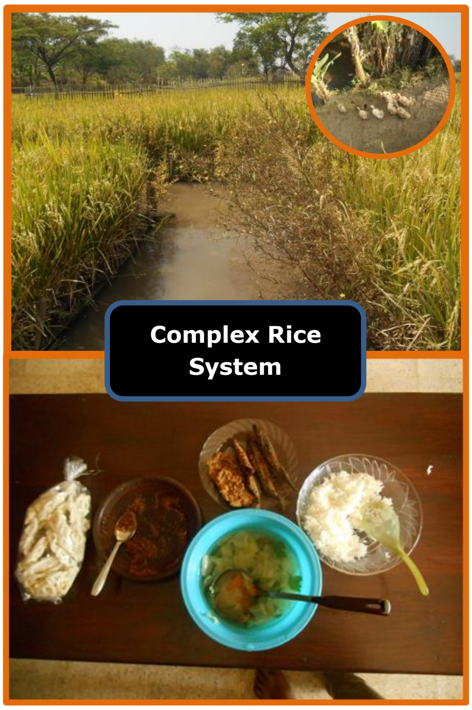
MSc Thesis Report

Evaluating the contribution of complex rice systems to the improvement of farmer's household nutrition in East Java, Indonesia



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Preface and Acknowledgments

This thesis topic is different with my academic background. During my working experience, most of my activities were related to the production of a crop, especially rice. But, this study gives me new insight about farmers' livelihood. Not only think about how to increase rice production to fulfil people needs but also to improve farmers' welfare in rural areas. The awareness of farmers' health, particularly on their household nutrition, brought me to this topic of study.

This study investigated the contribution of complex rice system to the farmers' household nutrition in East Java, Indonesia. It is a part of my MSc Programme in Plant Sciences (Natural Resource Management) at Wageningen University. Furthermore, this study also contributed to increasing my insight and knowledge in the scientific research, scientific community and might help me to develop my future academic career.

Big thanks to mbak Umma Khumairoh, a WUR Ph.D. candidate, who gives me an opportunity to do this thesis. She is very patient in guiding me and giving the information about the research. She and her families are very friendly and welcome from the first time I arrived at Malang. Although I separated far away from my family, I found a new family in her place.

I would like to extend my gratitude to my Supervisor, Dr.Egbert Lantinga, for your close supervision in Farming Systems Ecology (FSE) group which gives me a vast knowledge and experience in this research. Also, I would like to thank Dr.Jeroen Groot for his help by giving some articles related to the topic of my thesis.

Special thanks, I dedicate for my husband and my big families for their support and encouragement. It is an extraordinary challenge for me to continue my study abroad with different cultures, different education systems, and extreme weather conditions to achieve the MSc degree. Then, I also would like to thank all of my friends for their support in finishing my thesis.

Finally, I hope this research will be very useful for agriculture development especially for farmer's household nutrition in rural areas. It is the time to show that farmers also an important aspect of our life. Wherefore, they are the spearhead for the food security of our country. In the future, the collaboration between the researcher and the government might help to find the solutions to every agricultural problem.

Abstract

A study on the contribution of the complex rice system to the farmer's household nutrition was conducted in four regencies in East Java, Indonesia; Malang, Blitar, Pasuruan and Lamongan from June to December 2015. The objectives of this study were to identify the current rice systems in East Java and their contribution to the dietary diversity of a farmer's household and also to redesign the current rice system into more diverse systems based on the principles of the complex rice system design. The aims of this study were achieved through three different approaches: using a dietary diversity score, species diversity index and nutritional functional diversity. The data was collected through surveys, interviews and farm visits. There were 52 respondents for dietary diversity and 16 respondents for species diversity and nutritional functional diversity. The dietary diversity score was measured through 7 days of food records for both current and complex rice systems for the farmer's household. Species diversity of plants and animals was measured using Shannon-Wiener and Simpson's index. Nutritional functional diversity was measured through the edible plant and animal species composition in the rice farms, home garden, and other cultivated fields of farmers. All the data for analysis was observed during the visit and it does not reflect whole year farm activities. The results of this study showed that the current rice system and complex rice system did not significantly affect the dietary diversity score, species diversity index, and nutritional functional diversity of a farmers' household nutrition (*P*-value >0.05). However, the current rice system tended to have a lower dietary diversity score, species diversity index, and nutritional functional diversity compared to the complex rice system in a particular situation. There is also a strong correlation between these three approaches in both rice systems, i.e. between dietary diversity and species diversity, between species diversity and nutritional functional diversity, and between species diversity and nutritional functional diversity. In general, the current rice system contributed to the farmer's household nutrition through some factors such as economic ability, access to the market and eating habits. Redesigning the current rice system based on the principles of a complex rice system design also can contributed to the farmer's household nutrition through these factors and additional factors like increased the species diversity by the integration of plant and animal in the rice field, and also a tendency to consume the food produce from their own field.

Keywords: Farmers' household nutrition, current rice system, complex rice system, dietary diversity, species diversity, nutritional functional diversity and correlation.

I. Introduction

Agriculture is the primary livelihoods of rural households, especially in developing country. In Indonesia, the percentage of the rural household engaged in agriculture activities is around 36.5 % (Statistic Indonesia, 2014). One of the important agriculture crops in Indonesia is rice. It becomes main food crop for all of the Indonesian people (Pasaribu, 2010).

Indonesia has a lot of rice fields spreads in 5 big islands and 35 provinces. Every province has different rice production based on its environmental condition such as soil, weather, water, etc. Besides that, the difference of rice system also influences the rice production in every province. One of the highest rice production areas in Indonesia is East Java. Based on Statistic Indonesia (2014), East Java contributes 12.4 megatons from total rice production in Indonesia (71.2 megatons) as presented in Figure 1.

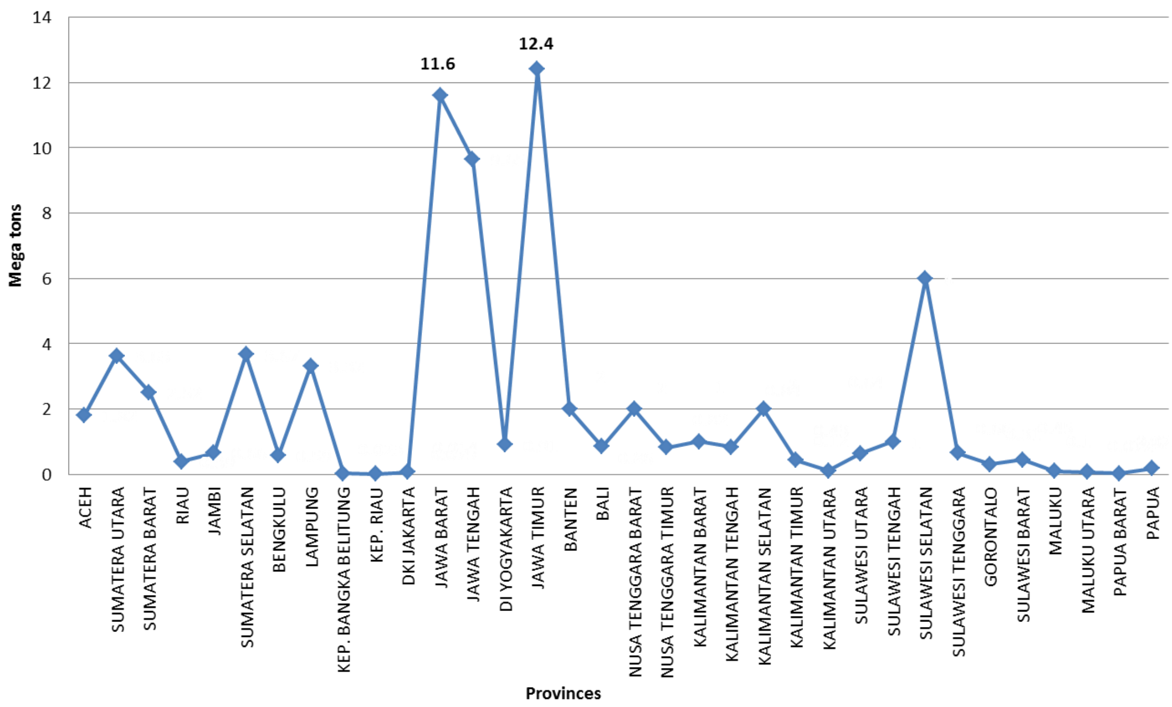


Figure 1. Rice production in 35 provinces (2014)

Most of the rice farmers cultivate their rice field using a conventional system, which is monoculture-farming system. Nevertheless, in some areas, rice farmers also utilize their rice field with other crops or using the intercropping system. Besides that, farmers also use the traditional farming system to utilize their rice field with the combination of rice and fish that called "Mina Padi" (Arlius and Ekaputra, 2011).

Agriculture and nutrition are two things that interconnected each other. In the current discussion, agriculture promotes nutrition with two critical pathways that are through economic effects or consumed own food production (Hoddinott, 2011). In the economic sector, crop diversification is one of alternative ways to increase farm income (Joshi *et al.*, 2004). Generally, low-income of farmer's household in developing country caused by the lack of crop diversification. By using the crop diversification in agricultural activities, the production risks will decrease and contribute to the nutrition of farmer's household (Papademetriou and Dent, 2001).

Frison *et al.,* 2011 reported one of the connections between biodiversity (crop diversification and animal integration in the crop production system) and nutrition is in the dietary level. Increasing agro-biodiversity by doing crop diversification improved food and nutrition security. It played a role in increasing human dietary diversity and health needs (Waswa *et al.,* 2013) by consuming diversified food and well-balanced diets to address malnutrition (Ruel, 2003). Moreover, crop production was also affecting the dietary diversity from agricultural revenue or household's economies (Ellis, 2000). According to FAO (2010), it needs to know how the farmer's household obtaining food, especially certain food groups such as cereals, fruits, and vegetables.

Dietary diversity used as a tool to measure the nutrition of farmer's household while nutritional functional diversity utilized as a means to measure nutrition in farm especially food crop diversity in farming system (De Clerk *et al.,* 2011). Dietary diversity is a qualitative measurement of food consumption in the household or individual level to gain the information about food variety, nutrition and economic ability to purchase the food. Dietary diversity is often used as an indicator to represent the food security in nutrition surveys (Moursi *et al.,* 2008). It gives a significant contribution to improving farmer's nutrition by diversifying agriculture and livestock production (USAID, 2014).

At the household level, Household Dietary Diversity Score (HDDS) is the tool to measure dietary diversity. HDDS developed by the Food and Nutrition Technical Assistance (FANTA) Project of the United States Agency for International Development (USAID) and has a maximum score of 12 food groups (Swindale & Bilinsky, 2006). Based on USAID (2014), HDDS utilized various purposes including monitoring seasonal fluctuations in food access, measuring the impact of a project on household food access and serving as an indicator within an early warning system. This measurement gives information about the household ability to buy food, the variety of food consumption (FAO, 2010) and strongly connected with household calorie availability (Ruel, 2003).

The current study in Malawi by Jones *et al* (2014) reported that there is a positive correlation between farm production diversity and farm household dietary diversity. Dillon *et al* (2014) also reported the result of their study about agricultural production, dietary diversity and climate variability in Nigeria. Based on the statistical analysis, the relation between dietary diversity and agricultural production showed that the increased 10% in agricultural revenue results in 1.8% increase in dietary diversity score, and increased 10% in crop diversity results in 2.4 % increase in dietary diversity score. Furthermore, the increased 10% in agricultural revenue also increase the household level such as increase vegetables consumption 7.2 %, fish 3.5 %, and tubers 5.2 %.

The relation between species composition in the farm and nutrition function in farmer's household can be gained by using the nutritional functional diversity. Nutritional functional diversity is a metric about human diets based on variety of plant species on farm and nutrition composition in these plant species such as carbohydrates, protein, fat, dietary fibre, calcium, iron, magnesium, vitamin A, vitamin C, etc (Remans *et al.,* 2011).

One current innovation in rice farming system is increasing the diversity in rice ecosystem by using the combination of ducks, fish, and Azolla to increase rice production, known as complex rice system. The mix of ducks, fish, and Azolla in complex rice system supplied nutrition especially vitamin A for people. Besides that, the net revenue is increased by 114 % than monoculture system for farmer due to the higher yield and diverse harvesting products such as fish and duck's products (Khumairoh *et al.,* 2012).

Based on the explanation above, the contribution of agricultural production on farmer's household nutrition in rice farming system is limited. Therefore, this study aimed to identify the current rice systems in East Java and its contribution to the dietary diversity of farmer's household, and to redesign current rice systems into more diverse system based on the principle of complex rice system design.

1.1 Objectives

The aims of this study are to identify current rice systems in East Java and its contribution to the dietary diversity of farmer's household and to redesign current rice systems into more diverse system based on the principle of complex rice system design.

1.2 Research Question

What is the contribution of complex rice system, which has the combination of Azolla, ducks, and fish in the farmer's rice field on farmer's household nutrition compared to the current rice systems in East Java?

1.3 Hypotheses

The hypotheses of this study are:

1. The current rice systems in East Java result in a lower contribution to the dietary diversity of farmer household.
2. Redesign of current rice systems in East Java by using complex rice system increases the diversity of farmer's household nutrition due to the increasing the species diversity on farm and off-farm income.

II. Materials and Methods

This study is part of Ph.D. student's project (Uma Khumairoh, 2013).

2.1 Location and time

The study took place in four regencies in East Java, Indonesia (Malang, Blitar, Pasuruan and Lamongan) as presented in Figure 2 from June to December 2015.

2.2 Overview

The contribution of current rice systems to the dietary diversity of farmer's households in East Java was investigated through surveys. The survey consisted of interviews, the daily record of family's diets and field observations during farm visits. The survey was conducted in four regencies, and 13 respondents were sampled in each regency. Thus, the total of respondents was 52. Each respondent represented one farmer's family.

2.2.1 Dietary diversity

Dietary diversity of farmer's households were collected through interviews and keeping records of farmer's household diets using questionnaire forms (Appendix 1 and Appendix 2). These respondents were the same as the respondents for characterization of rice systems in East Java conducted by Uma Khumairoh. Interviews were performed three times for each respondent in all regencies. First interview was done at first visit for general questions (see Appendix 1) to get information about farmer's households and their farming activities. In this first visit, respondents were given form to record their daily diet for seven days. Second visit was done three days after first visit to check if respondents are correctly keeping a record of their family diet. For some respondents, this second step was done by phone. The last visit was done after seven days from first visit. In this third visit, the household dietary forms were collected, and deeper interviews were conducted. Each interview was recorded using a recorder. The consumed food was categorized into primary food sources of the food such as cereal, fruit, vegetables, etc. the questionnaires form can be seen in Appendix 2.

