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# Role of different farming systems to assess households' food security: A case study in Yamethin District, dry zone region of Myanmar

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## Abstract

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Farming systems promoting crop production are important to match food security concerns. This research explores food security levels of different farming systems using the indicators of food availability, food access and food utilization. In Yamethin District, various households cultivated a combination of different crop of farming systems. Structured interviews were conducted with 282 farm households: monoculture farming system, multiple farming systems, and mixed farming system. The data were analyzed using weighted sum models. The assessment identified that the monoculture farming system had low food availability, high food access and moderate food utilization, while the multiple and mixed farming systems had moderate food availability, high food access and low food utilization. The study suggested that monoculture farm households should grow vegetables and build up crop exchanges to fulfill staple rice and increase food availability. Moreover, multiple and mixed farm households should allocate farm plots based on average farm land to hold high food security. Under adequate irrigation, 70% farm land for staple rice, 20% farm land for field crops and the rest (10%) for vegetables should be carried out from season to season. In rain-fed area, similar farm allocation should be performed during monsoon and short-season crops during post monsoon season.

*Keywords:* dry zone; farming system; food availability; food access; food utilization

## Introduction

In the Southeast Asia regions, farming systems are enormously diverse which are integrated faming systems, organic farming systems, nature farming systems, agro-forestry farming systems, as well as wetland and dry land farming systems (Dawe et al., 2019). Many researchers confirmed that farming systems have evolved to fit natural resources conditions for the production of crops, livestock, aquaculture and agro-forestry corresponding to different agro-ecological zones (Mahapatra & Bahera, 2004; Dixon et al., 2019).Rice, oil palm, rubber, fruit trees and vegetables are the most dominant crops in the complex and diverse farming systems of the Southeast Asian countries (Dawe et al., 2019).

Based on the different agro-ecological zones of Myanmar, the current agricultural farming systems are aquaculture farming in coastal zones, mixed farming of paddy and aquaculture in delta regions, and intensive farms of fruit and vegetables in mountainous regions (Haggblade et al., 2013). The dry zone predominantly practices paddy production with diverse crops such as cotton, pulses and vegetables through irrigation and rain-fed systems (ADB, 2015). The farm households are practicing farming system with different crops to reduce the increasing effects of climate change and to secure food for household consumption (Cho et al., 2016).

Consequently, the farming systems are classified into three categories: monoculture, multiple and mixed farming system. The monoculture farming system includes the farm that produces grape, rice, and parsley by mono cropping. The multiple farming system are practicing sequential cropping pattern producing diverse crops of rice, pulses, and oilseeds; and mixed farming systems involve the same crops as in multiple farming systems by mixed cropping patterns (Mahapatra & Bahera, 2004; Department of Agriculture, 2018). Based on the Food and Agriculture Organization (FAO)'s food security indicators: food availability, food access, and food utilization (are the indicators) stability (is the condition) of these three indicators (FAO, 2008). Food availability means sufficient and necessary food items available to individuals through production. Food access refers to individuals having adequate income or other resources to purchase or obtain appropriate food needed to maintain consumption of an adequate diet (FAO, 2008). Utilization of food means proper usage of food intake through adequate diet, clean water, health care, and adequate nutrition (Carletto et al., 2013).

Despite that Myanmar produces a surplus of different food crop items, many households suffer from food insecurity, which is significantly higher in the dry zone. A few studies have examined food security in rural areas, focusing on the calorie status of the households (Maung et al., 2016; WFP, 2011).In addition, Myanmar is still lacking, in-depth knowledge about the food security indicators and farming systems in the dry zone. Therefore, the empirical research on the assessment of farm households' food security and various farming systems is necessary to be carried out in the Yamethin District, dry zone of Myanmar.

