delay in monsoon period with limited precipitation makes the farm households particularly vulnerable to water availability. The main crops grown in Yamethin District are rice both local and high-yielding varieties, pulses (green gram, chickpea, and pigeon pea), oilseed crops (sesame, groundnut, and sunflower), kitchen crops (onion, coriander, and chili) and grapes.

Data collection

In the first stage of sampling, 15 villages were purposively selected from two townships. There were 40 165 farm households in Yamethin District. The Taro Yamane formula in equation (1) was used to calculate the sample size (Yamane, 1967).

$$n = \frac{N}{1+ N(e)^2} = 396 \quad (1)$$

where n is the numbers of households' sample, N is the numbers of households' population, and e is assumed as sampling error 0.05 (95% confidence level).

Stratified random sampling method was used to assess different crop diversification of farm households. The crop production of household, crop varieties, food groups, amount of food consumption in a week were included in the questionnaires. The data collection was carried during March to April, representing 2022–2023 season, through phone interview based on the data sources in the 2017–2018 cropping calendar in Yamethin district. A total of 396 farm households were interviewed using a structured questionnaire. The 114 farm households were excluded from the survey, because they did not report sufficient information and data. Finally, the data set included 282 randomly selected agricultural households that practiced monocropping, double cropping, intercropping, and multiple cropping patterns. Crop production and food consumption data were gathered during the 2017–2018 cropping season. Each survey lasted an average of 50 minutes.

Data analysis

Simpson Index of Diversification (SID) is a statistical method used in measuring dispersion of enterprises or firms in a particular geographical region (Simpson, 1949; Joshi et al., 2006). It has also been used to calculate the crop diversification index by utilizing the number of crop varieties, cultivated by the farm household in a particular geographic area (Shahidullah et al., 2008; Torheim et al., 2004, Jones et al., 2014, Cho et al. 2016). Previous studies that applied

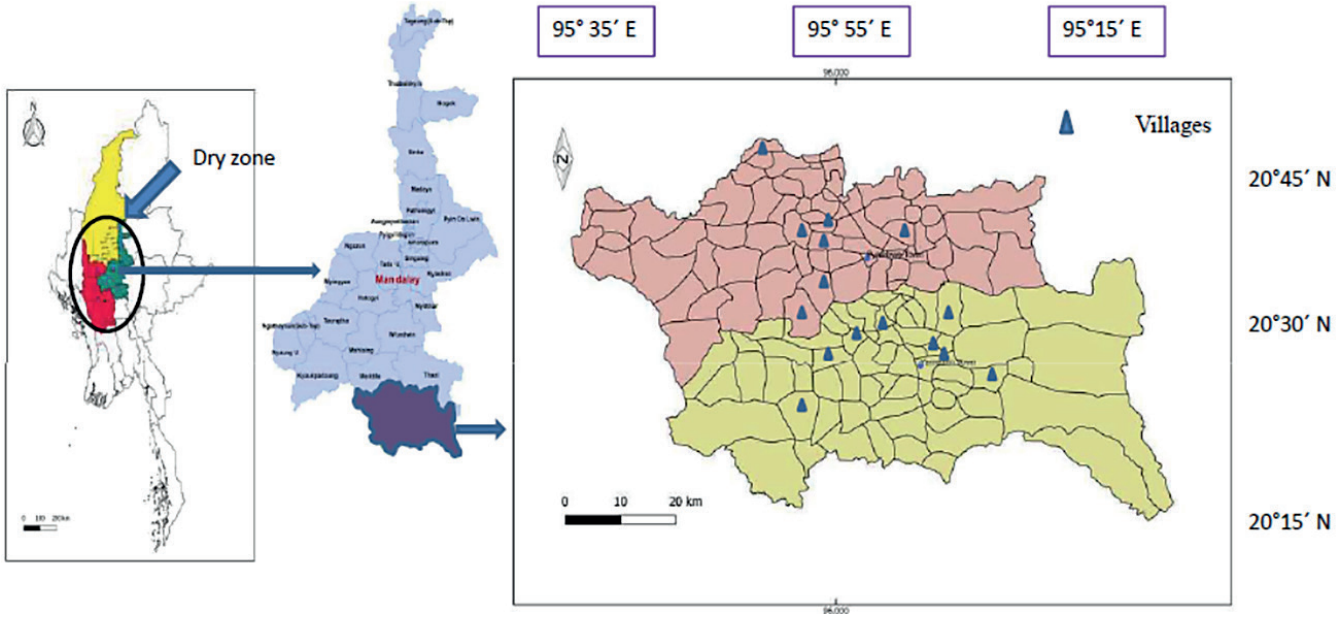


Fig. 1. Map showing the sampled villages in Yamethin District, Dry Zone of Myanmar
Source: Myanmar Information Management Unit