[1]**Figure 2. Map of the survey locations**

1 https://www.google.nl/search?q=peta+jawa+timur&espv=2&biw=1366&bih=667&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiTl6j2rMTKAhWEgA8KHTgbCn4Q_AUIBigB&dpr=1#tbm=isch&q=peta+buta+jawa+timur&imgrc=wwBM8eANANhuJM%3A;http://1.bp.blogspot.com/-Sw1VDrB7Px0/VL4vyEK4ZSI/AAAAAAAAAqM/p3DdHD6qYj0/s1600/pasuruan.%2Bzona%2Bindustri.jpg; http://3.bp.blogspot.com/-YkFp6D6qfWk/Uux8d-Iaq5I/AAAAAAAAAac/Wkjgxi5sPYE/s1600/Lamongan.jpg;https://luwakidhappydayschool.files.wordpress.com/2012/09/pkab-malang.gif; http://www.blitarkab.go.id/wp-content/uploads/2012/06/gambar-peta-kabupaten-blitar.jpg

2.2.2 Species diversity

Species diversity in rice fields was assessed by visiting 4 rice farms in each regency including current rice systems and complex rice systems, thus, the total sample was 16 rice farms for four regencies. Edible and non-edible plants and animals were observed, recorded, sampled and identified. The sample was collected by transect walk method. The visual observation and grabbed samples were confirmed with respondents during interview. Moreover, diversity and richness of different biodiversity components were quantified. There were two separated methods between plant and animal diversity. The plant diversity and abundance were assessed in 5 sampling plots randomly. The sampling should be done 0,5 m from the bunds (for diversity on rice field) or exactly on the bunds (for plant diversity on bund). Sampling was made in four points in each plot using 4 square pipes. The size of the square pipe is 0.25 m^2 as presented in Figure 3. Therefore, for points were accounted for 1 m^2. Every edible and non-edible plant inside the plot was identified and count. The questioners' form of this measurement is presented in Appendix 3. The guidelines book of plant and weeds in rice fields was used to classify the species on farms. Regarding edible animal species diversity (especially ducks and fish) interviews were done with the farmers about the numbers of animals present in the rice field in the early rice plantation and after rice harvest.

Figure 3. Species diversity method

2.2.3 Nutritional functional diversity

The nutritional functional diversity was assessed by taking all data of species diversity in all cultivated areas including rice farms, the household's home garden and other fragmented fields (Appendix 4). The assessment was done on main crops, intercrops, trees and animal species. After that, the database of edible plant and animal nutritional composition data was developed based on the existing studies and United States Department of Agriculture (USDA) to get nutritional trait data. Then, based on this database, we calculated the nutritional functional diversity for macronutrients, minerals and vitamins. Furthermore, we also looked at the Dietary Reference Intake (DRI) for Indonesian people based on the data from Indonesian Ministry of Health. The nutritional data was calculated by taking the amount of each nutrient that provided by edible plants and animals that consumed by the farmers' household, and then compared with DRI.

2.3 Data analysis

All of the data was analyzed by using SPSS 20. The significant difference means were compared using the t-test, Mann-Whitney Test, Pearson and Spearman correlation analysis (Dahlan, 2013; Field, 2014).

2.3.1 Dietary diversity

Dietary diversity of the respondent was determined through its score. The standard of the scoring was used based on Guidelines for measuring household and individual diversity, and adjusted with the local eating habit. Data analysis of dietary diversity was done in three steps that are establishing dietary diversity scores (after foodstuff has been grouped see Table 1), interpretation of collected data and estimation of dietary patterns based on the rice system (FAO, 2010).

The dietary diversity at the household level is measured through Household Dietary Diversity (HDD). A group of HDDs food has originally consisted of 16 groups is aggregated into 12 groups. These food groups have been defined by FAO (FAO, 2010). Scoring is done by giving a score of 1 if a household is eating one type of food which has been grouped and a score of 0 if not eating any food type in any group. Therefore, the HDDs score is ranging from 0-12. The total of the food groups consumed by a member is summed. Due to the type of Indonesian food which is consist many ingredients, the HDDs were categorized into three: a) low dietary diversity if the score value between 0 - 7.5, b) middle dietary diversity if the score value between >7.6 - 10, and c) high dietary diversity if the score value >10.

Table 1. Food groups to determine HDDS

Food groups
A. Cereals
B. White roots and tubers
C. Vegetables
D. Fruits
E. Meat and other meat products
F. Eggs
G. Fish and seafood
H. Legumes, nuts and seeds
I. Milk and milk products
J. Oils and fats
K. Sweets
L. Spices, condiments, beverages

HDDS (0-12)	Total number of food groups consumed by members of the household. Values for A through L will be either "0" or "1". Sum (A + B + C + D + E + F + G + H + I + J + K + L)

2.3.2 Species diversity

The species diversity was analysed using the Shannon-Wiener Index (Eqn.1) and Simpson's Index (Eqn.2). After collecting the species samples, we classify the collected species and counted each species numbers. We separated plant and animal species into different categories. Therefore, the output of the species diversity was divided into plant and animal species diversity. Based on Nicholas and Chao (2013), the formula to calculate the diversity in the farm using Shannon and Simpson's index are presented below:

Shannon-Wiener Index:

$$H' = -\sum_{i=1}^{S} \frac{n_i}{N} \ln \frac{n_i}{N} \quad \text{(Eqn. 1)}$$

Simpson's Index:

$$D = 1 - \frac{\sum_{i=1}^{S} n_i(n_i - 1)}{N(N-1)} \quad \text{(Eqn. 2)}$$

Where S is the number of species at sampling point, *i* is the species relative abundance, *ni* is the abundance of each individual and *N* is the total individuals in the farm. The calculations of the species diversity on the farm were conducted by using Excel.

2.3.3 Nutritional functional diversity

We calculated nutritional functional diversity followed two steps. First step was identification of the edible plant and animal species for current and complex rice system and created the database of nutritional composition based on 100-gram nutrient content. Second step was identification of edible plant and animal species that consumed by the farmer's household, and construction nutrient content based on the amount of consumable edible plant and animal species. The nutrient content covered 17 nutritional compositions, including four micronutrients, six vitamins and seven minerals (Table 2). An adjustment was made for the minerals group. In the previous step, sulfur was including as one of the minerals group. However, in the existing studies and USDA, there is no data of sulfur content for each edible plant and edible animal species. Then, we calculated the minerals group using 6 mineral i.e. calcium, iron, potassium, magnesium, manganese, and zinc. Thus, in total, we used 16 nutrients to calculated nutritional functional diversity (nutritional FD). Then, the nutritional functional diversity in the farm was calculated by summing each nutrient group produced by that farm. Therefore, there were four nutritional functional diversity groups, namely FD_{total}, $FD_{macronutrients}$, $FD_{minerals}$ and $FD_{vitamins}$. Finally, each nutrient of the farmers' household was compared to the DRI. The scheme of the first and second step is presented in Figure 4 and Figure 5 respectively.

Table 2. Nutrients and nutrient groups taken into account for calculation nutritional functional

Macronutrients	Minerals	Vitamins
Protein	Calcium (Ca)	Vitamin A
Carbohydrates	Iron (Fe)	Vitamin C
Dietary fiber	Potassium (K)	Thiamin
Fat	Magnesium (Mg)	Riboflavin
	Manganese (Mn)	Folate
	Zinc (Zn)	Niacin
	Sulfur (S)	

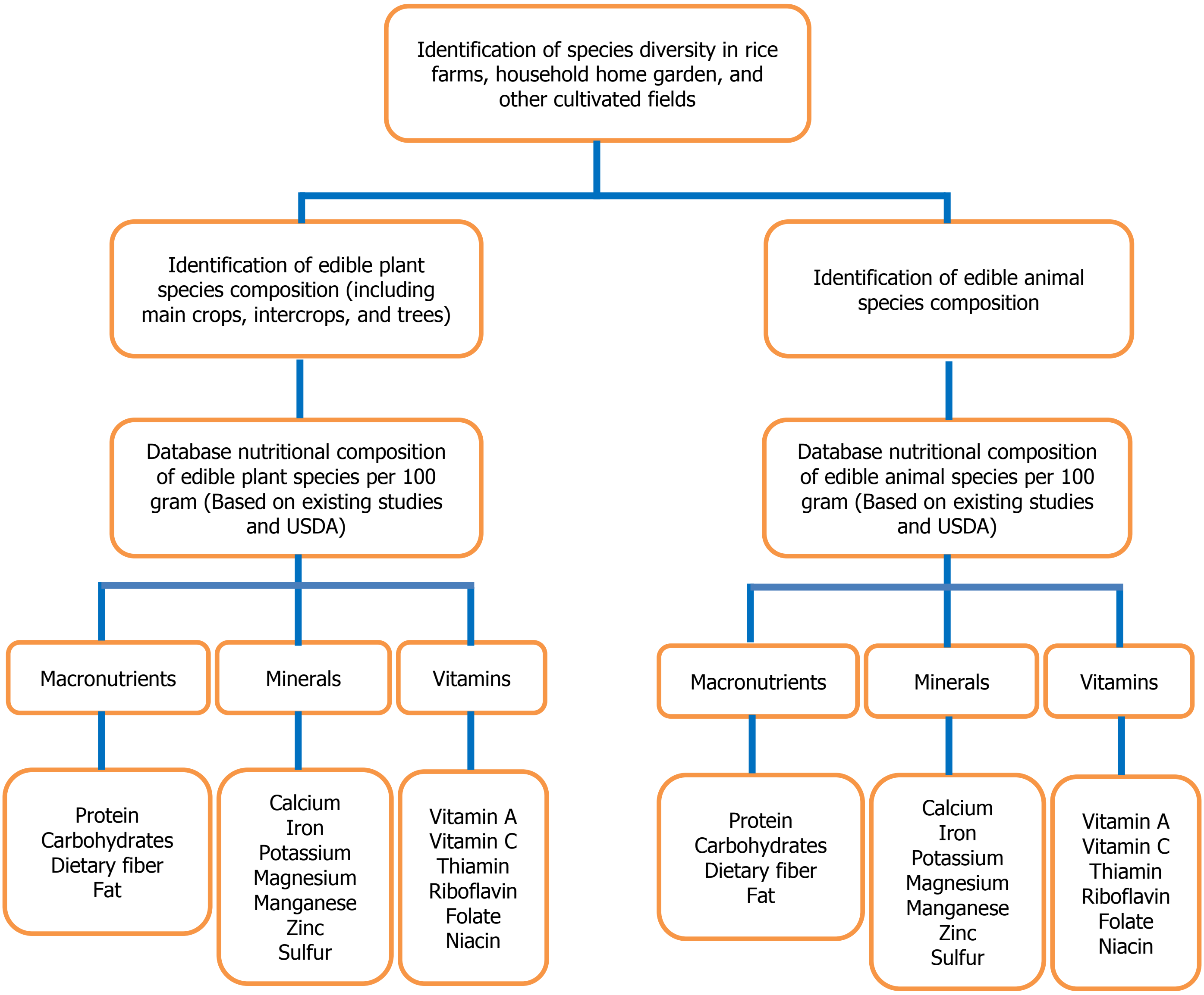


Figure 4. First step of nutritional functional diversity calculation

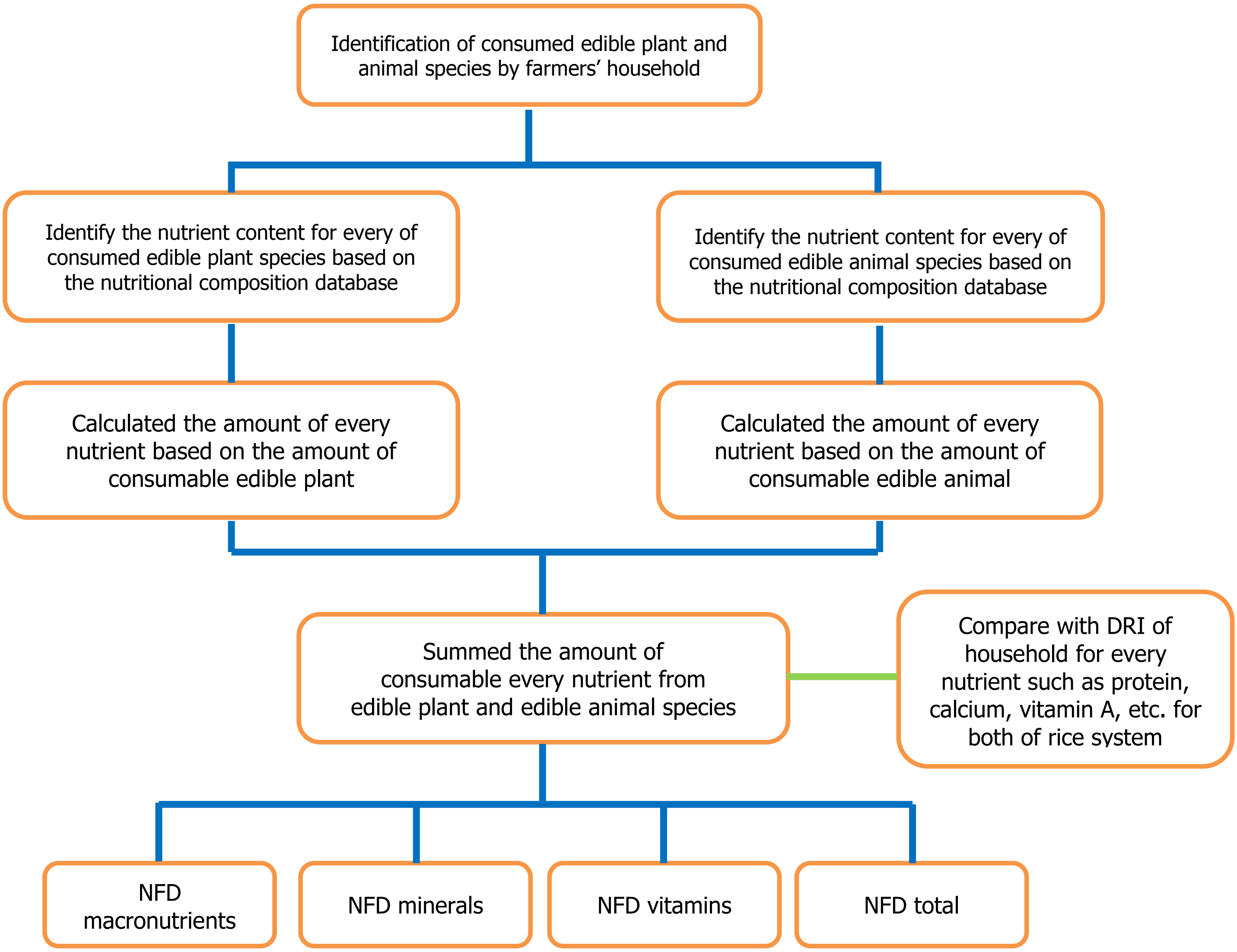


Figure 5.Second step of nutritional functional diversity calculation

2.3.4. Evaluating current and complex rice systems

Evaluation complex and current rice systems were done by making corelation between dietary diversity and species diversity, dietary diversity and nutritional functional diversity and nutritional functional diversity and species diversity in the rice production systems. The correlation was analysed using Spearman and Pearson correlation analysis by taking into account of the strength, the significant and the direction of correlation. The strength was categorized into six levels as presented in Table 3, then the significant was categorized become significant or not significant based on the statistical analysis, and the direction of the relations was categorized into positive and negative symbols that showed in front of the correlation value (Sarwono, 2009). The result of correlation analysis in current and complex rice system was compared descriptively.

Table 3. The strength of the Pearson and Spearman correlation analysis

0	:	No correlation
0.00 – 0.25	:	Weak correlation
0.25 – 0.50	:	Moderate correlation
0.50 – 0.75	:	Strong correlation
0.75 – 0.99	:	Very strong correlation
1	:	Perfect correlation

III. Results and discussion

In this research, the current rice system was consists of 46 respondents. These respondents have different type rice farming systems i.e. 8 monoculture conventional farms (17.38%), 1 monoculture organic farm (2.17%), 3 intercropping conventional farms (6.52%), 1 intercropping organic farm (2.17), 12 monoculture conventional and crop rotation farms (26.09%), 14 intercropping conventional and crop rotation farms (30.43%), and 7 do not have rice farms (15.22%). While, the complex rice system consist of 6 respondents.

In the current rice system, around 69.57% current rice system household is working as farmers. Besides that, some of the farmers in current rice systems also have additional job, such as 2.17% is working as village employee, 4.35% is working as government employee, 2.17% is working as people who are raising chicken in large scale to produce eggs, 2.17% is having 2 hectares orange plantation, 13% is also working on another farm as farm labour, 2.17% is working as building porter, 2.17% is working as agriculture consultant, and 2,17% is working as businessman. While, 100% of complex rice system household is working as a farmer.