***Farming Systems and Crop Production Profile in Yamethin District***

Farming system in the study district depends on uncertain climatic factors such as variations of temperature, irregular rainfall patterns and prolonged drought periods, all of which impact on the farmers who live in the areas with water scarcity. The reductions in crop yields and shifts in cropping seasons are the most common repercussions of climate change experienced by farm households (Dumenu&Obeng, 2016). These uncertainties influence the decisions of the farm households regarding the choice of a suitable farming system in a specific season to ensure crop yields and incomes.

Reduction in productivity may cause adverse impacts on food availability, and then on access to food and farm incomes. Therefore, the farm production profiles of different farming systems exhibit different food security conditions in the dry zone. In this study, the farming systems are mostly diversified owing not only to the nature of cropping pattern, and type of crop grown, but also the availability of irrigation facilities. The sequential and mixed cropping patterns are mostly practiced by a large proportion of the farm household in the selected villages. Mono cropping and relayed cropping patterns are also practiced (Department of Agriculture, 2018). The main cash crops grown in 2017- 2018 cropping season were rice, pulses (green gram, chickpea, pigeon pea), oilseed crops (groundnut, sesame, sunflower), cotton, fruits and vegetables such as grapes, onion, chili, and parsley (Department of Agriculture, 2018). Although rice is the staple crop in Yamethin District, the yield is uncertain without irrigation.

Considering the above mentioned factors, planting seasons and cultivated crops are very diverse. The categorized farming systems in this research are: (1) monoculture farming system; (2) multiple farming system; and (3) mixed farming system. Based on the farming systems, this study reflects the levels of households' food security of different farming system in the dry zone of Myanmar.

## Materials and Methods

***Profile of the Study Area***

The field survey was conducted using structured questionnaires in 15 villages from two townships of Yamethin District, dry zone of Myanmar (Figure 1). The dry zone is situated in central Myanmar. Dry zone is considered as one of the most food insecure areas in the country (Boori et al., 2017). The dry zone covers more than 75000 km$^2$ and represents 13% of the country's land area (Department of Agriculture, 2018). The total area of Yamethin District is about 3821.16 km$^2$, cultivated land area is roughly 1692.56 km$^2$(Department of Agriculture, 2018). The fieldwork was conducted from March to April 2018. This study focused on measuring the food security levels of farm households among different farming systems by collecting and analyzing the household' food availability (HHFAv), household' food access (HHFAc), and household' food utilization (HHFUt) indicators.

***Population and sampling***

The data collection was undertaken in Yamethin District and multi-stage sampling was used to select the farm households. In the first stage, Taro Yamane formula in the equation (1) was used to calculate the sample size ($n$ = 396) from the selected population of 40165 farm households from 15 villages purposively (Yamane, 1967).

$$n = \frac{N}{1 + \mathrm{N(e)}^2}, \tag{1}$$


**Fig. 1. Map showing the villages of Yamethin District, Myanmar (*Source*: Herridge et al., 2019)**

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).

Secondly, the 114 farm households were excluded from the survey because they did not report complete data of farming system. Table 1 shows the population and sample size of the different farming systems by using stratified random sampling technique.

**Table 1. Population and sample size of the different farming system (*n* = 282)**

| No | Farming systems | No. of households | Sample size |
|---|---|---|---|
| 1. | Monoculture farming system | 3.703 | 26 |
| 2. | Multiple farming system | 22.504 | 158 |
| 3. | Mixed farming system | 13.958 | 98 |
| Total | | 40.165 | 282 |

***Data analysis and household food security***

The weighted sum model of standard equations was used to determine food security status (Prapruit et al., 2015; Song & Kang, 2016). The weight of each criterion of the indicators was determined by using simple ranking analysis in the equation (2). For these parts, 46 key informants such as agricultural officers, farmer leaders, and managers from agricultural company in this district were involved.

$$wj = \frac{rj/N}{\sum \frac{rj}{N}}, \qquad (2)$$

where: $wj$ is weight of variable $j$,$rj$ is rank of the variable, $N$ is total number of $j^{th}$ variable.