Simpson's Index to measure crop diversification were mostly focused on crop production areas within their specified cropping season (Haddad, 2000; MOALI, 2017; Herforth, 2010; Jones et al., 2014; Linderhof et al., 2016). This study further advances to explore the total numbers of all harvested crops in one calendar year and the equation is presented in equation 2.

$$SID = 1 - \left(\frac{\sum n(n-1)}{N(N-1)} \right) \quad (2)$$

where *SID* is Simpson Index of Diversification, *n* is total numbers of particular crops varieties, and *N* is total numbers of all crop varieties cultivated annually by the farm households.

The value of *SID* ranges between zero (no crop diversification) and one (highest crop diversification). The probability value "zero" means, for example, that farm household cultivated only one crop. The value "one" denotes as, for example, farm household cultivating rice in monsoon period, pulses in post-monsoon season, and fruits and vegetables in winter season.

The Own Production Ratio (OPR) was also applied to count the number of food crop items from consumption of different nutritional food groups produced by a household in such a way to reflect the linkages between farm crop diversity and numbers of dietary groups of the farm household (Nandi and Nedumaran, 2022). It was formulated using the following equation (3).

$$OPR = \frac{\sum ji}{\text{total no. of food group}} \quad (3)$$

where *OPR* is the own production ratio of farm households, *j* is the production of crops from the *i* farm household distinguish between crops based on their contribution to daily food group diversity.

The average score of this ratio was used to determine the score for own production. In this study, the Simpson's Index and own production ratio of crop diversity indicators are used to reflect the correlation effect of production diversity on dietary diversity.

The household dietary diversity score (HDDS) was employed to assess household food access and diversity based on a 24-hour reference period. The HDDS was calculated by enumerating the presence or absence of seven food groups consumed by each household, including cereals, pulses, vegetables, fruits, meat, dairy, and oils/fats (Kant, 2004; Swindale and Bilinsky, 2006b; Vhurumuku, 2014). Households that consumed at least one item from a food group within the 24 hours were assigned a score of one for that group, while non-consumption was scored zero. The total HDDS ranged from zero to seven, with thresholds set to classify households into low (< 4.5), medium (4.5–6), and high (> 6) dietary diversity categories. This scoring system allowed for quantifying dietary diversity levels across households, facilitating correlation analysis with crop diversification and calorie intake data (Cho et al. 2016).

Moreover, the household calorie intake measurement was also used as a key indicator to evaluate the adequacy of household energy consumption, based on a 24-hour reference period. The total calorie intake per household was calculated by summing the caloric values of different food items consumed during typical meals, such as rice, vegetables, meat, and fruits. The study adopted the World Health Organization (WHO) minimum recommended daily calorie intake of 2100 kcal per person as the threshold for sufficient energy intake, classifying households with intake below this level as having low energy intake, those between 2100 – 2400 kcal as medium, and above 2400 kcal as good energy intake (WHO, 2004).

Pearson's correlation analysis is a statistical method used to measure the strength and direction of the linear relationship between two continuous variables. The correlation coefficient (r) ranges from -1 to +1, where values close to +1 indicate a strong positive relationship, values near -1 indicate a strong negative relationship, and values around 0 suggest no linear correlation. In this study, Pearson's correlation was employed to examine the relationships between variables such as crop diversification, dietary diversity, calorie intake, and household characteristics, helping to identify whether and how these factors are related. We employed SPSS- version 26 for data analysis and to generate descriptive statistics, providing a comprehensive overview of the study variables.