The respondents of current rice system farmers for species diversity and nutritional functional diversity approaches have rice field in average around 2200 m^2 while the complex rice system farmers have around 1768 m^2. This data based on the condition when we did the survey, thus area for planting rice can be different with previous or next planting season.

In general, the current rice system farmers grow many different crops in their rice field, household home garden and other cultivated fields including food crops (rice, maize, sweet potatoes and cassava), horticulture crops (green bean, eggplant, tomatoes, squash, banana, papaya, etc), and also perennial crops (coconut, *Leucaena leucephala*, etc) as well as complex rice system farmers.

3.1 Dietary diversity

Dietary diversity was not affected by the difference of the rice systems as presented in Figure 6.

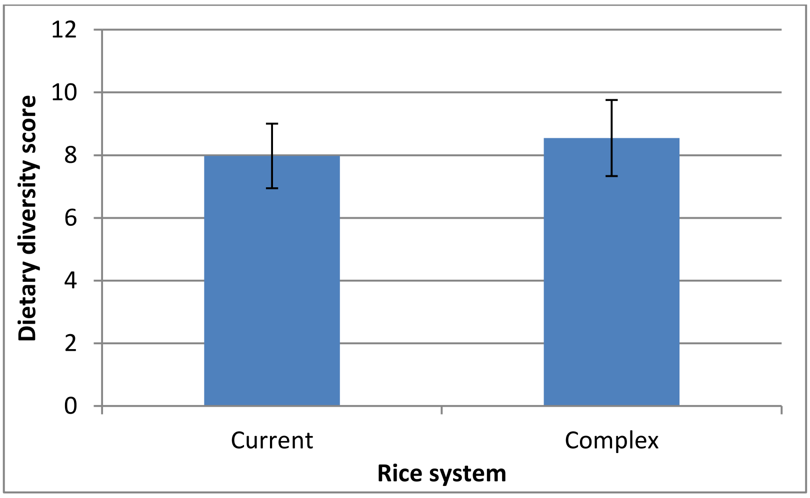


Figure 6. Dietary diversity score

Figure 6 shows that the dietary diversity score of farmer's household was not significantly different between the current rice system and the complex rice system (*P*-value > 0.05). The dietary diversity score of the current rice system was 7.97 while the complex rice system was 8.55. Both scores categorized as a middle class of dietary diversity score. However, the complex rice system tended to have a higher dietary diversity score than the current rice system. According to Hillbruner and Egan (2008), the dietary diversity has a positive relation with three pillars of food security i.e. availability, access, and utilisation. Based on this, we assume three main factors that influence this condition, first, the economic ability of the farmer's household. Some farmers of the current rice system had additional income sources such as raising chickens in a large scale, trader, consultant, government employee, etc. While most of the complex rice system farmers only worked as a farmer and get additional income through selling additional products from their rice field such as fish, duck's egg and duck's meat. Thus, although their rice system is different, their economic income is almost similar. The average income of current rice system farmers is 3359.86 USD/year and complex rice system is 3381.39 USD/year. Some of the farmers in current rice system is living together with their family, such as son, daughter, parents, etc. and they shared their income to buy some food. The map of entire farmer's rice field in four regencies that provide information about dietary diversity, rice systems and farmers' income is available in Appendix 5. This finding supports the result of Sanusi *et al* (2006) that the household's incomes have a strong association with the access to adequate food intake and food security.

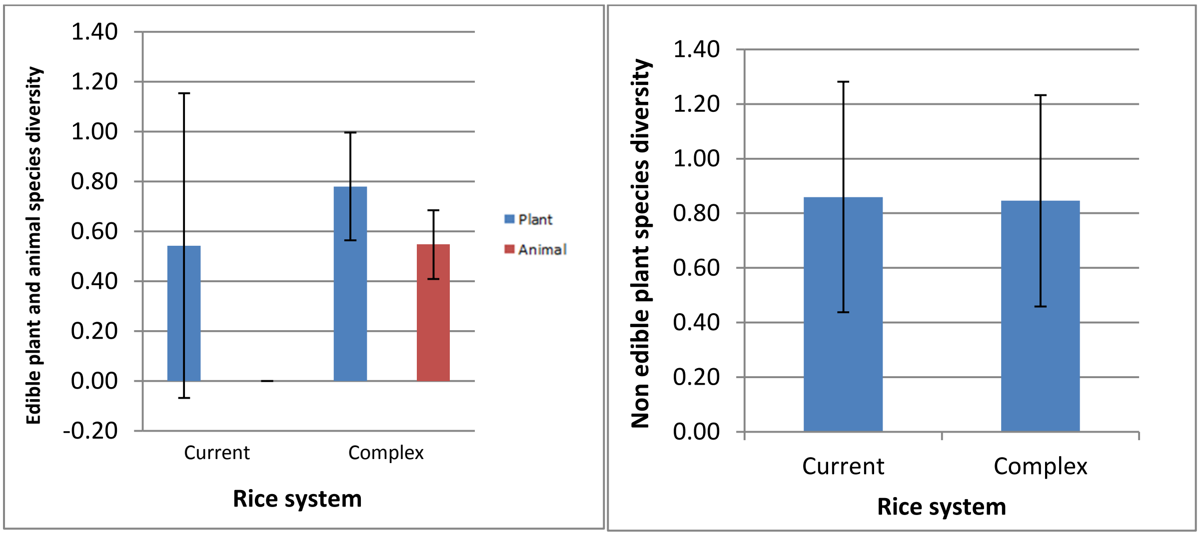
Second, the farmer's household access to the food sources. Most of the current rice system households purchased their food from the market and consumed some foods from their farm and home garden as well as the complex rice system households. The ability to purchase food from market is because of the increase of the farmer's income. As the result, the farmer's in both rice systems have more access to purchase different types of food from market, and consume various food types. This conformable with the result of Hoddinott (2011) that the economic ability influences the access to the food source. Moreover, the local tradition in Indonesia such as giving a food as a gift for their neighbourhood also contributes to the dietary diversity of the farmer's household in both rice systems.

Third, eating habits also influence the dietary diversity score. Some families of the farmer family liked to eat simple composition of food such as only rice and vegetables, while others liked to consume various types of food such as rice, vegetables, and animal protein/plant protein, and sometimes had fruits. This eating habit eventually contributes to their health status. Although some of them had the ability to buy a various types of food, but they did not buy it because they could not eat it, for example, they had an ability to buy beef as their food, but they could not consume it because they had a high blood pressure. The examples of food composition presented in Figure 7. Finally, Ray (2013) declared other possible factors that influence the dietary diversity of farmer's household such as age, education level, residence, types of family, and the number of people in a household.

Figure 7. The examples of food composition in farmer's household

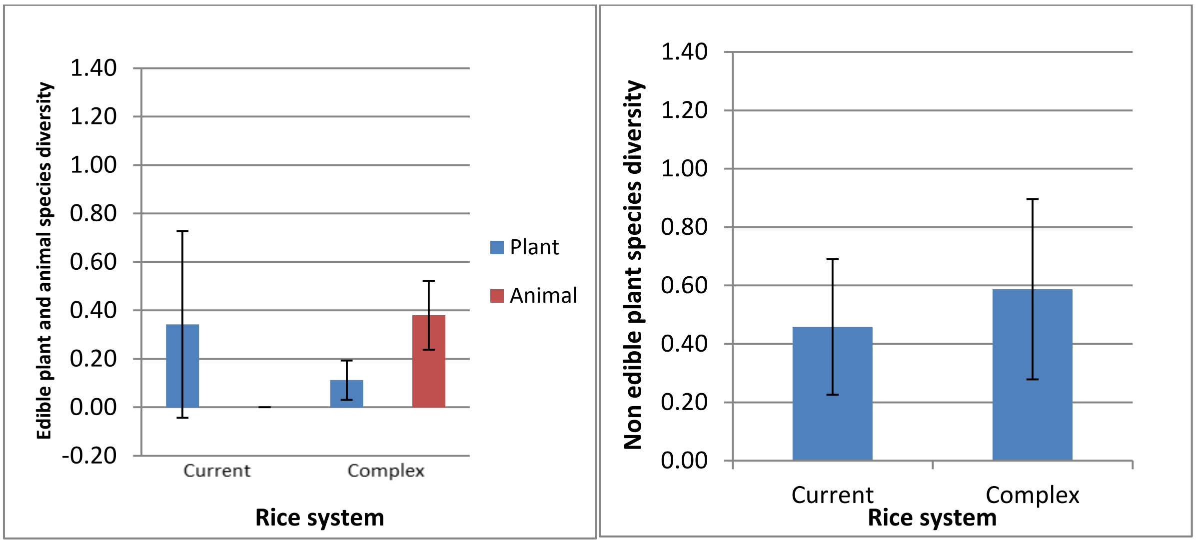
3.2 Species diversity

Both of Shannon-Wiener and Simpson's species diversity indexes showed that edible plant and non-edible plant species diversity were not affected by the difference of the rice systems. While the edible animal species diversity was affected by the different rice systems as presented in Figure 8 and Figure 9 respectively.



a. **b.**

Figure 8. a. Shannon-Wiener index of edible plant and animal species diversity; b. Shannon-Wiener index of non-edible plant species diversity



a. **b.**

Figure 9.a. Simpson's index of edible plant and animal species diversity; b. Simpson's index of non-edible plant species diversity

Figure 8 shows the species diversity based on Shannon-Wiener index. The species diversity index of edible plant species in the current rice system and the complex rice system was not significantly different (*P*-value > 0.05). However, the species diversity index of the complex rice system was higher than the current rice system. The current rice system had 0.54 as the diversity index and the complex rice system had 0.78. This value representing that the complex rice system has a greater number of species present. Based on Shannon-Wiener index assumes that the higher the species diversity index represent the richness of species in this farm. Furthermore, the types of the farm that grouped as the current rice system can influence the values of edible plant species diversity in the current rice system. Some farmers who categorized as current rice system farmers had sown their crop with the intercropping system that has many crops in the rice field. Thus, the number of species in the farm was various. However, based on Shannon-Wiener index, the edible species diversity index in current and complex rice system was categorized as low diversity index.

For the edible animal species, the diversity index was affected by the difference of rice systems. The current rice system had a lower edible animal species diversity index than the complex rice system. It can be due to the integrated system in the complex rice system, which combines between plant and animal in the rice field. This integrated system which uses animal such as ducks and fish in the rice field contributes to the agro ecosystem role (Jarvis *et al.*, 2007) i.e. natural enemies to control pest populations (Jervis, 2005). In this case, ducks and fish were helping to control insect's population in the rice field by eating them.

Hereafter, the non-edible plant species diversity was not affected by the difference of rice systems (*P*-value > 0.05). Non-species diversity related to the number of weed species that scattered in the rice field. The current rice system had a non-edible species diversity index around 0.86 while the complex rice system was about 0.85. This result was contrary to the result of Men *et al* (1999) that showed the presence of ducks in the early stage onwards of rice production protected the rice plant from insect pests and weeds. Furthermore, the higher value of the non-edible species diversity index in the complex rice system can be influenced by the sampling time. Some farmers of the complex rice system did not grow rice at the time we did the farm visit because they had already harvested the rice. In addition, this empty rice field had some weeds species. Besides that, others were growing other crop such as maize.

Figure 9 shows the species diversity based on Simpson's index. The species diversity index of edible plant in the current rice system and the complex rice system were not significantly different (*P*-value > 0.05). The current rice system had 0.34 as the diversity index while the complex rice system had 0.11. The complex rice system had a higher diversity index than the current rice system. It can be due to the principle of Simpson's index that focuses on the dominant species. The higher value in Simpson's index showed lower species diversity in edible plant species. The edible animal species diversity index was affected by the different rice systems. The edible animal species diversity index in the complex rice system was higher than the current rice system. Obviously, this result was due to the combination of plants and animals in the complex rice system that also raised ducks and fish together with rice crop.

Furthermore, the both rice systems did not significantly influence the species diversity index of non-edible plant species diversity (*P*-value > 0.05). However, based on Simpson's index, the diversity index in the current rice system (0.46) was higher than the complex rice system (0.59). It can be due to the principle of Simpson's index using the dominant species in the community. Therefore, the non-edible species diversity in the current rice system was higher than complex rice system.

The various results of species diversity index in the current rice system and the complex rice system were influenced by the human choices in agriculture system such as using a monoculture or intercropping system as their farming system. Besides that, the culture in the location of the study also influenced the species diversity index due to the social value of foods grown by the farmers. Finally, this diversity index was also influenced by the environmental triggers (Zapata, 2014) such as changes in the natural environment (Marinova, 2014), changes in nutrient levels in the soil (on land), and moisture levels which determine the species strengths in order to establish in the ecosystem (Adams, 2009).

3.3 Nutritional functional diversity

The data of species composition and the consumed species composition for plants and animals of the current and complex rice system in the rice farms, household home garden and other cultivated fields were presented in Figure 10 and Figure 11 respectively.

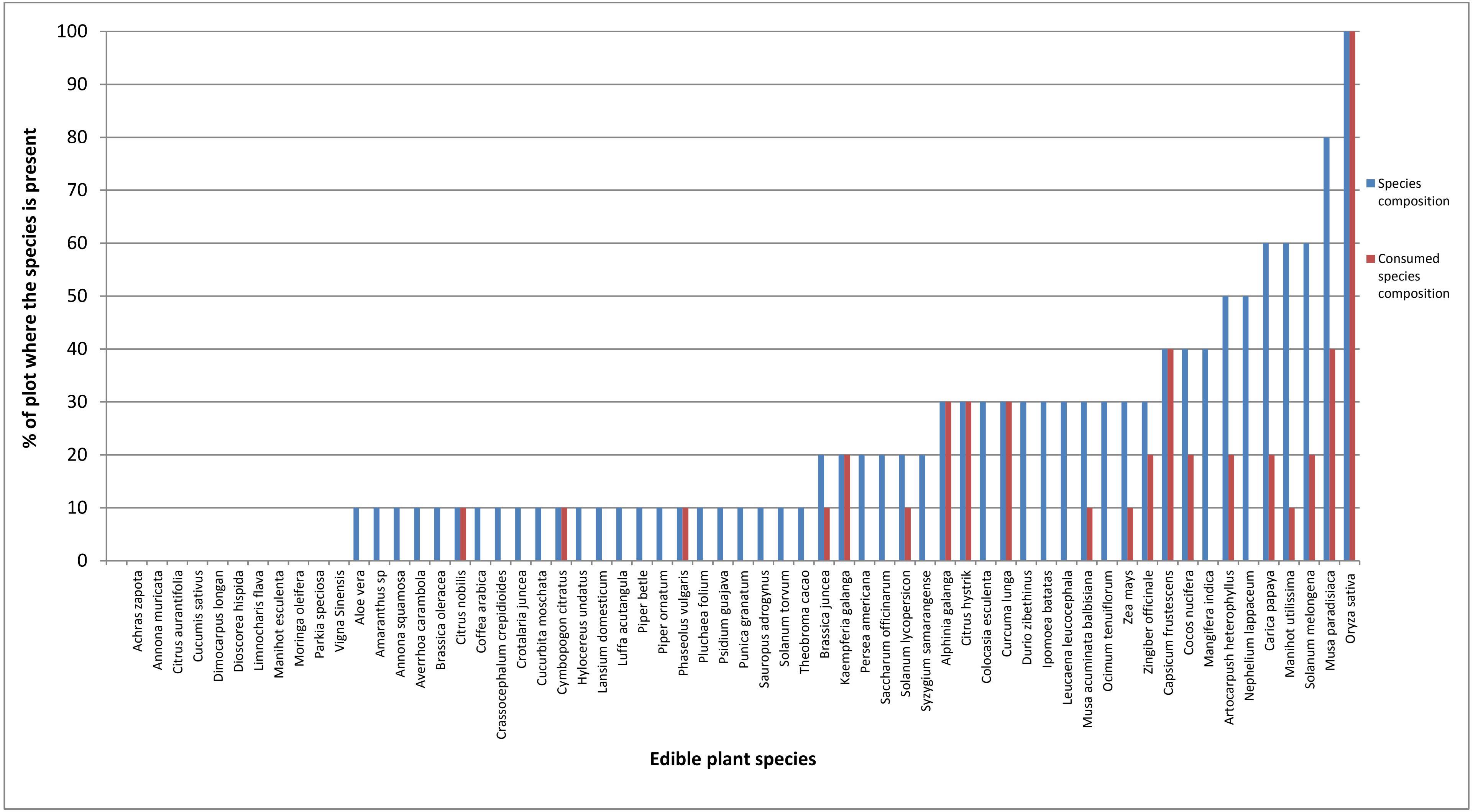


Figure 10. Species composition and consumed species composition of edible plants in current rice system