The variables of food availability (HHFAv) indicator in this analysis were measured according to their relative importance as shown in Equation (3), and the scores were based on the regional recommendation to the farming systems in the dry zone (Kyaw, 2009; Abdelaziz et al., 2015; Novide, 2018; Stein & Steinmann, 2018).

$$HHFAv = \Sigma bjYj = b_1Y_1 + b_2Y_2 + b_3Y_3 + b_4Y_4 \qquad (3)$$

where: $Y_1$ is the size of farm land, $Y_2$ is irrigation access, $Y_3$ is rice yield, $Y_4$ is cropping pattern, $b_1$ to $b_4$ are the weights of variables $Y_1$ to $Y_4$, and $j$ is the number of variables.

The values of $b_1$ to $b_4$ were (0.35, 0.25, 0.20, 0.20), which resulted from key informant interviews.

Food access (HHFAc) includes three variables (Abdullah et al., 2017; Paudel, 2016). Each variable was standardized in the same way as those of the food availability analysis and derived from Equation (4).

$$HHFAc = \Sigma\, ckXk = c_1X_1 + c_2X_2 + c_3X_3, \qquad (4)$$

where: $X_1$ is average monthly income, $X_2$ is food expenditure, $X_3$ is market access for food source, $c_1$ to $c_3$ are the weights of variables $X_1$ to $X_3$, and $k$ is the number of variables.

The values of $b_1$ to $b_4$ were (0.45, 0.25, 0.30) which resulted from key informant interviews, denote weights of variables of $X_1$ to $X_3$.

Food utilization (HHFUt) comprises of sufficient calorie intake using the calorie food list and the minimum recommended calorie requirement for daily activities in the developing countries (Maung et al., 2016; USDA, 2013) and drinking water sources (Florence et al., 2017) in Equation (5).

$$HHFUt = \Sigma\, di\, Zi = d_1 Z_1 + d_2 Z_1, \quad (5)$$

where: $Z_1$ is sufficient calorie intake, $Z_2$ is drinking water sources, $d_1$ and $d_2$ are the weights of $Z_1$ and $Z_2$ and $i$ is the number of variables.

The values of the $d_1$ and $d_2$ are referred to as (0.60) and (0.40) respectively which were resulted from key informant interview. Additionally, the food security (HHFS) analysis was calculated by summarizing HHFAv, HHFAc and HHFUt as shown in Equation (6).

$$HHFS = 0.55HHFAv + 0.27HHFAc + 0.18HHFUt, \quad (6)$$

where: *HHFS* is the households' food security, *HHFAv* is households' food availability, *HHFAc* is households' food access; and *HHFUt* is households' food utilization.

The values of 0.55, 0.27, and 0.18 are the weights (resulted from key informant data) of the HHFAv, HHFAc, and HHFUt, respectively.

The assessment of household food security and the scores of each variable of HHFAv, HHFAc, and HHFUt are presented in Table 2.

Both analytical and descriptive methods were used in this study. According to analytical results from the equations, the levels of each indicators and overall food security were determined by using the weighted scores (min= 1.00, max= 3.00, and levels of three measurement). The measurement is categorized into low (1.00-1.67), moderate (1.68- 2.34), and high (2.35-3.00) levels, respectively. The levels and scores of the HHFAv, HHFAc, and HHFUt were based on the regional recommendation for the farm households and the assumption from the global range for the farm households from the previous studies (FAO, 2001; Haggblade et al., 2013; Maung et al., 2016; Kyaw, 2009; Abdelaziz et al., 2015; Novide, 2018; Stein & Steinmann, 2018; Abdullah et al., 2017; Paudel, 2016; USDA, 2013; Florence et al., 2017).

## Results and Discussion

Table 3 shows the percentage of levels of food security variables of farming systems.