Results and Discussion

Results

Household Calorie Intake Measurement (kcal/day)

The survey results show that in Yamethin District, the common breakfast, lunch, snacks, and dinner were more or less similar in all farm households, and the average household size is five. The calorie intake values of one person for the breakfast was around 391 g where one dish (250 g) of rice, 81 g boiled peas, fried vegetables with rice flour, 50 g dry fish, and a glass of hot tea were consumed. For lunch, the food items such as 650 g of uncooked rice, meat such as pork, chicken, egg, and fish) curry containing 320 g meat, 10 g garlic, 10 g ginger, 163 g tomatoes, 81 g onion, and 50 g of oils, five bowls of Roselle soups, fried seasonal veg-

etables (okra, eggplant, pumpkin, water green, etc.,) chili and fish paste of 80 g were generally consumed. For dinner, the household members consumed rice and curry similar to lunch. Some fruits such as banana, pineapples, and mango were consumed as a snack. The consumption number of fruits, vegetables and meat were slightly different according to households' preferences. The calorie intake scores were set at 2100 kcal per day as minimum calorie requirement for well-functioning healthy person recommended by the World Health Organization (WHO) and the U.S Committee on International Nutrition (Swindale and Bilinsky, 2006a). To construct the calorie scores, the 2100 kcal/day was considered as minimum intake, 2100–2400 kcal/day as medium intake, and more than 2400 kcal/day as good energy intake.

Correlation analysis results

Pearson's correlation was used to analyze the relationship between crop diversification, dietary diversity and calorie intake of farm households in Yamethin district. Furthermore, differences in farm size and household size were considered and included in the correlation analysis to test their effect on production and dietary diversity. Pearson's correlation coefficient, where criteria set by Evans (1996) was applied as follows:

Coefficient (r) value
0.00 to 0.19 = very weak correlation
0.20 to 0.39 = weak correlation
0.40 to 0.59 = moderate correlation
0.60 to 0.79 = strong correlation
0.80 to 1.00 = very strong correlation

The measurement indexes of crop diversification, OPR and HDDS scores are presented in Table 1. This study follows the measurement indexing methods used by (Cho et al., 2016).

Table 1. Measurement indexes of crop diversification level, OPR and HDDS (n = 282)

Indicators	Levels of Measurement		
	Low	Moderate	High
Simpson's Index	0–0.33	0.34–0.66	0.67–1.00
OPR	0.14–0.43	0.44–0.72	0.73–1.00
HDDS (7 food groups)	< 4.5	4.5–6	> 6
Calorie Intakes (kcal/day)	< 2100	2100–2400	> 2400
Household size (members)	1–4	5–8	> 8
Farm size (ha)	< 2	2–4	> 4

Source: Authors' own elaboration

Table 2 presents the descriptive statistics of the Simpson's Index, OPR, HDDS, calorie intake, and farm household variables. The results of descriptive analysis revealed that the sampled farm households in Yamethin District adopted low crop diversification with its average score of 0.16, where own production ratio was found as (0.44), dietary diversity was medium (5.45) and calorie intake was found as low (1736.46 kcal/day). The SID and OPR measures were applied to estimate the effect of crop production diversity on HDDS, dietary diversity and calorie intake of the households.

Table 2. Descriptive statistics of indicators analysis of farm households in Yamethin District, dry zone, Myanmar

Indicators	Mean	Std. Dev.	Min	Max
SID	0.16	0.19	0.00	1.00
OPR	0.44	0.18	0.14	1.00
HDDS score	5.45	0.79	3.00	7.00
Calorie intake (kcal/day)	1736.46	585.73	619.52	4218.95
Household size (members)	4.89	1.76	1	12
Farm size (ha)	2.76	2.01	0.28	16

Source: Authors' own elaboration

Therefore, the frequencies and percentages of crop varieties cultivated by farm households resulted from total number of crop counts are described in Table 3. According to crop count results in Table 3, the most commonly practiced cropping patterns in Yamethin District were rice-pulses, rice-oilseeds, rice-vegetables, and rice-pulses-oilseeds patterns. And rice and pulses varieties were recorded as the highest cultivated crops among the farm households. Among 282 farm households, 7.4% of grape farm households practiced monocropping of grapes where 2.8% of farm practiced one improved variety and 4.6% of farm households practiced two improved varieties. Furthermore, a considerable percentage of farm households cultivated rice, pulses, and oilseeds, by relying solely on one improved crop variety.

Table 4 indicates that Simpson's Index, production ratio, household dietary diversity, calorie intakes, and household characteristics of the survey results. Only 3.2% of farm households were found to have a high number of household members, while 52.5% were found to be moderately household sized and 44.3% to be small household size (see also Table 1). Nearly 40% of farm households were found with both low and moderate value of farm size and only 20% of farm households with high farm size, respectively.