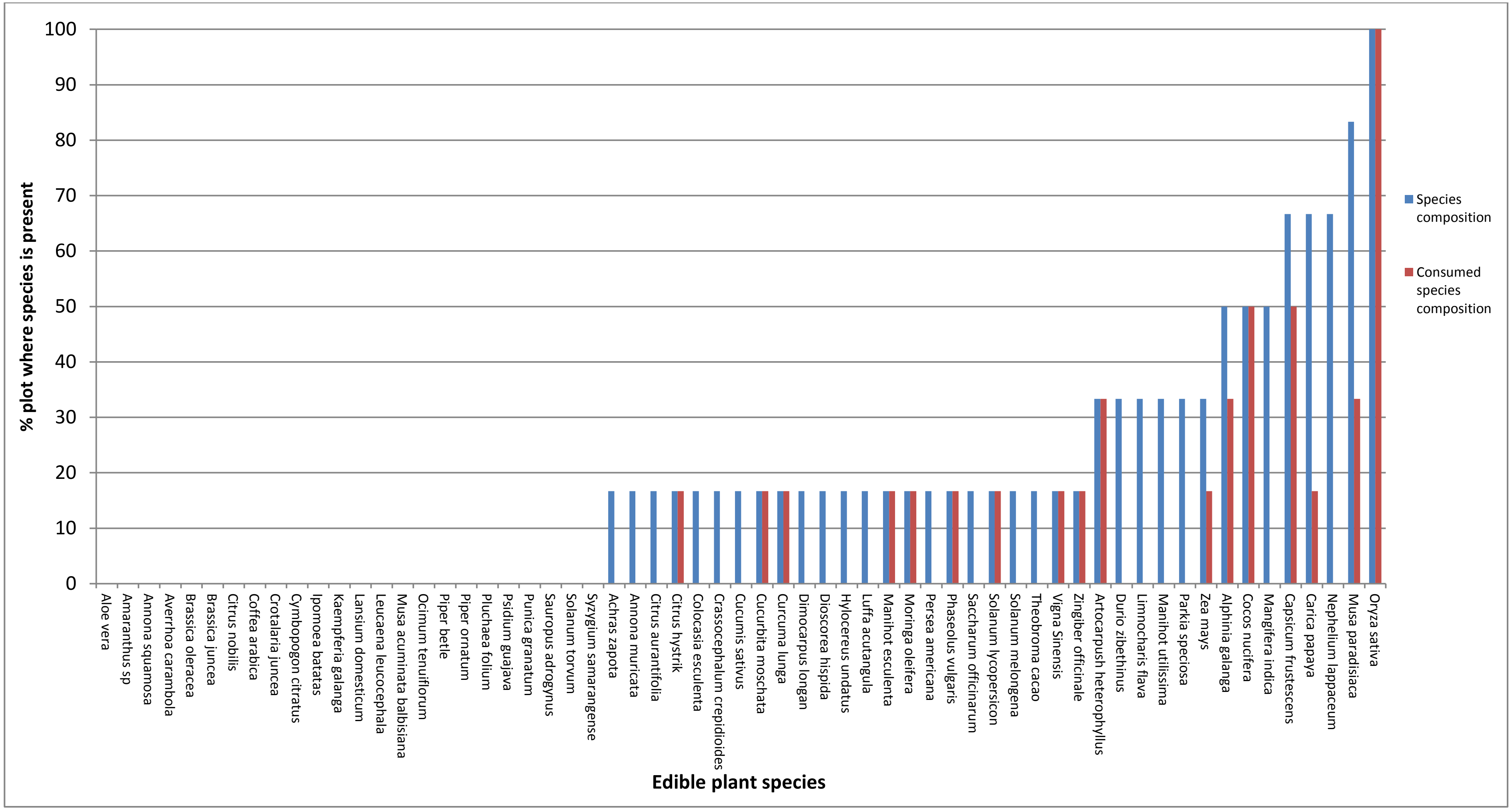


Figure 11. Species composition and consumed species composition of edible plants in complex rice system

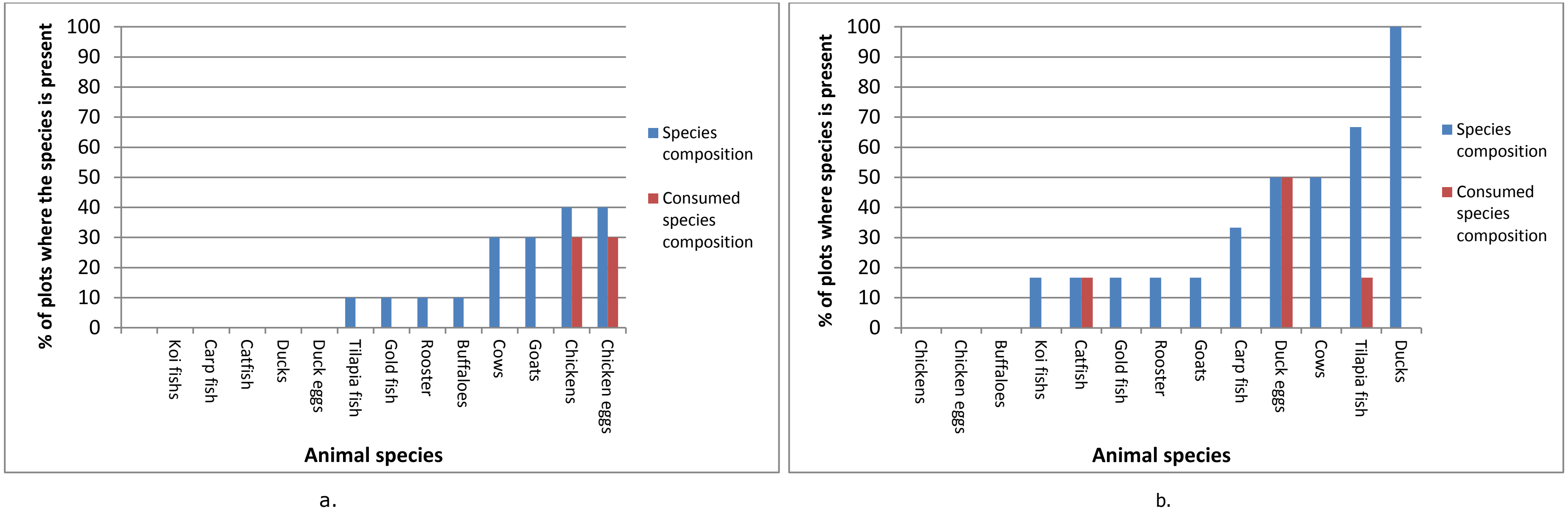


Figure 12. a. Species composition and consumed species composition of edible animal in current rice system; b. Species compositiona and consumed species composition of edible animal in complex rice system.

Figure 10, 11 and 12 show the composition of edible plant and animal species in the current and complex rice system. These figures also show the composition of consumed edible plant and animal species in both rice systems. Regarding these figures, the edible plant species composition of the current rice system was higher than the complex rice system. It can be due to the different types of farm that categorized into current rice system, for example, monoculture and intercropping systems in the rice field. However, the number of consumed plant species composition of both rice systems was almost the same.

In contrary to the edible plant species, edible animal species composition in the current rice system was lower than the complex rice system as well as the number of consumed animal species composition for both rice systems. It can be due to the different principle between the current and complex rice system. In the current rice system, the edible animal species were located in their home garden or other cultivated fields, while the edible animals in the complex rice system were located not only in the home garden or other cultivated area but also in their rice field.

In order to gain more information about the nutrient consumption for the current and complex rice system in the farmer's household, the nutrient composition of the edible plant and animal species that consumed by the farmer was presented in Table 4. The total nutritional functional diversity based on the nutrient group was presented in Table 5.

Table 4 shows the nutrient composition of consumed edible plant and animal species between the current and complex rice system. For macronutrients including protein, carbohydrates, dietary fiber and fat, all were not significantly different between the current and complex rice system. There was no significant difference between the current and complex rice system in minerals such as calcium, potassium, magnesium, manganese and zinc while the iron was affected by the different of the rice systems. For vitamins, including vitamin A, vitamin C, Thiamin, Riboflavin, Folate and Niacin, not all were affected by the difference of the rice systems. However, the macronutrients, minerals and vitamins in the complex rice system were higher than the current rice system. It can be due to the different composition of the edible plant and the edible animal species that consumed by the farmers' household in both rice systems. Furthermore, it also related to the nutrient composition in every consumed edible plant and animal species.

Table 4. Consumed nutrient composition in current and complex rice system based on consumed plants and animal species composition.

No	Nutrients (unit)	Current rice system	Complex rice system
1	**Macro nutrients**		
	Protein (g)	71.8[a]*	98.8[a]
	Carbohydrates(g)	685[a]	1030[a]
	Dietary fiber (g)	20.2[a]	29.6[a]
	Fat (g)	24.3[a]	50.8[a]
2	**Minerals**		
	Calcium (mg)	294[a]	466[a]
	Iron (mg)	9.6[a]	16.5[b]**
	Potassium (mg)	2272[a]	3039[a]
	Magnesium (mg)	312[a]	507.9[a]
	Manganese (mg)	9.1[a]	13.7[a]
	Zinc (mg)	10.8[a]	16.2[a]
3	**Vitamins**		
	Vitamin A (mg)	0.3[a]	1.1[a]
	Vitamin C (mg)	45.9[a]	73.7[a]
	Thiamin (mg)	0.8[a]	1.4[a]
	Riboflavin (mg)	0.9[a]	1.2[a]
	Folate (mg)	0.1[a]	0.2[a]
	Niacin (mg)	18.3[a]	24.6[a]

*Same letters is indicates not significant differences according to Fisher's protected LSD-test ($P < 0.05$)
** Different letters is indicates significant differences according to Fisher's protected LSD-test ($P < 0.05$).

Table 5. Nutritional functional diversity based on nutrient group for current and complex rice system.

Nutritional FD (unit)	Current Rice System	Complex Rice Systems
Nutritional FD Macro nutrients (g)	801[a]*	1209[a]
Nutritional FD Minerals (mg)	2908[a]	4059[a]
Nutritional FD Vitamins (mg)	66.3[a]	102[a]
Nutritional FD Total (g)	804[a]	1213[a]

*Same letters is indicates not significant differences according to Fisher's protected LSD-test ($P < 0.05$).

Table 5 shows the nutritional functional diversity of the current and complex rice system, especially for macronutrients, minerals, vitamins, and the total of all nutrient groups. The nutritional functional diversity was not significantly affected by the different rice systems. However, the complex rice system had a higher nutritional functional diversity for macronutrients, minerals, vitamins than the current rice system. As previously mentioned, the difference between the nutritional functional diversity of the current rice system and the complex rice system was due to the different nutrient composition in the consumed edible plant and animal species of farmer's household.

Furthermore, information about Dietary Reference Intake (DRI) of farmers' household in the current and complex rice system was used to examine the nutritional functional diversity. The comparison of the DRI (the amount of nutrients needed for every farmers' household in the current and complex rice system) and the amount of nutrients consumed by the farmers' household based on the edible plant and edible animal species on their rice farm, household home garden and other cultivated fields especially for macronutrients, minerals and vitamins were presented in Figure 13, 14 and 15 respectively.

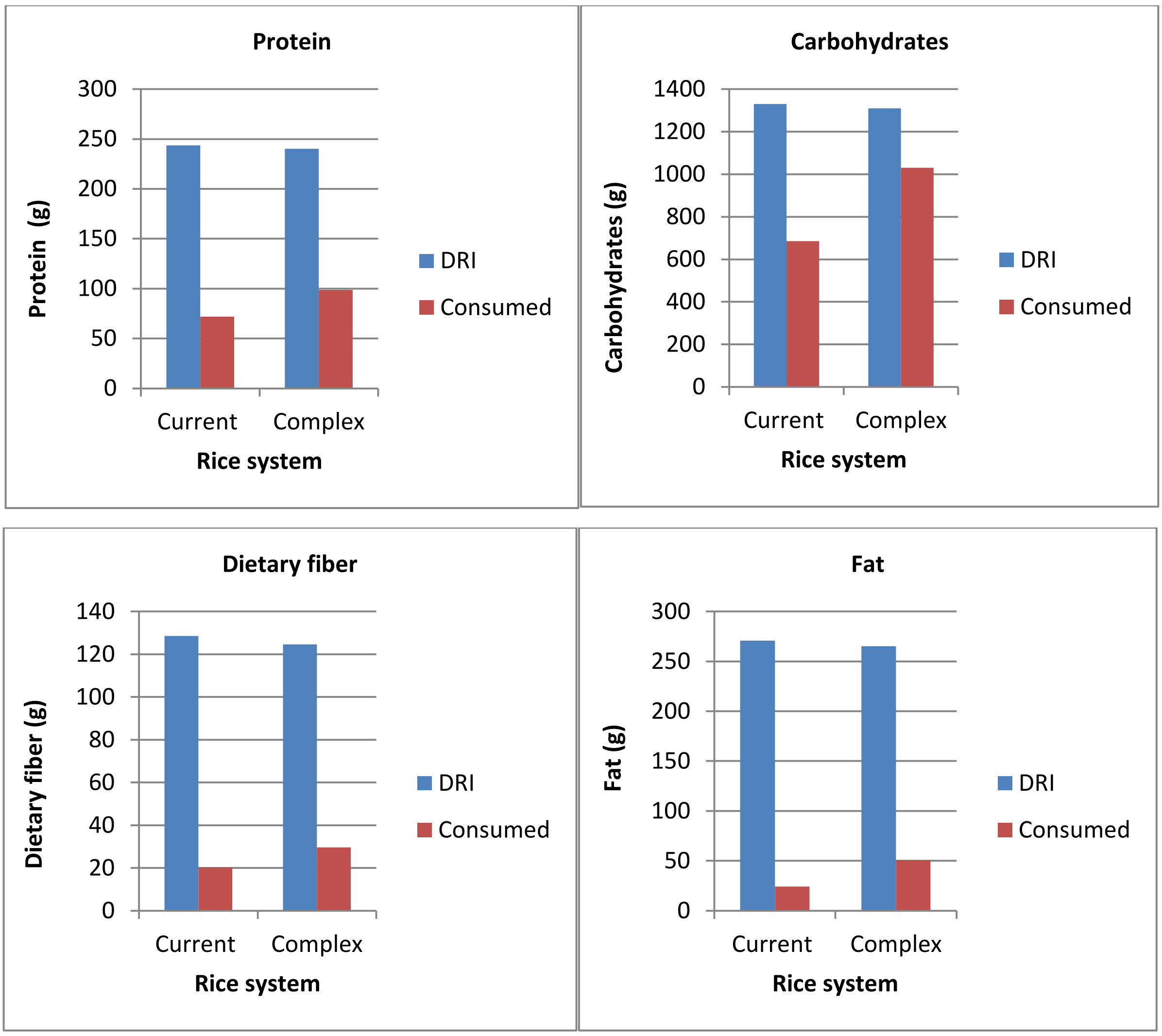


Figure 13. Comparison of macronutrients including protein, carbohydrates, dietary fibre and fat in current and complex rice system