Initially, it was found that 65% of the monoculture household owned less than 2 ha and this was the highest percentage among the farming systems. In terms of possessing 2-4 ha of farm land, 46% of the households were found in the multiple farming systems and nearly 40% were found in the mixed farming system. Moreover, mixed farming systems had the farm size of more than 4 ha, amounting to 23.5 % and this amount was higher than that of the monoculture and multiple farming systems.

The irrigation systems in the study villages were rain fed, dam/canal, and use of underground water by digging tube wells. These two types of irrigation were majorly found among all the farming systems: 76.9% in the monoculture farming system, and 67.7% in the multiple farming system, and 64.3 % in the mixed farming system, respectively. How-

**Table 2. Levels and score used in food security analysis**

| Indicators | Measurement and scores | | |
|---|---|---|---|
| | First level (score = 1) | Second level (second = 2) | Third level (score = 3) |
| HHFAv | | | |
| Farm land size (ha) | < 2 ha | 2-4 ha | > 4 ha |
| Irrigation access rain fed | | two types of irrigation | > two types of irrigation |
| Rice yield[1] (kg/ha) | no yield | < 3,780 | > 3,780 |
| Cropping pattern | mono cropping | Double/sequential cropping | Double/sequential cropping |
| HHFAc | | | |
| Avg. income (USD)[2] | < 106 USD | 106 -159 USD | > 159 USD |
| Food expenditure | > 100% of expenditure | > or = 50 % of expenditure | < 50 % of expenditure |
| Market access for food sources | < 40 % on market | 41- 70 % on market | > 70 % on market |
| HHFUt | | | |
| Suf. calorie (kcal/day) | < 2,100 kcal | 2,100 – 2,400 kcal | > 2,400 kcal |
| Drinking water sources | (no treatment) | treated water | purified water |

*Note:* 1 The optimum rice yield of dry zone recommended by Rice Division, Department of Agriculture, Myanmar, 2016.
2 The National Committee for minimum wage. 2017-2018. Myanmar, (1 USD = 1.356 MMK from March to April, 2018)

**Table 3. Percentage of levels of food security variables of different farming systems**

| Food security variables | Farming system | First level | Second level | Third level |
|---|---|---|---|---|
| HHFAv | | | | |
| Farm land size (ha) | Monoculture farming system | 65.4 | 19.2 | 15.4 |
| | Multiple farming system | 35.5 | 46.8 | 17.7 |
| | Mixed farming system | 37.8 | 38.7 | 23.5 |
| Irrigation access | Monoculture farming system | 3.8 | 76.9 | 19.3 |
| | Multiple farming system | 31.0 | 67.7 | 1.3 |
| | Mixed farming system | 16.3 | 64.3 | 19.4 |
| Rice yield (kg/ha) | Monoculture farming system | 80.8 | 0.0 | 19.2 |
| | Multiple farming system | 0.0 | 73.4 | 26.6 |
| | Mixed farming system | 11.2 | 74.5 | 14.3 |
| Cropping pattern | Monoculture farming system | 100 | 0.0 | 0.0 |
| | Multiple farming system | 0.0 | 75.3 | 24.7 |
| | Mixed farming system | 0.0 | 39.8 | 60.2 |
| HHFAc | | | | |
| Avg. monthly income (USD) | Monoculture farming system | 3.8 | 0.0 | 96.2 |
| | Multiple farming system | 24.7 | 19.6 | 55.7 |
| | Mixed farming system | 17.3 | 17.3 | 65.4 |
| Food expenditure % | Monoculture farming system | 3.8 | 0.0 | 96.2 |
| | Multiple farming system | 0.6 | 43.0 | 56.4 |
| | Mixed farming system | 2.0 | 31.7 | 66.3 |
| Market access for food source | Monoculture farming system | 0.0 | 34.6 | 65.4 |
| | Multiple farming system | 5.7 | 72.8 | 21.5 |
| | Mixed farming system | 11.2 | 65.3 | 23.5 |
| HHFUt | | | | |
| Sufficient calorie intake (kcal/day) | Monoculture farming system | 61.5 | 11.6 | 26.9 |
| | Multiple farming system | 74.7 | 12.0 | 13.3 |
| | Mixed farming system | 80.6 | 7.2 | 12.2 |
| Drinking water sources | Monoculture farming system | 19.2 | 53.8 | 27.0 |
| | Multiple farming system | 23.4 | 73.4 | 3.2 |
| | Mixed farming system | 37.8 | 55.1 | 7.1 |

ever, rain fed irrigation was found at 31%, being still higher in the multiple farming systems in Yamethin District.