Simpson's Index: The results indicated that the vast majority (93 %) of farm households adopted low crop diversification, 5% and 2% of farm households adopted moderate and high crop diversification respectively (Table 4). Although, Yamethin District practiced high in cultivation of rice, pulses, oilseed, vegetables, grapes varieties, significant percentage of low crop diversification were observed owing

Table 3. Frequencies and percentages of cultivated crops of farm households in Yamethin District, dry zone, Myanmar

Crops	Number of Crop Counts			
	No variety	One variety	Two varieties	Three varieties
Rice (Local and High yielding variety)	21 (7.4)	187(66.3)	74 (26.3)	0 (0.0)
Pulses (Green gram, Chickpea, and Pigeon pea)	155 (55.0)	104 (36.9)	21(7.4)	7.0 (2)
Oilseed (Sesame, Groundnut, and Sunflower)	139 (49.3)	83 (29.4)	53 (18.8)	7 (2.5)
Vegetable crops (Onion, Chili, and Coriander)	190 (57.4)	53 (18.8)	25 (8.9)	14 (5.0)
Grapes (local and hybrid)	261 (92.6)	8 (2.8)	13 (4.6)	0 (0.0)
Total	282 (100)			

Note: Parentheses denote frequencies (percentages).
Source: Authors' own elaboration

Table 4. Identifying levels of indicators measurements on farm households practicing crop diversification

Indicators	Levels of Measurement		
	Low	Moderate	High
Simpson's Index (0–1)	262 (93.0)	14 (5.0)	6 (2.0)
Own production ratio (x100%)	193 (68.0)	78 (28.0)	11 (4.0)
HDDS (1–7 food groups)	36 (12.8)	231 (81.9)	15 (5.3)
Calorie Intake (kcal/day)	213 (75.5)	29 (10.3)	40 (14.2)
Household size (members)	125 (44.3)	148 (52.5)	9 (3.2)
Farm size (ha)	110 (39.0)	1.0)	55 (20.0)

Note: Parentheses denote frequencies (percentages).
Source: Authors' own elaboration

to its low and moderate levels of household members and farm size in dry zone area.

Own Production Ratio (OPR): The percentage of own production ratio potentially encourages dietary diversity, because it could be linked to daily consumption of a range of food groups (see Table 4). The results found that 68% of farm household were practiced lower OPR while 28% and 4% of farm household produced moderate and high OPR, respectively. The findings highlighted the majority of farm households were sufficient in production of own food groups such as rice, pulses, onion, chili, coriander, oilseeds, and grape.

HDDS: The majority of farm households (81.9%) were found medium HDDS level, while 12.8% of farm households were at low HDDS level. Only 5.3% of farm households had a high level of HDDS. This study indicated that the food crops such as rice, various pulses, oilseed (groundnut, sesame, sunflower), vegetables and green leafy vegetables, and some fruits produced from own farm are important food sources for a households' dietary diversity. Majority of farm households with medium HDDS level consumed dairy products and meat groups such as poultry, pork, beef, and eggs which were depending on their purchasing power.

Sufficient Calorie Intake: Based on the calculation of calorie intake from food groups (Kant, 2004; Raneri et al., 2023), the highest percentage of farm households (75.5%) was found as low-calorie intakes. The 10.3% of households with medium calorie intake and 14.2% of household with high calorie intake were observed. The result also suggest that calorie intake are more likely related to the quantity of food consumed rather than the index of crop diversification of farm households.

Pearson's Correlation: In order to evaluate the effects of crop production, on dietary diversity and calorie intake, this study applied Pearson's correlation analysis with variables such as household size, farm size and own production ratio. From analysis, Table 5 showed the indicators of crop diversification, HDDS and calorie intake were essential indicators for the development of food crop production and increasing HDDS of farm households in Yamethin District. The findings highlight that crop diversification is an important factor of farm household for ensuring diverse food group and sufficient calorie intake of households. Therefore, correlation between Simpson's Index, HDDS, calorie intake and farm household characteristic are briefly described in Table 5.

