Journal of Positive School Psychology http://journalppw.com
2022, Vol. 6, No. 5, 4523– 4538

Analysing Effect of Socio-Demographics, Paddy Management Practices, and Biotic Constraints on Paddy Productivity across Muda Agricultural Development Authority (MADA) Regions, Malaysia

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Abstract

Among the important and dynamic factors influencing paddy productivity are rising level of environmental threats and proliferations of harmful biotic factors in paddy fields. These are mainly associated with climate change and thus demand innovative management practices to mitigate. There are limited studies that examined the variations of environmental, biotic, technology use and management practices in relation to socio-economics of paddy farmers, especially in different MADA paddy regions in Malaysia. Thus, current study assesses the effect of socio-demographic, management practices (planting schedule, fertilizer application, seed rate), biotic constraints (weeds, insect pests, diseases) and environmental factors (flood, drought, wind) on paddy productivity. The study relied on 2020 NKEA and Crop Cutting Survey (CCS) data from MADA. Analysis involved both descriptive statistics and regression analysis. The result of the mean and maximum loss from each constraints indicates that animal: resulted to a average loss of 0.4% (Region 1), maximum loss of 10% (Regions 2 and 4), snails: average loss was 2.5% (Region 1) and maximum loss of 10% (Region 2) insects: the average loss was 8.5% (Region 2), while, the maximum loss was 50% (Region 2). Also, on disease, the highest average loss was 2.7% in Region 4, while the maximum loss of 50% was recorded in Region 3. For wind paddy, the average loss was 3.5% (Region 4), the maximum of 30% loss was incurred in Region 2. Weed attack resulted to a mean loss of 3.2% and maximum loss of 15% both in Region 3. Based on flood event, the mean loss was 0.2% (Region 3), the maximum loss was 15% (in Region 4). Concerning drought, the highest average loss of 0.1% and maximum loss of 10% were recorded in Region 4. The factors affecting productivity at MADA includes, land area, primary occupation of farmers, gender, educational status, management compliances, and diseases. In conclusions, efforts to minimise these constraints are critical in improving productivity and to limit food insecurity especially as climate change poses more environmental threats and disease proliferations.

Keywords: Environmental Factors; Food Loss; Food Security; Paddy Productivity; Socio-demographics.

I. INTRODUCTION

World hunger is on the rise, yet, an estimated one third of all food produced globally is lost or goes to waste (FAO, 2021). Increasing food supply, by reducing food losses is critical to creating a Zero Hunger world and reaching the world's Sustainable Development Goals (SDGs), especially SDG 2 (End Hunger) and SDG 12 (Ensure sustainable consumption and production patterns). Among the cereal crops, rice is the most important one due to its use as a staple food for more than half of the world. As the world population is increasing so the supply of rice must be doubled to fulfil the demand for food by 2050 (FAO, 2019). Throughout and particularly in the most countries of Asia, rice is an essential food crop considered as a measure for food security. Particularly, Malaysia have focused on agriculture as a National Key Economic Area (NKEA) and specifically improving paddy productivity as the 10th Entry point project (EPP). However, rice productivity is hampered severely due to climate change related factors including sea level rise and intrusion of saline water in the coastal area (Ali et al., 2019).

Also, climate change have further worsen the intensity of effects regarding the environmental, and biotic threats to paddy productivity thus, a major challenge worldwide. Therefore, the challenge of this century is to feed the population without destroying the planet, and this balance depends on maximising productivity and reduce loses (Sakaguchi et al., 2018). Mostly, developing countries faces productivity challenges from different sources, however there is insufficient information owing to the diverse and dynamic nature of determinant factors **(**Ali et al., 2019**)**. While the literature on the nexus between paddy productivity loses and determinants have examined variants of environmental factors, biotic and management related factors as major productivity limiting factors (Kaya-Altop et al., 2019; Cesari et al., 2017; Houma et al., 2021).

Management practices of paddy farmers are thus essential in ensuring sustainable rice production in the changing climatic condition. A number of studies have established the nexus between production inputs and management practices on technical efficiency and paddy productivity (Ali et al., 2019). Several inputs usage for example, water management influences rice productivity and the emissions from rice cultivation systems. Irrigated rice fields are an integral part of the rice production system in Asia and contribute about 75% to global rice production. Single or multiple drainages during a rice growing season are reported to reduce carbon emissions by 48–93% compared to those observed under continuous flooding systems (LaHue, et al., 2016; Xu et al., 2015). Mid-season drainage and intermittent flooding were found effective for increasing productivity and quality of rice as well as reducing methane emissions in Japan (Ali et al., 2019).

Another major threat to productivity are biotic factors that attacks the paddy during production stage (John, 2014). Like other crops the ability of rice to attain high production has been reduced due to the presence of biotic and abiotic factors. In biotic factors the most important one is diseases of rice, viz, sheath blight, bacterial blight, rice blast, brown spot, narrow brown spot, bacterial leaf streak, and grassy stunt. Rice crops are attacked by a number of insects like terrestrial arthropods and non-rice pest insects that visit rice fields, causing further concerns (Asghar et al., 2013; Thongphak et al., 2012). According to Pathak and Khan (1994) there are about 800 species worldwide, of which around 100 species attack rice while rest are considered friendly insects. Rice crop has almost 20 insect-pests, including stem borers, gall midge, defoliators, and vectors (leafhoppers and plant hoppers) which cause economic damage to the rice crop directly or act as vector in disease transfer (Pathak and Khan, 1994).