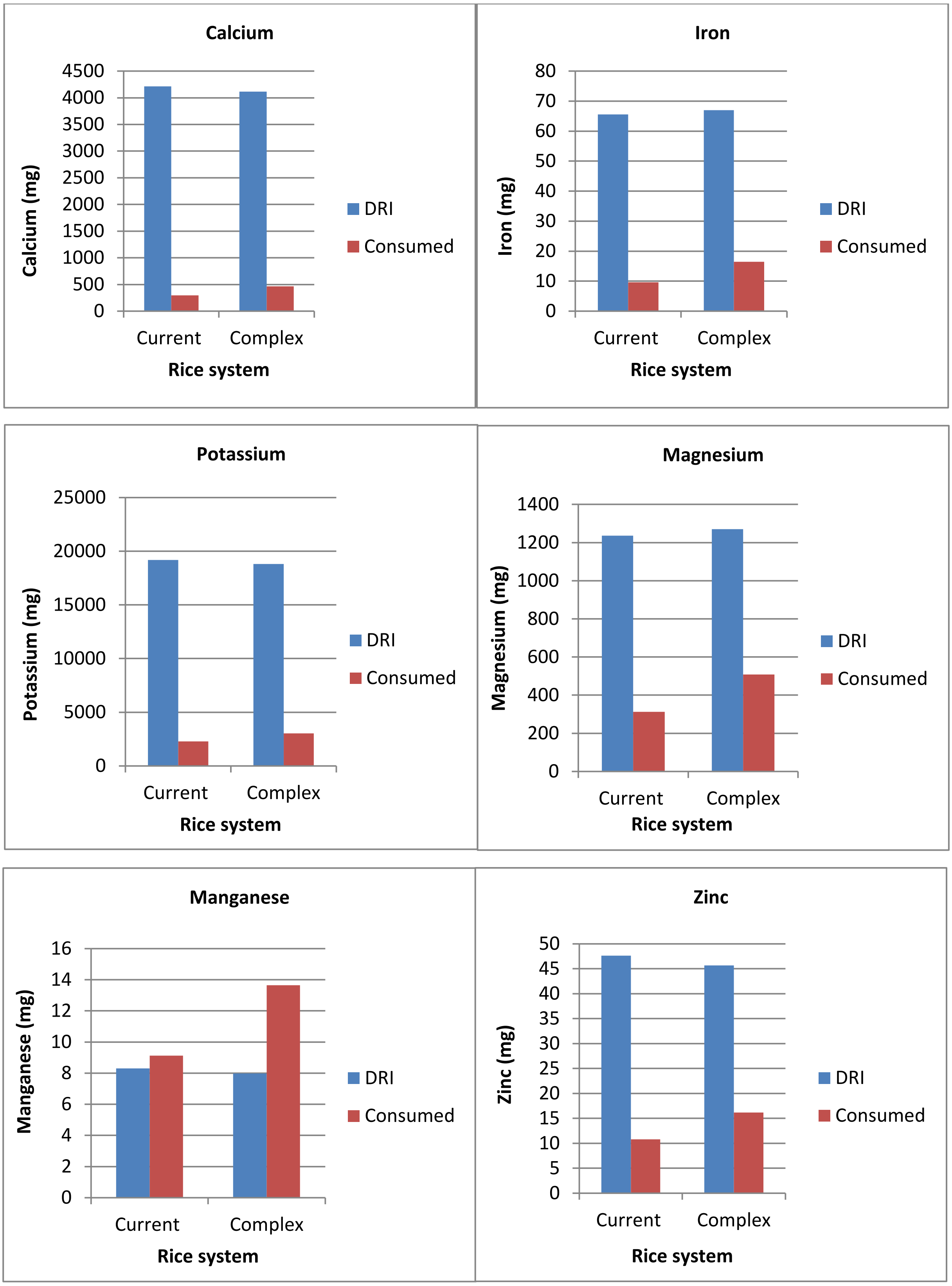


Figure 14. Comparison of minerals including calcium, iron, potassium, magnesium, manganese, and zinc in current and complex rice system

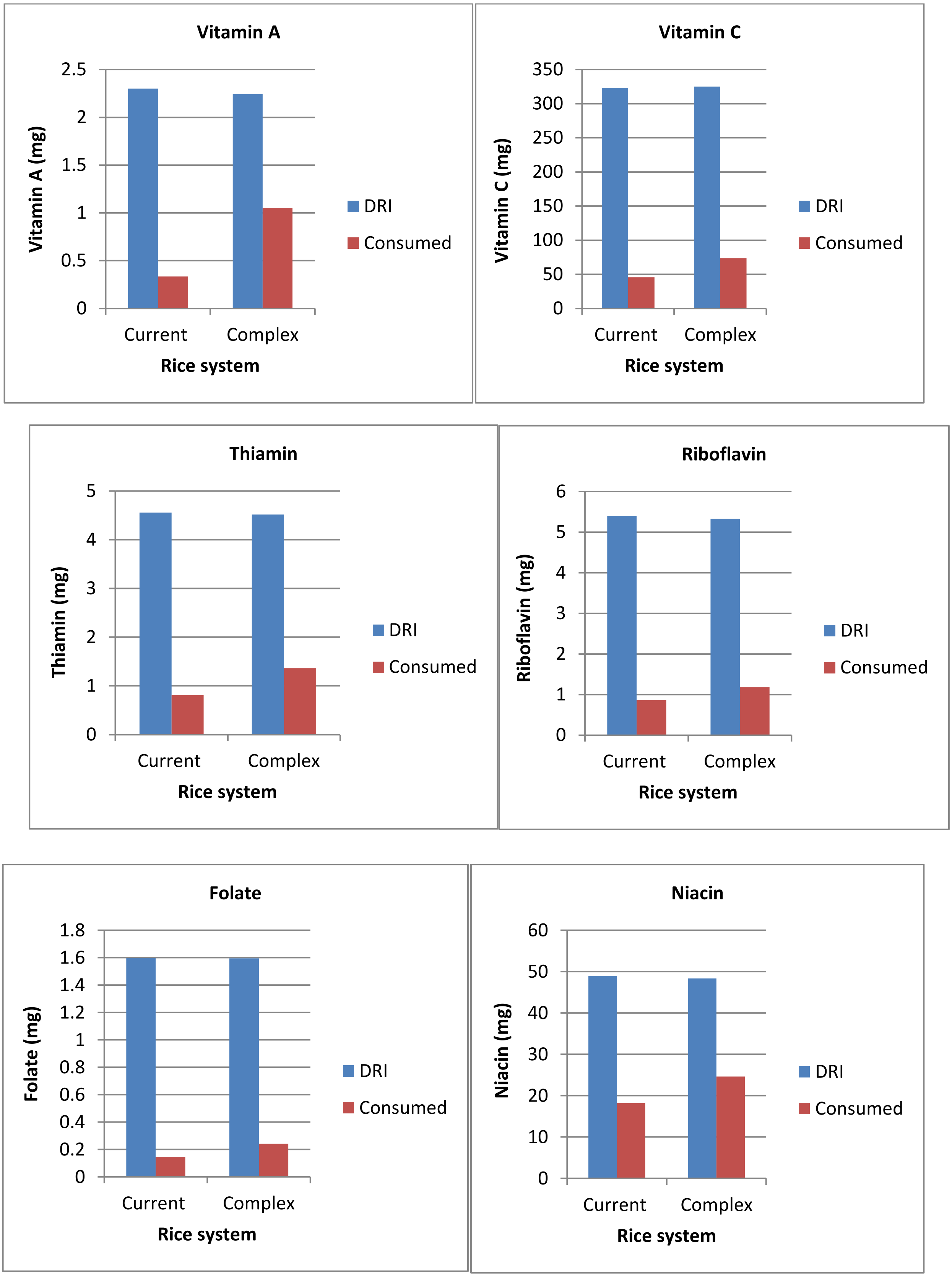


Figure 15. Comparison of vitamin including Vitamin A, Vitamin C, Thiamin, Riboflavin, Folate and Niacin in current and complex rice system.

Figure 13 shows the comparison of macronutrients composition in the current and complex rice system based on DRI and the amount of consumed edible plant and in the farmers' household. Regarding these figures, the macronutrients in the current and complex rice system did not fulfill the amount of nutrients needed by the farmers' household. However, as can be seen that the complex rice system can fulfill the farmers' household nutrients better than the current rice system.

Figure 14 shows the comparison of minerals composition in the current and complex rice system based on DRI and the amount of consumed edible plant and animal species and the farmers' household. Based on these figures, the minerals especially calcium, iron, potassium, magnesium, and zinc in the current and complex rice system did not fulfill the amount of nutrients needed by the farmers' household while the manganese content from the edible plant and animal consumed in the current and complex rice system were excessed as compared to the DRI requirement.

Figure 15 shows the comparison of vitamins composition in the current and complex rice system based on DRI and the amount of consumed edible plant and animal species in the farmers' household. The vitamins in the current and complex rice system did not fulfill the amount of nutrients needed by the farmers' household. However, the complex rice system can fulfill the farmer's household nutrients better than the current rice system.

The difference in nutrition content for every nutrient group in the current and complex rice system might be influenced by the difference in plant and animal composition consumed in the rice farms, household home garden, and other cultivated fields. Besides that, different part of edible plant and animal species contain different nutrients such as in cassava plant, nutrients content in the leaves is different with the nutrients content in the tuber. This result was consistent with the data from FAO (2016) showed different parts of the plant (leaves, stem, roots, tubers, etc.) consisting specific nutrients content. Thus, it is clear that nutritional functional diversity depends on species diversity. Furthermore, the amount of nutrient that consumed by the farmers in current and complex rice system was counted based on the food ingredients that taken from the farmer's rice field, household home garden and other cultivated fields and cooked in the farmer's home.

3.4. Evaluating current and complex rice systems

3.4.1 Correlation between dietary diversity and species diversity

The correlation value between dietary diversity and Shannon-Wiener edible plant species diversity index in the current rice system was –0.704 wherein $P>0.05$. It means the changes in dietary diversity were strongly correlated with the changes of edible plant species diversity. The dietary diversity score will increase when there is small number of edible plant species in the rice field as presented in Figure 16.

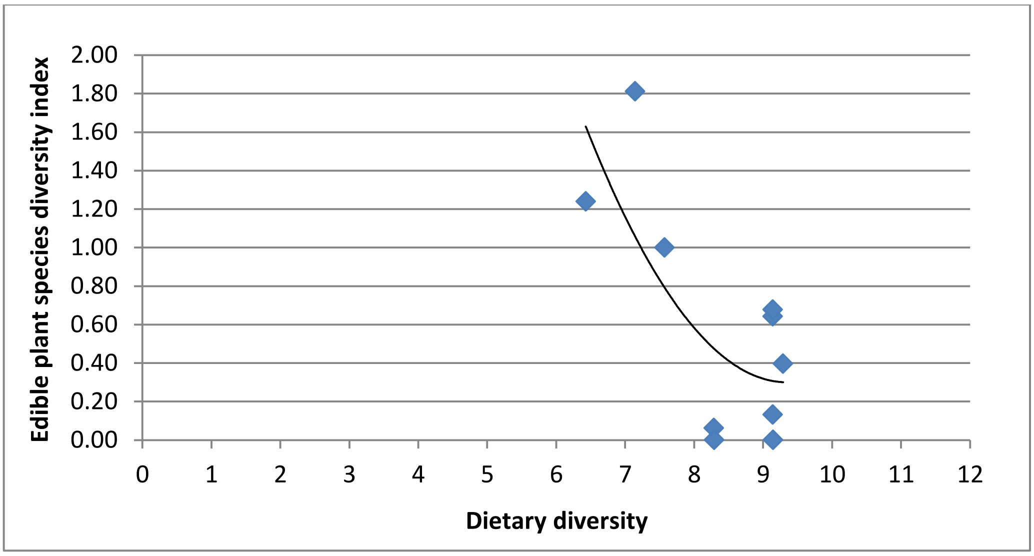


Figure 16. Correlation between dietary diversity and Shannon-Wiener edible plant species diversity index in current rice system.

Then, the correlation value between dietary diversity and Shannon-Wiener edible plant species diversity index in complex rice system was 0.695 (P>0.05). It shows a strong correlation between dietary diversity and Shannon-Wiener edible plant species diversity. Increasing the number of edible plant species in the rice field results in the increase of dietary diversity as presented in Figure 17. Furthermore, the correlation between dietary diversity and Shannon-Wiener edible animal species diversity index in the current rice system was not measured due to the unavailable data of the edible animal species diversity. While, in the complex rice system, there was a very weak correlation between dietary diversity and Shannon-Wienner edible animal species diversity (-0.061) wherein P>0.05. It shows that adding the animal species in the rice field tends to decrease the dietary diversity of the farmer's household as presented in Figure 18.

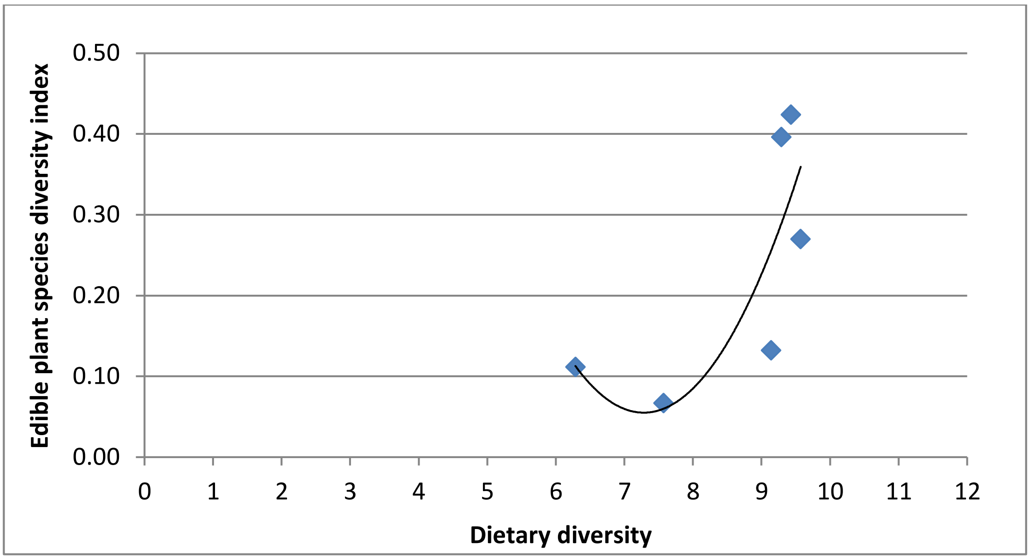


Figure 17. Correlation between dietary diversity and Shannon-Wiener edible plant species diversity index in complex rice system.