In the monoculture farming system, the mono crop grower did not grow rice such as grape mono-crop farm and parsley mono-crop farm had no rice yield and the households focused solely on cultivating grapes and parsley. However, 19.2 % of rice monoculture farmers received rice yield of more than 3,780 kg per ha within a one cropping season. On the other hand, the rice yield was still lower in rice multiple farming systems and mixed farming system because the group of less than 3,780 kg per ha was found as 73.4% and 74.5% respectively.

The major cropping patterns of the farming system are mono cropping, double cropping (relayed cropping, intercropping), and sequential cropping (double cropping, and triple cropping). Out of the farming systems, mono cropping such as grape, rice, and parsley was solely practiced by monoculture farming system. The analysis identified that 75.3% of multiple farming system practiced double cropping pattern and 24.7% of this farming system practiced sequential cropping pattern with three times per year such as rice-chili-parsley, cotton-rice-cotton, pulses-rice-oilseed. On one hand, mixed farming system practiced all of the double cropping, intercropping, and sequential cropping pattern. Consequently, 39.8% of the farm households practiced double and intercropping such as rice-chili plus parsley in one plot, pigeon plus green gram in separate plot of their farm land at the same time. Furthermore, 60.2% of the mixed farming systems cultivated sequential and intercropping pattern by integrating the many type of crops.

As shown in Table 2, average monthly income, food expenditure, and market access were used to set the level of HHFAc. The minimum wage (106 USD) by the National Committee was used to calculate the income level developed from farm crop productivity and farm related incomes. The minimum wage per month can cover the expenses of food for average household size in the rural area of Myanmar. As a consequence, the households that had income than minimum can be considered to be food insecure.

The monoculture farm households received the highest income (more than 159 USD) however only 3.8% of the farm household received less than 106 USD. This may be due to the facts that grape mono cropping was the most profitable crop in the areas and other rice and parsley crops in small farm size contributed low income. In multiple farming systems, 24.7% household obtained income less than 106 USD and this means that they were insecure to buy food in term of income. Meanwhile, 19.6% households had the medium income with 106 USD- 159 USD whereas the rest (55.7%) had higher income. On the other hand, 65.4% households in the mixed farming system had the income of more than 159 USD. However, less than 106 USD were found 17.3% in the mixed farming systems and also 17.3% of the mixed farming systems experienced income insecurity.

The monoculture farm households, representing 96.2% of the total households, spent less than 50% of their income on food. However, 3.8% of the households had to spend 100% of their income only on food, highlighting that their income was not enough for daily expenditure. Similarly, 0.6 % of the multiple farm household and 2.0% of the mixed farm households had to spend 100% of their income only on food expenditure and they were not also able to buy enough food. However, the majority of multiple farm household and mixed farm households had the low food expenditures amounting to 56.3% and 66.3% respectively.