The results revealed that the indicators between Simpson's Index, own production ratio, HDDS score, and calorie intake have a positive correlation with a significant value of 0.01. The household size and other indicators were not significantly correlated, and thus, it can be noted that household size did not affect the level of crop diversification and HDDS. The farm size was found negatively correlated be-

Table 5. Pearson's correlation on crop diversification, dietary diversity and calorie intake of farm households in Yamethin District, dry zone, Myanmar

	Simpson's Index	Own production	HDDS	Cal Intake	Household size	Farm size
Simpson's Index	1					
Own Production	.383*** (.000)	1				
HDDS	.182*** (.002)	.116* (.051)	1			
Calories Intake	.685*** (.000)	.619*** (.000)	.200*** (.001)	1		
Household size	.072 (.226)	.058 (.330)	.014 (.818)	.076 (.201)	1	
Farm size	.020 (.739)	.185*** (.002)	-.006 (.915)	.030 (.619)	-.054 (.365)	1

Note: ***, ** and * indicate statistically significant at the 1%, 5% and 10% levels, respectively. P-values are presented in parentheses.
Source: Authors' own elaboration

tween household size and HDDS, but not with calorie intake of farm households.

The own production ratio was positively and significantly correlated with farmland size (r = 0.185) and calorie intake (r =. 0.619). The Simpson's Index was weakly associated with HDDS (r = 0.182), but strongly associated with calorie intake level (r = 0.685). However, HDDS and calorie intake were weakly correlated with a coefficient value of (r = 0.200). This could be because farm households were found as medium dietary diversity. The findings of this study are consistent with the previous findings on the increasing crop diversification resulted in increasing dietary diversity, while calorie intake have a positive relationship with dietary diversity of food groups (Linderhof et al., 2016; FAO, 2011; Dillion et al., 2014).

Discussion

The findings from this study emphasize the significant relationship between crop diversification, dietary diversity, and calorie intake among farm households in Yamethin District. The strong positive correlation between crop diversification and dietary diversity. Specifically, the results reveal that 93% of households practiced low crop diversification, with only 5% and 2% exhibiting moderate and high levels, respectively. Despite this dominance of low diversification, households with higher crop diversification indices demonstrated noticeably increased dietary variety and caloric intake, indicating the importance of crop diversification as a strategic approach to enhance nutrition and food security. The findings also show that diversified cropping systems provide households with a broader array of food groups, which contribute to higher dietary diversity scores (HDDS). This observation corroborates previous findings by Torheim et al. (2004) and Jones et al. (2014), who concluded that crop production diversity positively influences household dietary diversity and energy intake. Households practicing moderate to high crop diversification exhibited better calorie intakes, often exceeding the minimum thresholds, which aligns with findings by (Cho et al., 2016), emphasizing that crop diversity enhances the availability of food resources necessary for meeting energy needs. This finding is also consistent with the finding in Uganda that households practicing more crop diversification have higher calorie intake (Linderhof et al., 2016).

The correlation analysis revealed a strong relationship between own production ratio (OPR) and dietary diversity, supporting the hypothesis that reliance on household-produced crops can elevate dietary variety. Notably, 68% of households had low OPR, which might partially explain the prevalent low crop diversification levels. Increasing OPR through diversified cropping could serve as an effective intervention to improve household nutrition (Ickowitz et al., 2019; Okwero et al., 2017). These findings reinforce earlier research by (Kant, 2004; Jones et al., 2014), who documented that higher local food production correlates with better nutrient and calorie intakes. However, despite these positive associations, the study identified challenges in promoting crop diversification, such as limited market access, resource constraints, and climatic adversities like water scarcity and droughts in the dry zone of Myanmar. The low adoption rate (only 2% practicing high diversification) indicates significant barriers that prevent households from diversifying crops extensively. Therefore, policy interventions should focus on enhancing farmers' access to resilient crop varieties, extension services, and market linkages to overcome these impediments. Similar studies have highlighted the role of government-supported programs in promoting diversification improves household

nutrition, but also provides livelihood resilience, especially in vulnerable regions facing climate-related challenges (Babatunde et al., 2010; Ickowitz et al., 2019; Okwero et al., 2017). The results indicate that crop diversification significantly enhances dietary diversity and caloric intake among farm households in the dry zone of Myanmar. To maximize these benefits, multifaceted interventions, including technical support for crop variety improvement, market development, and educational programs, are essential.