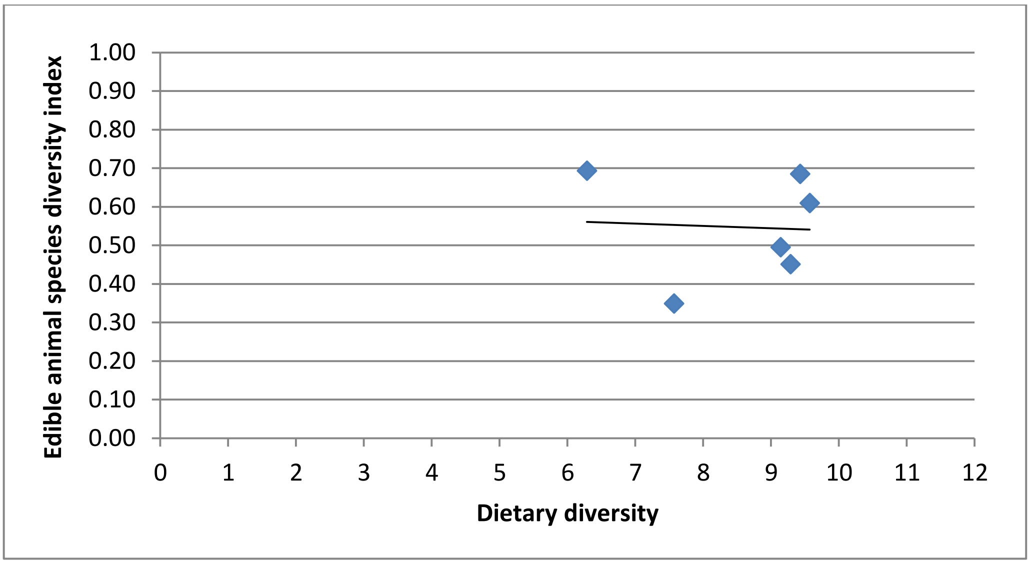


Figure 18. Correlation between dietary diversity and Shannon-Wiener edible animal species diversity index in complex rice system.

The species diversity of the edible plant and animal species diversity was also measured through Simpson's diversity index. Based on the Simpson's diversity index, the correlation between dietary diversity and Simpson's edible plant species diversity index in the current rice system was – 0.437 which categorized as moderate correlation (P>0.05). When the number of plant species diversity increase in the rice field, the dietary diversity will decrease as presented in Figure 19. In contrast, the correlation between dietary diversity and Simpson's edible plant species diversity in complex rice system was 0.670 wherein P>0.05. The increase in dietary diversity is caused by the increase of edible plant species diversity as presented in Figure 20.

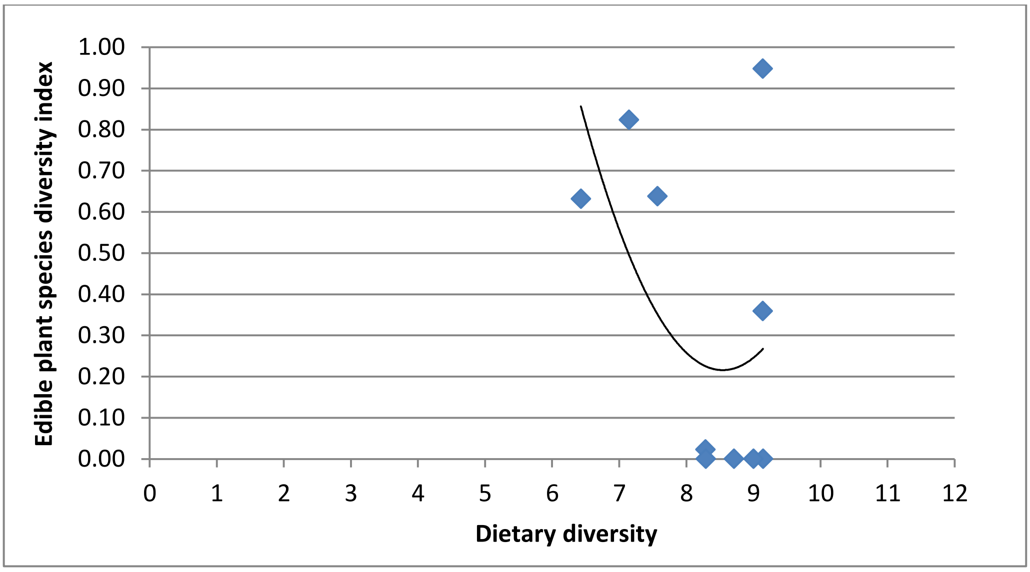


Figure 19. Correlation between dietary diversity and Simpson's edible plant species diversity index in current rice system.

Figure 20. Correlation between dietary diversity and Simpson's edible plant species diversity index in complex rice system.

Similar to the correlation between dietary diversity and Shannon-Wiener edible animal species diversity index, there was no data available for Simpson's edible animal species diversity in the current rice system. While, integration the edible animal species diversity in the rice field result in lower dietary diversity score in complex rice system (r=-0.230) wherein *P*>0.05 as presented in Figure 21.

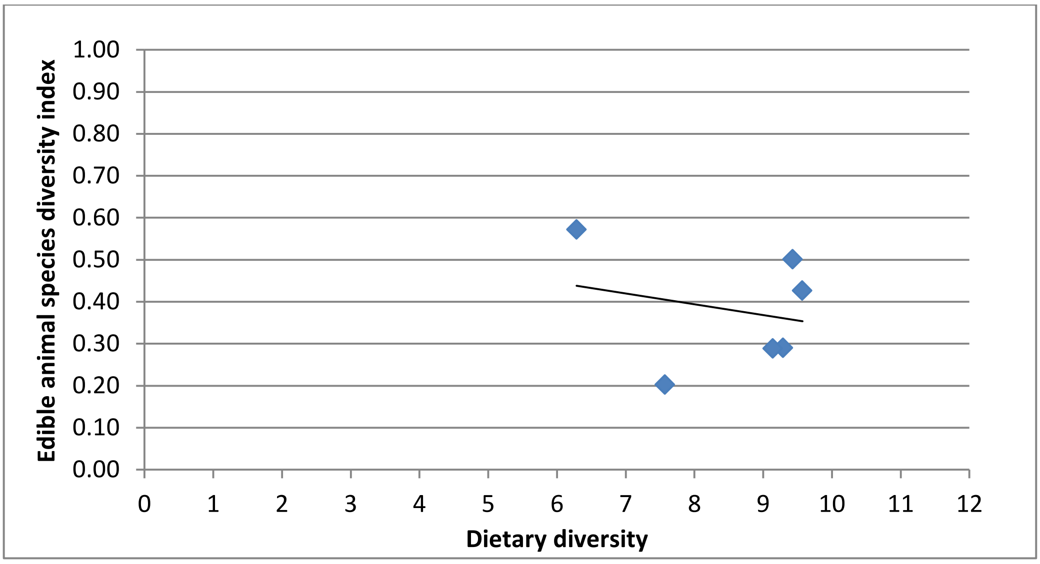


Figure 21. Correlation between dietary diversity and Simpson's edible animal species diversity index in complex rice system.

Shannon-Wiener and Simpson's index show that both rice systems had a strong correlation between dietary diversity and species diversity index. The current rice system had a tendency to decrease the dietary diversity with the increase of the species diversity or vice versa. While the complex rice system had a tendency to increase the dietary diversity with the increase of species diversity. This result is consistent with the result of Sibhatu *et al* (2015) that on-farm production diversity is positively associated with dietary diversity in particular situations such as when farmers directly consume all their farm production.

In case of the current rice system, when the production diversity on-farm is lower, the dietary diversity of the farmer's household is higher. It is due to the additional income sources of the farmers of the current rice system. Some farmers had other income sources besides farming activities such as raising chickens, working as a consultant, trader, etc. Then, this additional income source contributed to the farmer's ability to buy different kinds of food such as animal protein. Furthermore, when the farm production diversity is higher (high number in plant species), the dietary diversity is lower. It might be because the farmers of the current rice system consumed their own food production but it was not diverse and tended to consume vegetables product or they tended to sell their farm production to get more money rather than to consume it. It is similar to the result of Popkin *et al* (2001) and Johns (2007) that the farmer's did not directly consume their food production, which had various plant and animal species in the rice field.

Furthermore, in the complex rice system, the increase the species diversity will also increase the dietary diversity. It can be because most of the farmers of the complex rice system tended to consume their own production such as fish and duck's egg. Besides that, the increase of dietary diversity of the farmers also because they obtained more income by selling the additional products from their rice field such as fish, duck's egg and duck's meat. For example, one of the farmers in the complex rice system could sell around 200 duck's egg every week. These eggs were collected from 40 adult ducks. Then, by selling these products, they get more money and can purchase different types of food in the market.

For edible animal species, no information available about the edible animal species diversity in the current rice system, while the complex rice system had a tendency to decrease the dietary diversity with the increase of edible animal species diversity. It can be due to the health reason of the farmers of the complex rice system. As we know, the farmers of the complex rice system raised fish and ducks in their rice field. Usually, they consumed fish and small amount of duck's egg. While, for duck's meat, they did not consume it due to the reason that ducks' meat contains high cholesterol, which is not good for their health. However, adding the edible animal species diversity in the complex rice system still contributed to the dietary diversity through providing animal protein for consumption. It is similar to the result of Halwart and Bartley (2007) that stated the aquatic biodiversity especially fish in rice-based production systems gave a contribution to the food security of the rural population and provided nutritional benefits to the population.

Generally, market access also had positive effects on dietary diversity for both rice systems. The easiness to get the various types of food due to the closer access to the market also helped the farmers to provide source of nutrition intake for their family. Sometimes, even though the market was far away from their home, the farmers could still obtain food from pitchman or as a gift from their neighbourhood.

3.4.2 Correlation between dietary diversity and nutritional functional diversity

The correlation between dietary diversity and nutritional functional diversity of the current rice system was 0.256 while in the complex rice system was 0.550 (P>0.05). The increase of the dietary diversity contributes to the increase of the nutrition functional diversity especially when the farmers consumed their own food production as presented in Figure 22 and Figure 23 respectively.

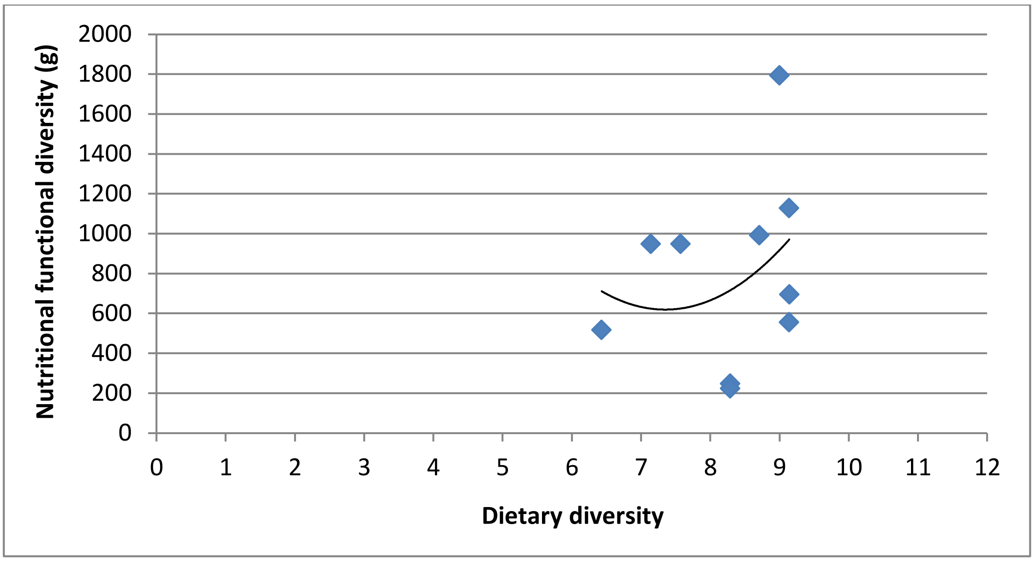


Figure 22. Correlation between dietary diversity and nutritional functional diversity in current rice system.

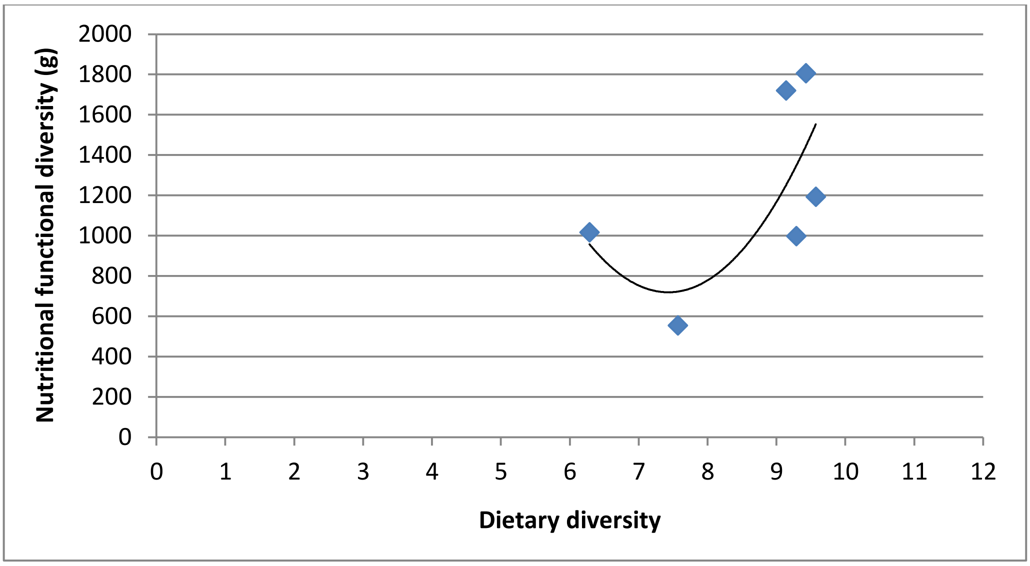


Figure 23. Correlation between dietary diversity and nutritional functional diversity in complex rice system.

The correlation value between the dietary diversity and nutritional functional diversity in the current rice system was lower than the complex rice system. Even though the value of these two rice systems is different, but both of these rice systems were categorized in the same group of correlation that is in a strong correlation level. Both rice systems tended to increase the nutritional functional diversity with the increase of the dietary diversity, but the increase did not have the same value. It can be due to the reason that both rice systems had a slightly different value of the dietary diversity score and the different edible plant and animal species composition in the rice farm, household home garden and other cultivated fields that consumed by the farmer's households. It is related with the study of Chen (2012) that the dietary diversity consumption influenced the nutritional outcomes and improved micronutrient intake, especially for a long term. Moreover, HatlØy, *et al* (1998); Johns (2003) showed a higher food diversity consumption also influenced the nutritional quality of the diet. In contrast, Johns (2007) stated the changes in dietary pattern gave a little impact to the human nutrition. Overall, the relation between dietary diversity and nutritional functional in the complex rice system was better than in the current rice system.

3.4.3 Correlation between nutritional functional diversity and species diversity

The correlation value between nutritional functional diversity and Shannon-Wiener edible plant species diversity index of the current rice system was 0.018 while in the complex rice system was 0.423 ($P>0.05$). In both rice systems, the higher number of edible plant species in the rice field will increase the nutritional functional diversity of farmer's households. However, the correlation value of the complex rice system was stronger than the current rice system. Adding small number of edible plant species in the rice field contribute to the small increase value in the current rice system and a high increase value in the complex rice system as presented in Figure 24 and Figure 25.