In the context of food sources, the majority of farm households in Yamethin District primarily relied on food sources of their own production and bought some meats from the markets. The reliance of the monoculture farm household on market access to food sources was higher

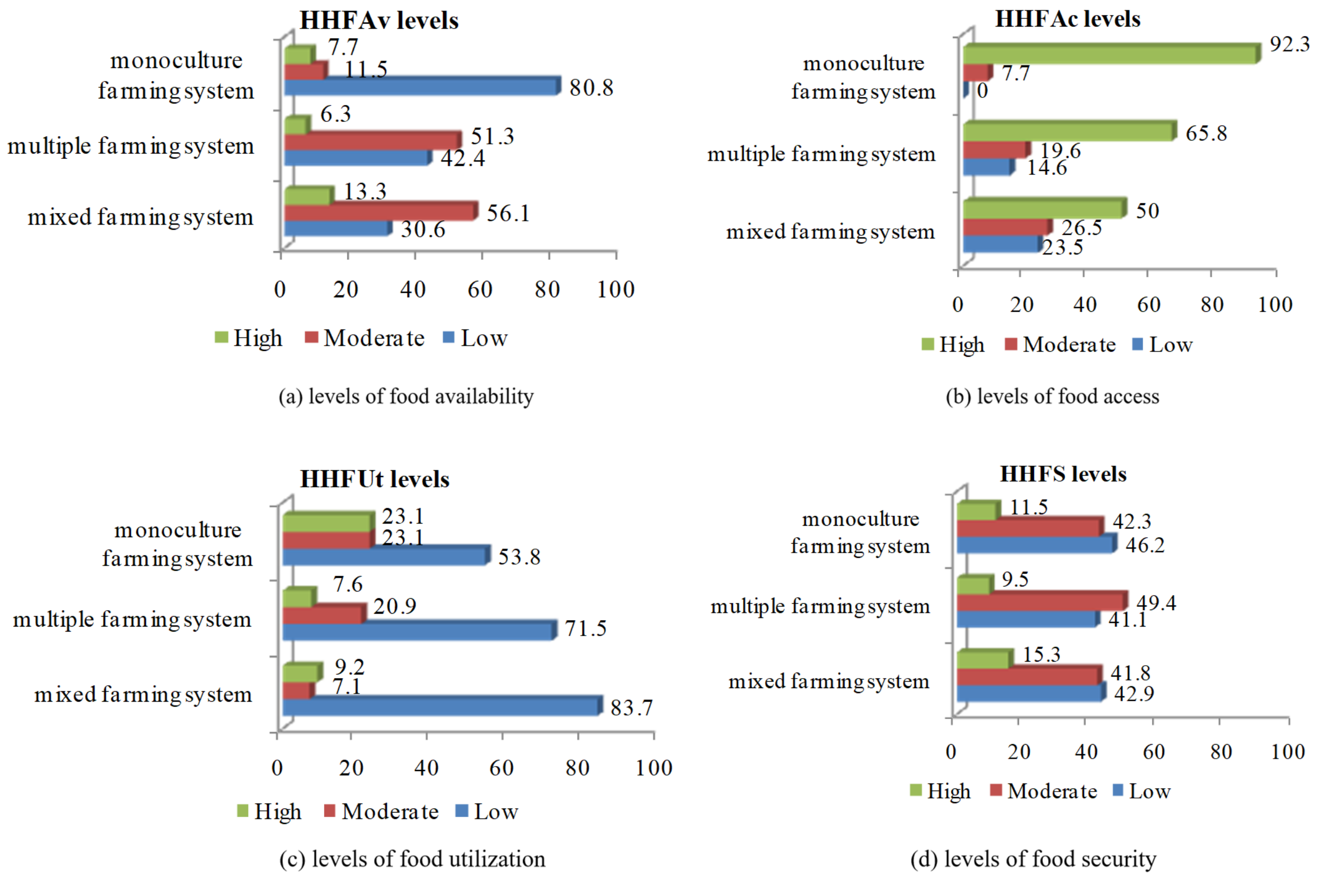


**Fig. 2. Levels of food security indicators (a), (b), (c) and overall food security (d) of different farming systems**

*Note:* HHFAv = household' food availability, HHFAc = household' food access, HHFUt = household' food utilization, HHFS = household' food security.

than the multiple and mixed farm households. As a result, 65.4 % of the monoculture households purchased more than 70% of the foods from market whereas 34.6% of these farm households bought food from market with the proportion of 40-70%. This was due to the fact that the cultivation of staple rice was found small units of 19.2% in the monoculture farming system. On the other hand, the majority of food sources in the multiple and mixed farm households primarily relied on their own production, thus purchasing food items was found to be lower. Also medium and low market access were found in multiple and mixed farm households. Alternatively, a high rate of food crop production might significantly have impacts on the multiple and mixed farming systems.