Conclusions

This study provides evidence that crop diversification plays a crucial role in enhancing dietary diversity and calorie intake among farm households in Yamethin District, Myanmar's dry zone. The findings demonstrate that households practicing higher levels of crop diversification, as measured by Simpson's Index, tend to have better access to a variety of food groups and achieve caloric intake needs or exceeding the minimum recommended levels of the farm households in Myanmar. The positive association between own production ratio (OPR) and dietary quality further highlights the importance of diversified cropping systems in improving household nutrition. Therefore, it suggests that double cropping or mixed-cropping pattern could improve the crop diversification level in study area. Due to complex and multidimensional nature of dietary diversity, this study suggests that next research should undertake improved evaluation of the items of specific food groups, portion size of meals, and calorie intake relationship. The findings suggest that policy measures, aimed at supporting diversification such as distributing high-yield and climate-resistant crop varieties, enhancing farmers' knowledge, could significantly boost dietary diversity and caloric intake. Promoting crop diversification not only enhances nutritional outcomes, but also builds resilience against climate change impacts, which will ensure food security and improved livelihoods for smallholder farmers in the dry zone of Myanmar. Ultimately, establishing dietary diversity and variety diversifying program at township level is essential for ensuring increase calorie intake of farm households in dry zone of Myanmar.

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Conflict of interest

There is no conflict of interest.

References

Abdulai, A. & Aubert, D. (2004). Nonparametric and Parametric Analysis of Calorie Consumption in Tanzania. *Food Policy*, *29*(2), 113–129. https://doi.org/10.1016/j.foodpol. 2004.02.002

Altieri, M. A., Funes-Monzote, F. R. & Petersen, P. (2012). Agroecologically efficient agricultural systems for smallholder farmers: contributions to food sovereignty. *Agron. Sustain. Dev.*, *32*(1), 1–13.

Babatunde, R. O., Adejobi, A. O. & Fakayode, S. B. (2010). Income and Calorie Intake among Farming Households in Rural Nigeria: Results of Parametric and Nonparametric Analysis. *Journal of Agricultural Science, 2*(2), 135–146.

Cho, A., Oo, A. T. & Speelman, S. (2016). Assessment of Household Food Security through Crop Diversification in Natmauk Township, Magway Region, Myanmar. In: *Proceedings of the Conference on International Research on Food Security*, Natural Resource Management and Rural Development organized by the University of Natural Resources and Life Sciences (BOKU Vienna), Austria, 18–21 September 2016.

Dillion, A., McGee, K. & Oseni, G. (2014). Agricultural production, dietary diversity and climate variability. *The journal of development studies, 51*(8), 976–995. Policy Research Working Paper 7022. World Bank. Available from: http://documents.worldbank.org/curated/en/984981468159331083/pdf/WPS7022.pdf

Evans, J. D. (1996). Straightforward Statistics for the Behavioral Sciences. *Brooks/Cole Publishing*, Pacific Grove, Calif. ISBN 0-534-23100-4.

Food and Agriculture Organization (FAO) (2011). Guidelines for Measuring Household and Individual Dietary Diversity. Authors: Kennedy, G., Ballard, T., Dop, M. C. Rome, Italy. ISBN: 978-92-5-106749-9.

Food and Agriculture Organization (FAO) (2020). The State of Food Security and Nutrition in the World 2020. Food and Agriculture Organization.

Food and Agriculture Organization (FAO) (2024). The State of Food and Agriculture 2024 – Value-driven transformation of agrifood systems. Rome, Italy. https://doi.org/10.4060/cd2616en

Gibson, J. & Rozelle, S. (2000). How Elastic is Calorie Demand? Parametric, Nonparametric, and Semiparametric Results for Urban Papua New Guinea. Working Paper No. 22, Department of Agricultural and Resource Economics, University of California, Davis.

Haddad, L. A. (2000). Conceptual Framework for Assessing Agriculture–Nutrition Linkages. *Food and Nutrition Bulletin*, *21*(4), 367–373. https://doi.org/10.1177/15648265000 2100405

Hawkes, C. & Ruel, M. T. (2006). Understanding the Links between Agriculture and Health. 2020 vision focus 13, International Food Policy Research Institute (IFPRI).

Herforth, A. (2010). Promotion of Traditional African Vegetables in Kenya and Tanzania: A Case Study of an Intervention Repre-

senting Emerging Imperatives in Global Nutrition. Ithaca, NY: Cornell University. https://hdl.handle.net/1813/17139

Ickowitz, A., Powell, B., Rowland, D., Jones, A. & Sunderland, T. (2019). Agricultural intensification, dietary diversity, and markets in the global food security narrative, *Global Food Security*, *20*, 9–16. https://doi.org/10.1016/j.gfs.2018.11.002

Jones, A. D., Shrinivas, A. & Bezner-Kerr, R. (2014). Farm production diversity is associated with greater household dietary diversity in Malawi: Findings from nationally representative data. *Food Policy*, *46*, 1–12.