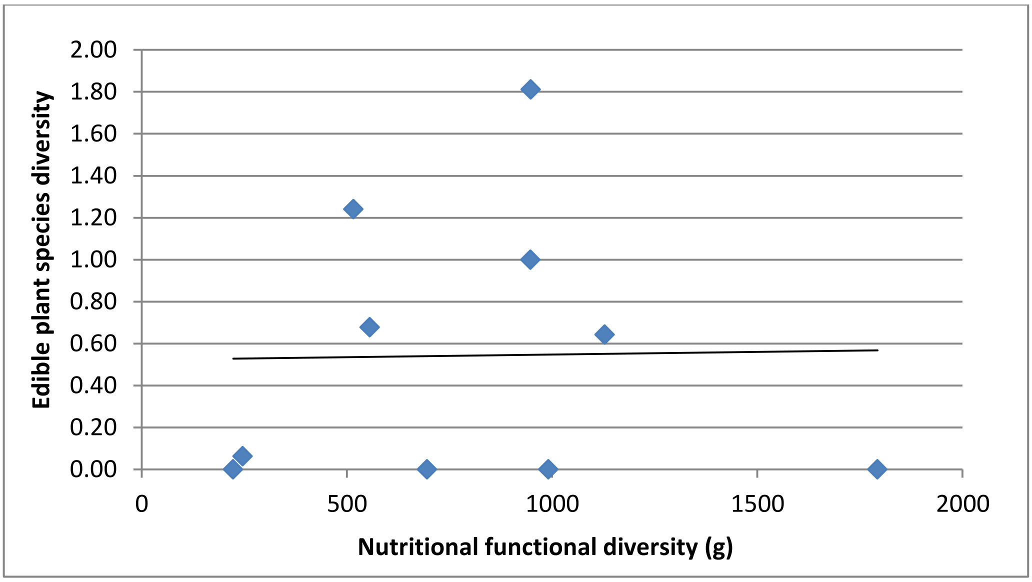


Figure 24. Correlation between nutritional functional diversity and Shannon-Wiener edible plant species diversity index in current rice system.

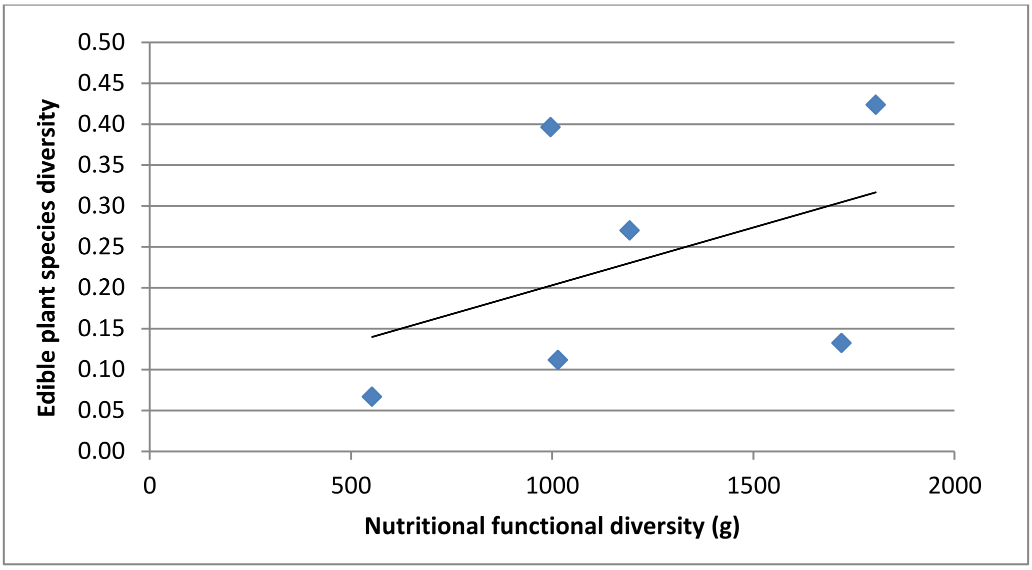


Figure 25. Correlation between nutritional functional diversity and Shannon-Wiener edible plant species diversity index in complex rice system.

Furthermore, the correlation between nutritional functional diversity and Shannon-Wiener edible animal species diversity index of the current rice system was not available due to the characteristic of the current rice system such as monoculture and intercropping that only has plants species. In the complex rice system, the nutritional functional diversity will increase when the edible animal species diversity increases in the rice field (0.527 wherein P>0.05) as presented in Figure 26.

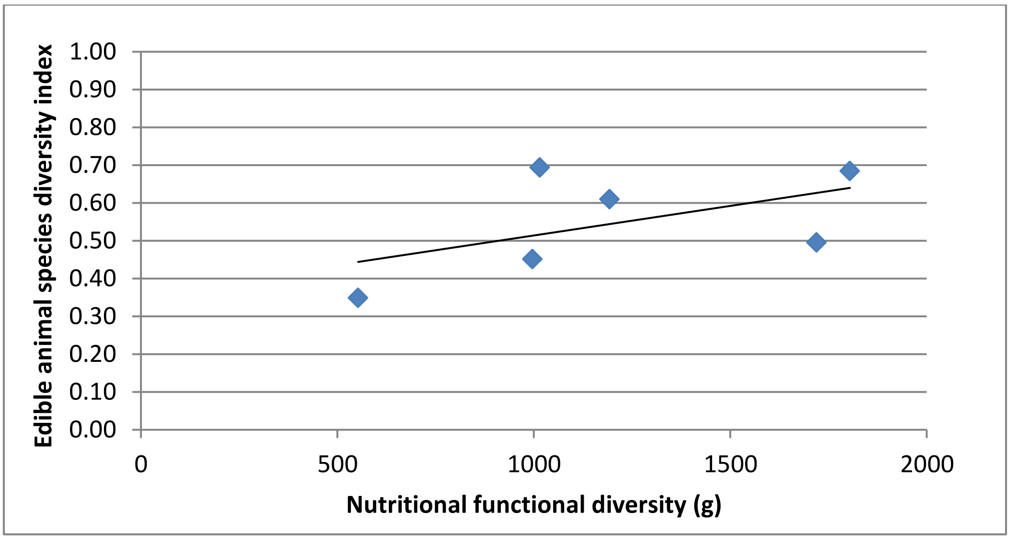


Figure 26. Correlation between nutritional functional diversity and Shannon-Wiener edible animal species diversity index in complex rice system.

In contrast, the correlation between nutritional functional diversity and Simpson's edible plant species diversity index is different with Shannon-Wiener edible plant species diversity index. In the current rice system, the correlation value was -0.064 while in the complex rice system was 0.457 (P>0.05). In the current rice system, adding edible plant species diversity in the rice field causing the decrease of the nutritional functional diversity as presented in Figure 27. In contrast, the complex rice system increases the nutritional functional diversity by adding edible plant species in the rice field as presented in the Figure 28.

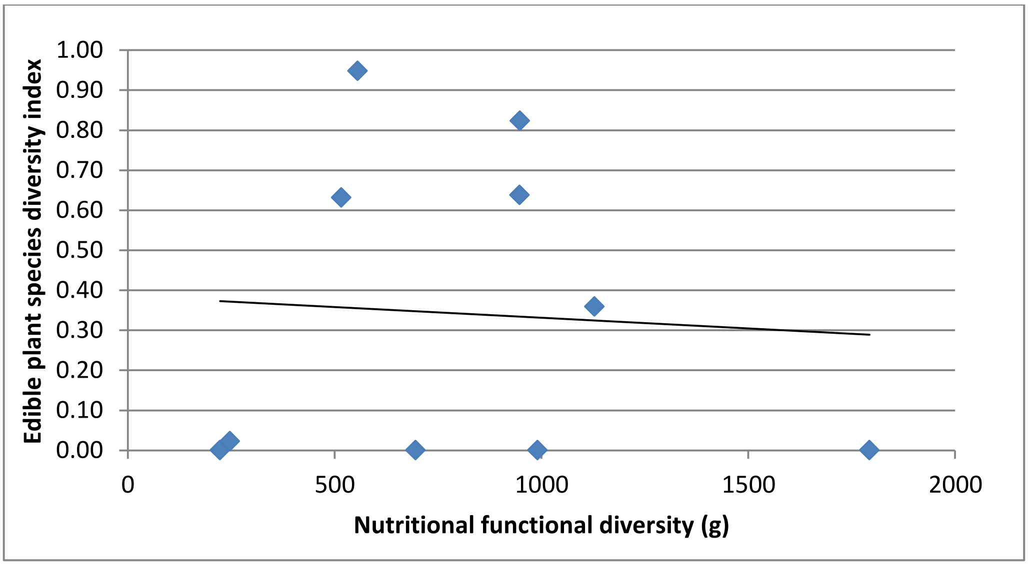


Figure 27. Correlation between nutritional functional diversity and Simpson's edible plant species diversity index in current rice system.

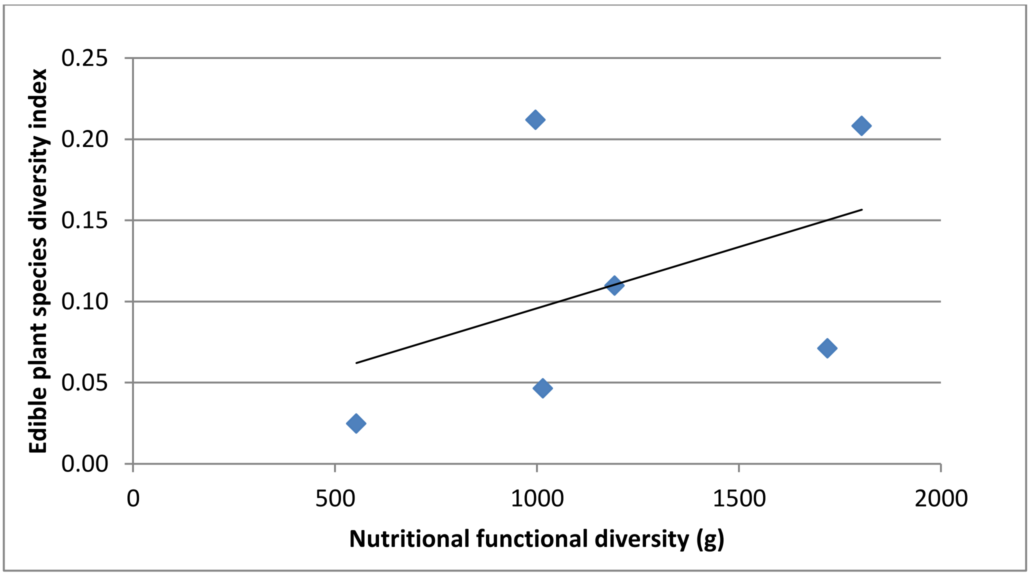


Figure 28. Correlation between nutritional functional diversity and Simpson's edible plant species diversity index in complex rice system.

Similar to the previous explanation, the data of the edible animal species diversity index in the current rice system was not available. Thus, we did not measure the correlation between the nutritional functional diversity and Simpson's edible animal species diversity index in the current rice system. While, in the complex rice system, the correlation value was 0.369

(P>0.05). Adding the edible animal species diversity will increase the nutritional functional diversity in the farmer's household as presented in Figure 29.

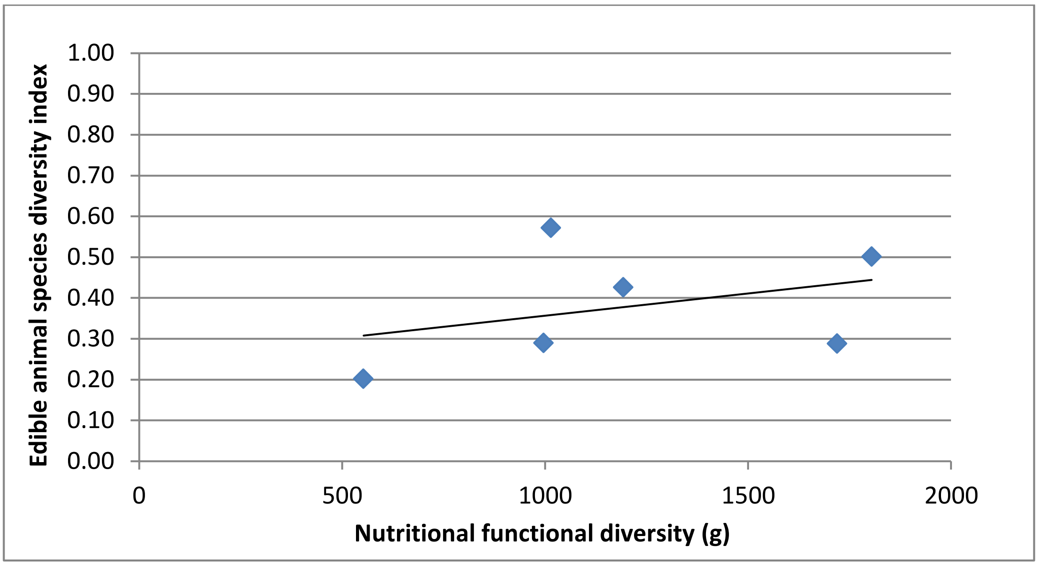


Figure 29. Correlation between nutritional functional diversity and Simpson's edible animal species diversity index in complex rice system.

In general, based on Shannon-Wiener, the complex rice system had a tendency to increase nutritional functional diversity with the increase of the edible plant and animal diversity as well as the current rice system. However, the increased value of the current rice system was lower than the complex rice system. The reason behind this is that the farmers in both rice systems consumed various food plant that grown in their rice field which contributed to the nutrition of the farmers' household. Particularly for the complex rice system that combining the plant and animal species in the rice field provided more nutrient from raising the animal in the rice field (especially animal protein such as fish and duck's egg).

In contrast, based on Simpson's index especially for edible plant species diversity in the current rice system, the increase of the edible plant species diversity in the rice field caused the decrease of the nutritional functional diversity. It can be due to the principle of Simpson's diversity index that measured only the dominant species. Thus, the variation of nutrient content that consumed by the farmer from edible plant in their rice farm was limited. On the other hand, the Simpson's index shows that in the complex rice system, the nutritional functional diversity increased with the increase of edible plant and animal species diversity in the rice field. It can be due to the reason that the farmers directly consumed their own food production. Moreover, it is also because the farmers in the complex rice system also consumed their edible animal products such as fish and duck's egg.

Finally, both Shannon-Wiener and Simpson's species diversity index in the complex rice system had a higher correlation value than the current rice system, not only for the edible plant species diversity but also for the edible animal species diversity. It is consistent with the study by Mazunda *et al.,* (2016) that the diversity in plants played an important role in human nutrition, health and sociocultural needs. Notably, this study emphasized that the species diversity increased the nutrition security in the farmers' household.

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IV. Conclusions

Based on the findings of this study, it can be concluded that the current rice system and the complex rice system did not significantly affecting the dietary diversity score of the farmers' household nutrition. However, the current rice systems tended to have a lower dietary diversity score than the complex rice system. It might be due to the higher species diversity at farm level in the complex rice system because of the integration of plant and animal species. This species diversity contributed to the dietary diversity through the agricultural system used by the farmers such as monoculture, intercropping or complex system, which provide different species diversity of food plants and animal for farmers' households. Then, this species diversity also contributed to the nutrition of the farmers' household through the availability of food in the rice farms, household home garden or other cultivated fields especially when the farmers consumed their own food production. Therefore, the nutritional functional diversity of the complex rice system especially for macronutrients, minerals and vitamins tended to be higher than in the current rice system.

Furthermore, redesigned the current rice system based on the principles of the complex rice system also contributed to the dietary diversity of farmers' households nutrition through other factors such as economic ability, access to the food sources, and eating habits. The enhancement of economic ability achieved through additional income sources from the rice field such as selling the fish, duck's egg and duck's meat. Furthermore, the easiness access to get the food from market, gift from their neighbourhood as local tradition in Indonesia, and consumed some plant and animal species that grown in their rice farms, household home garden, and other cultivated fields became one of the determining factors in dietary diversity score. Then, the eating habits of the farmers' households also contributed to the dietary diversity score through the types of consumable food. It is depending on the farmers' preference and health condition. Even though the farmers had the ability to buy different kind of foods but they could not consume it because of their consideration on health condition.

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Appendixes

Appendix 1. Respondent's general information.

Regency :
Village :
Hamlet :
RW :
RT :
Respondent number :

GGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGG

GGGGGGGGGGGG

1. Name :

....

2. Gender : 1. Male 2. Female
3. Address :

....

4. Interview date (dd,mm,yy)

INFORMATION ABOUT HOUSEHOLD SOCIAL DEMOGRAPHY

No	Name	Status in family (1)	Gender (2)	Age/Place and date of birth (hh/mm/th)*	Education (3)	Job (4)	Religion (5)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

*Asked about place and date of birth for children under 5 years.