Regarding the HHFUt context, the monoculture farm household had the highest average calorie intakes, with 1,982 kcal/day, followed by the multiple farm households (1,741 kcal/day) whereas the mixed farm households had minimum calorie, respectively. The analysis indicated that the households in all the farming systems predominantly had insufficient energy intakes. The majority of the farm households received lower calories than the recommended intake (2,100 kcal/day). It was observed that 11.5% of the monoculture households, 12.0% of the multiple households, and 7.2% of the mixed farm households ranged between 2,100-2,400 kcal/day. On the other hand, 26.9% of the monoculture farming system had over the calorie intakes of 2,400 kcal/day whereas the remaining farming systems had nearly the same calorie intakes.

Drinking water resources are also an important parameter of food utilization. The results revealed that the highest percentage of all the farm households drank well water by a boiling treatment. Despite that 27.0% of the monoculture farm households had access to purified water, it was only a small percentage in the multiple and mixed farming systems. The percentages of households that directly used the water without any treatment, was found to be higher in the mixed farming system. By summarizing the food security indicators, an overall level of household food security and its indicators resulted from the equation (3), (4), (5) and (6) are illustrated in Figure2.

According to the three levels of the indicator scores as shown in Figure 2, the HHFAv levels of the mixed farming system and multiple farming systems were higher than the monoculture farming system and the majority was found at low food availability. The cropping pattern and rice yield were mostly related to increasing the food availability level of all the farming systems.

In terms of food access, the majority of the farm households in all the farming systems had high HHFAc. Moreover, the monoculture farming system had higher HHFAc than other farming systems amounted to a high level of 92.3%. Firstly, the higher income of grape, parsley, the higher rice yield in rice mono farm households and the income from the selling of several crops such as rice, pulses, oilseeds and cotton in the multiple and mixed farming systems were the explanation of high food access level. Consequently, the higher income devoted to more food items on market access and it also contributed to lower expenditure for food.

Based on the average values of HHFUt, the monoculture farming system was identified as the moderate level of HHFUt whereas the multiple and mixed farming systems were found at low food utilization. This was due to that both the average calorie intakes and the drinking water sources of the monoculture farming system were higher than the multiple and mixed farming systems.

**Table 4. One-way ANOVA analysis of food security and its indicators among different farming systems**

| Items | ANOVA | | | | | |
|---|---|---|---|---|---|---|
| | | Sum of Squares | df | Mean Square | F | Sig. |
| Food availability level | Between Groups | 2.991 | 2 | 1.496 | 13.727 | .000** |
| | Within Groups | 30.399 | 279 | .109 | | |
| | Total | 33.391 | 281 | | | |
| Food access level | Between Groups | 6.049 | 2 | 3.025 | 12.139 | .000** |
| | Within Groups | 69.518 | 279 | .249 | | |
| | Total | 75.568 | 281 | | | |
| Food utilization level | Between Groups | 1.603 | 2 | .802 | 3.519 | .031* |
| | Within Groups | 63.559 | 279 | .228 | | |
| | Total | 65.162 | 281 | | | |
| Food security level | Between Groups | .055 | 2 | .027 | .156 | .856$^{ns}$ |
| | Within Groups | 49.074 | 279 | .176 | | |
| | Total | 49.129 | 281 | | | |

*Note:* ** significant at $p < 0.01$ level, * significant at $p < 0.05$ level, $^{ns}$ non-significant

According to the indicator measurement of food availability, food access, and food utilization, results showed that the majority of all the farming systems were moderately food secured. Table 4 shows the analysis of the differences in food security indicators of the different farming systems by using one–way ANOVA. Although food security level was not statistically significant, the indicators of HHFAv and HHFAc were statistically significant among different farming systems at less than p value 0.01, HHFUt were less than p value 0.05 levels respectively.