Joshi, P. K., Joshi, L. & Birthal, P. S. (2006). Diversification and its impact on smallholders: evidence from a study on vegetable production. *Agric. Econ. Res. Rev., 19*(2), 219–236.

Kant, A. K. (2004). Dietary patterns and health outcomes. *Journal of the American Dietetic Association, 104*(4), 615–635.

Linderhof, V., Powella, J., Vignes, R. & Rubena, R. (2016). The influence of household farming systems on dietary diversity and caloric intake: the case of Uganda. Paper presented at the 5th conference of the African Association of Agricultural Economists, Addis Ababa, Ethiopia, 23–26 Sept, 2016.

Ministry of Agriculture, Livestock and Irrigation (MOALI) (2017). Myanmar Agriculture in Brief. Nay Pyi Taw, Myanmar.

Nandi, R. & Nedumaran, S. (2022). Rural Market Food Diversity and Farm Production Diversity: Do They Complement or Substitute Each Other in Contributing to a Farm Household's Dietary Diversity? Front. *Sustain. Food Syst.*, *6*, 843697. doi: 10.3389/fsufs.2022.843697

Okwero, W. F., Westendorp, A. & Nederlof, S. (2017). The Contribution of Dairy Commercialization to Household Food Security; A case of Gisambai Dairy Commercial Village in Hamisi, Vihiga Kenya. *Journal of Food Security*, *5*(5), 176–186. https://doi.org/10.12691/jfs-5-5-4

Oo, A. T., Van Huylenbroeck, G. & Speelman, S. (2017). "Determining factors for the application of climate change adaptation strategies among farmers in Magwe District, dry zone region of Myanmar". *International Journal of Climate Change Strategies and Management*, *9*(1), 36–55. https://doi.org/10.1108/IJCCSM-09-2015-0134

Oyarzun, P. J., Ross, M. B., Stephen, S. & Vicente, P. (2013). Making Sense of Agrobiodiversity, Diet, and Intensification of Smallholder Family Farming in the Highland Andes of Ecuador. *Ecology of Food and Nutrition, 52*(6), 515. https://doi.org/10.1080/03670244.2013.769099

Pinstrup-Andersen, P. (2007). Agricultural Research and Policy for Better Health and Nutrition in Developing Countries: A Food Systems Approach. *Agricultural Economic, 37*(12), 187–198. DOI:10.22004/ag.econ.25414

Raneri, J. E., Boedecker, J., Fallas Conejo, D. A., Muir, G., Hanley-Cook, G. & Lachat, C. (2023). Can common dietary assessment methods be better designed to capture the nutritional contribution of neglected, forest, and wild foods to diets? *Front. Nutr., 10*, 1186707. doi: 10.3389/fnut.2023. 1186707

Shahidullah, S., Talukder, M., Kabir, M. & Abvkhan, N. E. (2008). Cropping patterns in the South East Coastal Region of Bangladesh. *Journal of Nutrition*, *4*(1), 53–60.

Simpson, E. H. (1949). *Measurement of Diversity. Nature*, 163–688.

Swindale, A. & Bilinsky, P. (2006a). Household Dietary Diversity Score (HDDS) for Measurement of Household Food Access: Indicator Guide. *Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development, 220*.

Swindale, A. & Bilinsky, P. (2006b). Development of a Universally Applicable Household Food Insecurity Measurement Tool: Process, Current Status, and Outstanding Issues. *The Journal of Nutrition, 136*(5), 1449S–1452S.

Torheim, L. E., Ouattara, F., Diarra, M. M., Thiam, F. D., Barikmo, I., Hatløy, A. & Oshaug, A. (2004). Nutrient Adequacy and Dietary Diversity in Rural Mali: Association and Determinants. *European Journal of Clinical Nutrition, 58*(4), 594–604. https://doi.org/10. 1038/sj.ejcn.1601853

Vhurumuku, E. (2014). *Food security indicators. In Integrating Nutrition & Food Security Programming for Emergency Response Workshop.* Food and Agriculture Organization, Nairobi.

World Health Organization. (2004). Vitamin and Mineral Nutrition Information System. Report on the nutrition of populations: assessing global and regional dietary patterns. Geneva: WHO.

Yamane, T. (1967). *Statistics: An Introductory Analysis* (2nd ed.). Jon Weatherhill. Publisher: *Harper & Row*; Weatherhill, New York, NY [etc.], Tokyo, 1967.

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