Notes :

[1]Status in family:

1. Husband/Dad
2. Wife/Mom
3. Children
4. Grandchildren
5. Parents/Parents in law
6. Siblings
7. Housemaid
8. Others, mentioned................

[2]Gender:

1. Male
2. Female

[3]Education:

1. Never went to school
2. Did not finish elementary school
3. Finished elementary school
4. Finished junior high school
5. Finished senior high school
6. Diploma/Bachelor

[4]Main job:

1. Not working (ex: house wife and student)
2. Farmer
3. Labor
4. Craftsman
5. Entrepreneur/businessman
6. Government employee
7. Army/police
8. Building porter
9. Housemaid
10. Others, mentioned.....
11. No idea
12. Not answer

[5]Religion:

1. Islamic
2. Catholic
3. Christian
4. Hinduism
5. Buddha

SOCIAL ECONOMIC INFORMATION					
1. How much the average of family income? (Rp/month)?	No	Status	Daily	Weekly	Monthly
2.How much expenditure for : a. Food (Rp/month) b. Non – Food (Rp/month)	....				

OWNERSHIP OF ASSETS	
3. What kind of livestock do you have?	
4. In what form of livestock production used by the family? 01. Sale 02. Consume 03. Used for next year 04. Others	☐☐
5. Where are you raising livestock? 01. The cage outdoors 02. Outside the house without cage 03. The cage in the house 04. In a house without cage	☐☐
6. How often do you clean your livestock pens? 01. Everyday 02. ≥ every 2 days	☐☐
7. What is the distance of livestock cage to your home? 01. ≥5 meter 02. <5 meter	☐☐

8. Asset Ownership: 01. Yes 02. No Do you have: a. Rice fields b. Farm/garden c. Livestock (cow, goat, buffalo, fowl) d. Bicycle e. Motorcycle f. Car g. Savings h. Gold deposits i. Others mentioned..	
9. What kind of agriculture activities that you did? ………………………………………………………………………………………..	
10. In what form of agricultural production utilized by family? 01.Sale 02.Consume 03.Used as seed 04.Others………………………….	
11. Status of home ownership: 01. Own by respondent 02. Rent 03. Official home 04. Others ………………………	
CONDITION OF RESIDENCE	
12. Does building a permanent home? (buildings made of strong materials and durable) 01. Yes 02. No	

13. How is the condition of the floor residence? 01. Ceramic / granite / marble 02. Plaster 03. Soil 04. Others..............	☐☐
14. How is the condition of the walls of dwelling? 01. Wall 02. Wall plywood 03. Walls of wood 04. Wall bamboo 05. Others..............	☐☐
15. How is the condition of the roof of dwelling? 01. Tile 02. Seng 03. Bamboo 04.Others..............	☐☐

FOOD SECURITY ACCESS	
16. Where are you got the groceries? 01. Own produce, such as....... 02. Buy, such as .... 03. Given, such as .... 04. Others...........	☐☐
17. How much time should be reached (used answer from question number 8) to the usual place to get food supplies? 01. ≤ 5 minutes 02. > 5 - 15 minutes 03. > 15 - 25 minutes 04. Others	☐☐
18. Is there an easy access to the place of groceries seller? 01. Yes 02. No	☐☐

19. Usually, do you buy groceries at the market / supermarket / shop nearby by: 01. Walking 02. Using motorcycle 03. Using bicycle 04. Using car 05. Public transportations 06. Others………………..	☐☐
20. Is the family get food aid from the government? 01. Yes 02. No	☐☐

GENERAL HOUSEHOLD DIETARY DIVERSITY SCORE

Questions	Coding category	
I will ask about the type of food that you or your family eat yesterday. Give the value of 1 in the box when one of family member consume food presented in question, and give it a value of 0 in the box when there is no family member who consume these foods.		
A. Do you eat rice, bread, noodles, biscuits, corn?	A. ………………………………………………	☐
B. Do you consume tubers such as potatoes, cassava, yams, taro, etc.?	B. ………………………………………………	☐
C. Do you eat vegetables?	C. ………………………………………………	☐
D. Do you eat fruits?	D. ………………………………………………	☐

E. Do you eat beef, chicken, lamb, liver, spleen, intestines, duck, and quail?	E.	☐
F. Do you eat eggs?	F.	☐
G. Do you eat fish fresh or preserved fish such as anchovies, shellfish, etc.?	G.	☐
H. Do you consume foods made from beans (tempeh, tofu, oncom)?	H.	☐
I. Do you consume milk or dairy products (cheese, yogurt)?	I.	☐
J. Do you eat foods that are processed with oil (butter, margarine)?	J.	☐
K. Do you consume sugar or cheese?	K.	☐
L. Do you eat a snack such as coffee, tea?	L.	☐

Appendix 2. Dietary diversity form

7 Day Food Records

Name :

Date :

Address :

Farm type* :

No	Time		Food name	Quantity	Processing	Materials			
						Materials name	Type**	Amount	Food source***
1.	**Breakfast** Time : Place :								
2.	**Snack** **Father** Time : Place :								
	Mother Time : Place :								
	Children Time : Place :								
	.... Time : Place :								
	.... Time : Place :								

3.	**Lunch** Time : Place :								
4.	**Snack** **Father** Time : Place :								
	Mother Time : Place :								
	Children Time : Place :								
	.... Time : Place :								
	.... Time : Place :								
5.	**Dinner** Time : Place :								

Note:

*Monocropping / intercropping /mina padi / conventional /organic / complex rice system

** Carbohidrate, protein, vegetables, etc.

***Food source:

1. Own production
2. Purchased
3. Borrowed, bartered, exchange for labour, gift from friends or relatives
4. Food aid
5. Other

Appendix 3. Species diversity form

Location :

Date :

Farmer's name :

Farm type* :

Location**	Size (m^2)	Plot (sampel no)	Plant / animal species	Edible/non-edible	Used for***	Amount consumed	Additional information

Note :

*Monocropping / intercropping / Mina padi / conventional /organic /complex rice system

**Farm / rice field / home garden

***Consumed by farmer household / take by other people / allowed in the rice field

Appendix 4. Nutritional functional diversity form

Location :

Date :

Farmer's name :

Farm type* :

Location**	Size (m^2)	Plot (sampel no)	Plant / animal species	Edible/non-edible	Used for***	Amount consumed	Additional information

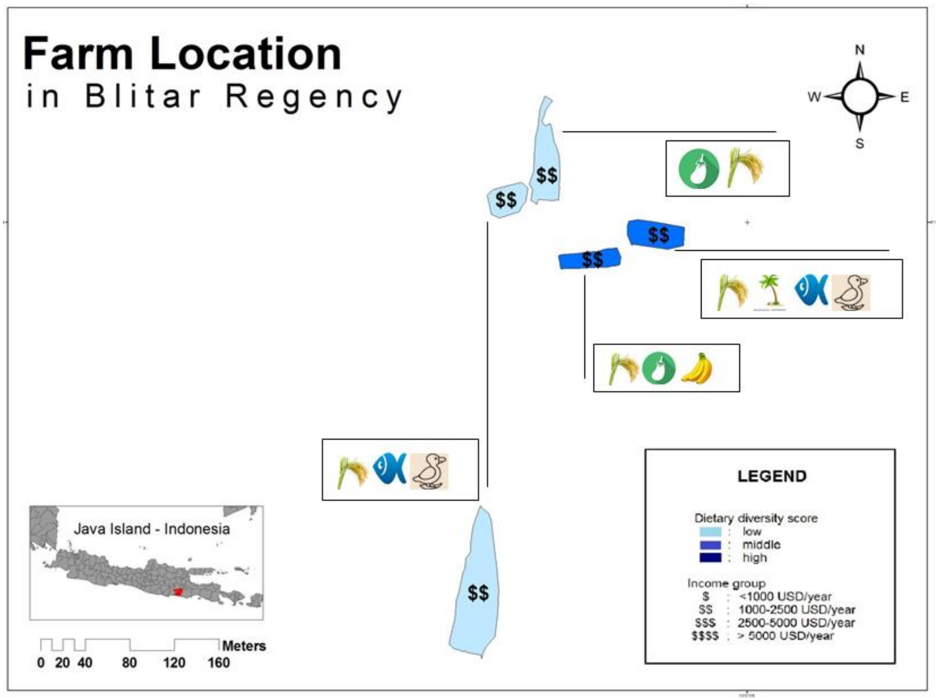
Note :

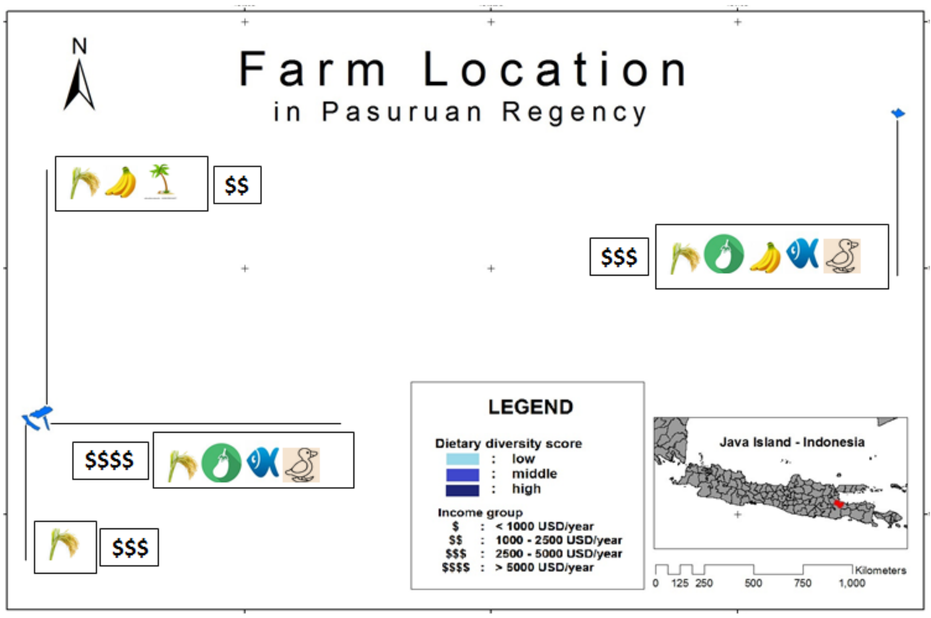
*Monocropping / intercropping / Mina padi / conventional /organic /complex rice system

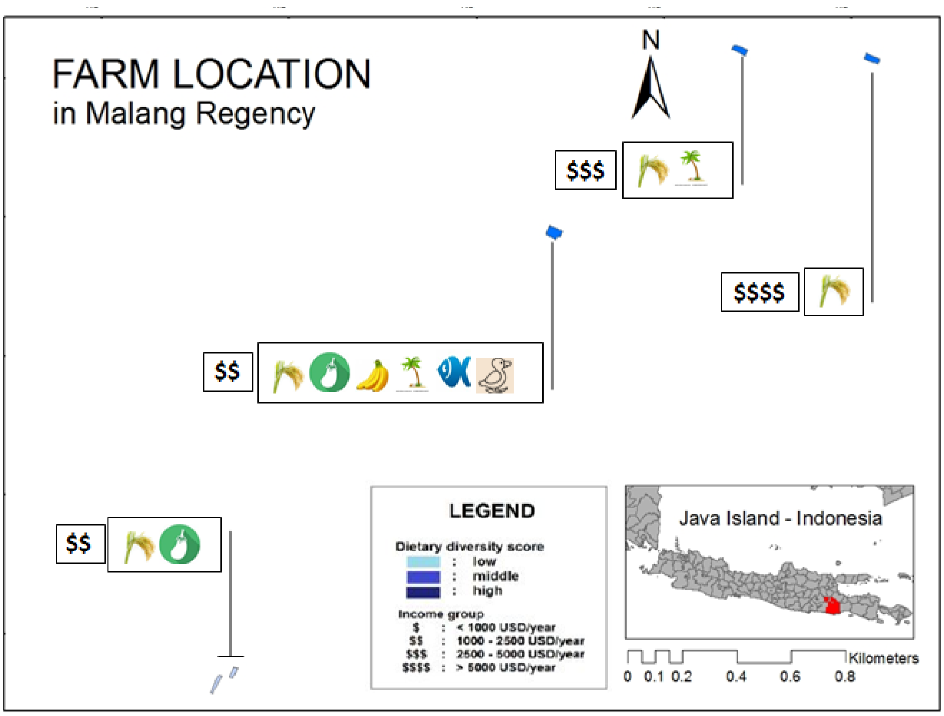
**Farm / rice field / home garden

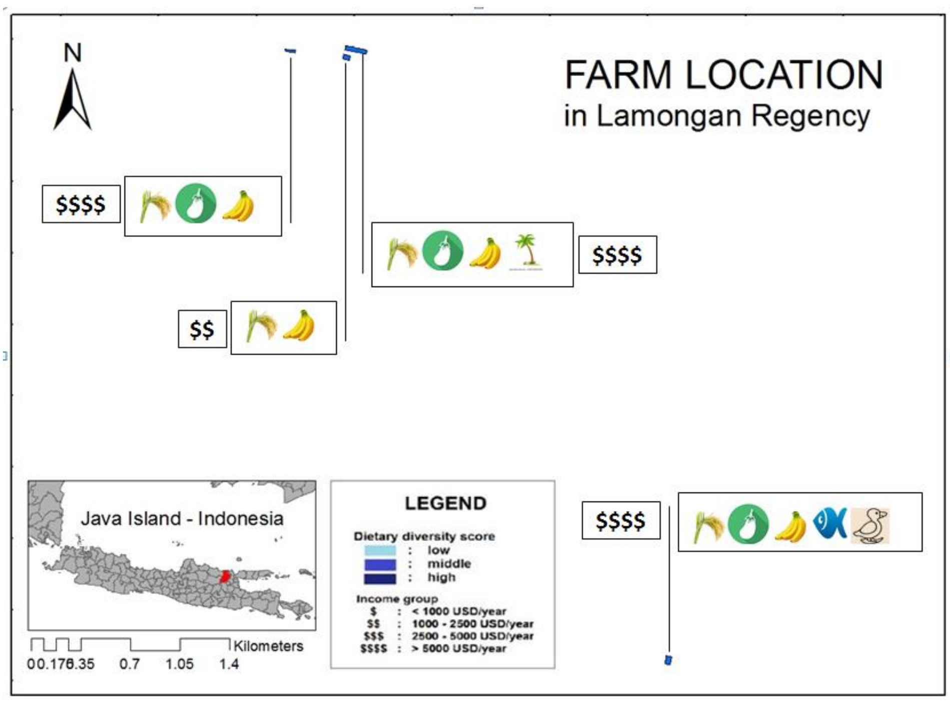
***Consumed by farmer household / take by other people / allowed in the rice field

Appendix 5. Maps of the farmer's rice field in four regencies that provide information about dietary diversity, rice systems and farmers' income.






FARM LOCATION
in Malang Regency
N
$$$
$$$$
$$
$$
LEGEND
Dietary diversity score
: low
: middle
: high
Income group
$: < 1000 USD/year
$$: 1000 - 2500 USD/year
$$$: 2500 - 5000 USD/year
$$$$: > 5000 USD/year
Java Island - Indonesia
Kilometers
0 0.1 0.2 0.4 0.6 0.8


N
FARM LOCATION
in Lamongan Regency
$$$$
$$$$
$$
Java Island - Indonesia
Kilometers
00.170.35 0.7 1.05 1.4
LEGEND
Dietary diversity score
: low
: middle
: high
Income group
$: < 1000 USD/year
$$: 1000 - 2500 USD/year
$$$: 2500 - 5000 USD/year
$$$$: > 5000 USD/year
$$$$