***Discussion of farming system and indicator for household food security***

The different indicators of food security and farming systems are being impacted by the specific factors of HHFAv, HHFAc, and HHFUt, respectively. Basically, the assessment of food availability from this study showed that the HHFAvlevels of the mixed farming system and multiple farming systems were higher than the monoculture farming system. The cropping pattern and rice yield of the monoculture farming system were found to be lower than the multiple and mixed farming systems. Similarly, small farm size may encounter low food availability in the monoculture farming systems. These findings are supported by the previous studies (Maung et al., 2016; Kyaw, 2009; Abdelaziz et al., 2015; Novide, 2018; Fuss et al., 2015). Sequential cropping pattern can improve food availability level in all the farming systems and the result is consistent with other findings (Stein & Steinmann, 2018).

The food access analysis (HHFAc) identified that the majority of the farm households in all farming systems had high HHFAc. Generally, the higher income of grape, and parsley in monoculture farming system and the income from the selling of several crops such as rice, pulses, oilseeds and cotton in multiple and mixed farming systems can contribute high HHFAc level. Consequently, high incomes led to the low food expenditure of the farm households. Moreover, the market access to food was higher in the monoculture farming systems because the HHFAv level and staple food crops were lower. This is comparable to other studies by (Abdullah et al., 2017; Paudel, 2016; Nyikahadzoi et al., 2012) which highlighted that food self-reliance support lower market access.

The present study has also shown that the importance of sufficient calorie intakes and treatment of drinking water towards high food utilization of different farming systems. The majority of all the farming systems were found to be at low calorie intakes. Hence, reducing the numbers of farm households experiencing low food utilization are required to be carried out in the Yamethin District. This result is supported by the previous study indicated that lower calorie intakes may ultimately result in food insecure (Maung et al., 2016). Additionally, despite that all the farming systems had low access to purified drinking water, the monoculture farming system had more access than the multiple and mixed farming systems. This finding is consistent with the fact that drinking water without treatment can limit the household food utilization (Ludi et al., 2017).

## Conclusions

In this study, the household food security levels of the different farming systems were investigated by the indicators in Yamethin District. Although the HHFAv, HHFAc, and HHFUt indicators showed the different trends for the different farming systems, the data confirmed that low food availability, high food access, and moderate food utilization were found in the monoculture farming system. This study also pointed out that both the multiple and mixed farming systems have the same trend of moderate food availability, high food access and low food utilization.

The study recommends that the grape farm households should grow the vegetables under grape vines, should store rice from multiple and mixed farm households by means of crop exchanges to increase food availability. Based on the average farm land size, rice and parsley mono crop growers, the multiple and mixed farm households should allocate their farm plots to hold high food security. Under adequate irrigation, the allocation pattern of farming system should be carried out from season to season as follow: 70% of a farm land for staple rice cultivation, 20% of a farm land for the field crop such as pulses, oilseeds and cotton, and the rest (10%) for vegetables such as chili, parsley, and onion. Another important suggestion is that if a farm land is located in rain-fed area, the farm households should cultivate the similar farm allocation of irrigated farm during monsoon season. In the post monsoon season, farm households should cultivate short season crops. Consequently, small-holder farm households should cultivate rice in monsoon season and high cash crop vegetables such as parsley and onion in post monsoon season with private irrigation. Moreover, the succeeding crops should be the short season crops or should be based on the residual moisture of previous crop. Moreover, the knowledge sharing such as water saving technology and crop water use should be provided in this dry zone region to get the efficient utilization of irrigation in all the farming systems. To increase food utilization in all farming systems, the consumption of more food items such as nutritious food and more protein sources is required in Yamethin District, Myanmar.

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