Also, rice fields may have a variety of weeds, often from the previous year's seed, rhizomes, tubers, and bulbs surviving in the soil. The presence of weeds in a rice field is greatly influenced by cultural practices like, continuous planting of rice on the same piece of land. Such continuous growing and unchanged cultural system encourages the adapted weed to grow. Just like insects, pests, and diseases, weeds are also major constraints in achieving high productivity (Savary et al., 2000). Based on previous research reviews, it is difficult to extrapolate results from the relevant local data or from a particular cropping situation for a large-scale study. (Savary et al., 1999).

Generally the productivity losses are due to the assembly of many weeds present in crop, and it is difficult to differentiate them substantially in competitive ability (Weaver & Ivany, 1998). Usually the cultural practices vary among the countries, which is why the resulted productivity losses are variable. According to Mondal et al. (2017), the overall production loss due to pests in India is 33%, whereas weeds caused 12.5% production losses. The major impact of weeds on rice crops include increased production cost, serving as hosts for rice pests, effect rice harvesting and its quality, aquatic weed problem, social costs, and rice weed competition.

While the literature on the nexus between paddy productivity loses and determinants have examined variants of environmental factors, biotic and management related factors as major productivity limiting factors. Previous studies affirmed that it is insufficient to generalize findings from existing local data or another cropping location (Savary et al., 1998). However, few studies analysed the differences in the sub regions and the implications on productivity (Cicatiello et al., 2016) particularly in MADA, Malaysia. At MADA, two paddy production schemes are recognised. First, is the existing paddy growing scheme under MADA granary area and for this scheme, MADA conducts annual survey titled the cross cutting survey (CCS) for the first scheme (KRI, 2019). Then the NKEA project which was introduced to improve productivity to a target of 10Mt/ha, with adjustment in management services, input support to farmers, and technology introduction. Also an annual survey is done under the NKEA project as well. The two schemes covers the four MADA regions thus the basis for a comparison of variations in performance between the schemes and across the region.

II. LITERATURE REVIEW

2.1 Theoretical Review

In determining the model used to examine factors influencing paddy productivity in the MADA regions, this study follows the existing application of Cobb-Douglas model. This basic Cobb-Douglas model is as depicted in equation 1.

$$Y_t = A_t K_t^{\alpha} L_t^{\alpha-1} \qquad (1)$$

Where: Y is regarded as productivity. Which is a function of capital (K) and labour (L). While A is a constant or “technological progress”. Note that an increase in A results in higher output without having to raise inputs (Rehan, Yusuf & Idham, 2020).

This model has been adapted by Rehan, Yusuf and Idham (2020). The model used in this study composed of farm factors, input usage, environmental factors in addition to basic factors in the production model. As such, this study examines environmental factors, socio-economic factors, and management factors as determinants of paddy productivity. The additional factors in the current model include biotic factors, the management practices, and the socio-economics status of the paddy farmers and it will be the regional difference.

2.2 Empirical Reviews

In China, three studies including Deng et al., (2019); Shan et al., (2021); Mboyerwa et al. (2021) assessed management practices in paddy with each using different measurement. While Deng, et al. (2019), examined effect of different cropping systems on productivity, Shan et al., (2021) assessed effect of soil management technique like mixing straws with N-fertilizer on productivity, and Mboyerwa et al. (2021) examined the effect of irrigation and soil fertility level on productivity. For example, Senthilkumar et al. (2020) compared different rice-growing management practices across different locations. Then they identified that, across rice-growing locations in Eastern and

Southern Africa, the major cause for productivity variability includes straw management, duration of growth for seed variety, weed cover, weeding frequency, fertilizer application frequency, and land levelling.

However, Li et al., (2018) examined the response of paddy productivity to fertilizer nitrogen and soil chemical properties in Japan. Whereas, Abas (2016) examined aspects of technology management and natural resource management. The study found that managerial subsystem, self-owned seeds, organic fertilizer and farm work were the factors influencing paddy self-reliance. Also in Iran, study by Yousefian et al., (2019) analysed the production process and then ranked factors influencing paddy productivity gap in Sari, Iran. Also, Harun et al., (2021) examined production and application of fertilizer and pesticides, on rice production and then its impact on the environment. Result indicated such impact includes, global warming, water consumption potential, and fossil fuel depletion.

Alternatively, other category of studies were concerned with environmental factors on paddy productivity. Notably, in East Asia, Kim et al., (2012) investigated how climate change influences paddy production with focus on temperate climate regions in East Asia using crop simulation model (CERES-Rice 4.0). Also, in Korea, Yoon and Choi (2020) examined shift in growing season resulting from climate change and how paddy productivity respond. Similarly in Korea, Kim et al., (2021) argued on the issue of climate change and the implications on food security and suggests the need for a shift in water use management practices associated with paddy rice production. While, Todd et al. (2018) using the interaction of genotypic and genotype by environmental (GGE) to assess the effect of environment on sugarcane production. They affirmed the interaction effect of location on productivity of sugarcane in south Louisiana fields.

Another category of literature focused on biotic factors such as weeds, diseases, rodents, animals, insects and their influence on paddy productivity. They acknowledged that these biotic factors attack crops on the field which leads to various degree of loses. Among the notable studies that examined biotic constraints on productivity includes; Pathak and Khan (1994), Dass (2017), Mondal et al., (2017), Haque et al. (2021), Toffa et al., (2021); Thongphak et al. (2012). As affirmed by Pathak and Khan (1994), about 800 species of insects exists globally and out of these, around 100 species invade paddy field. These pests cause damage to rice plants by chewing its tissues, boring into stems, or sucking fluid saps from stems which disturbs the physiology of the grains and ultimately reduce paddy productivity. Also, Mondal et al. (2017), affirmed that, the gross loss of paddy resulting from pests is estimated at 33% in India. They highlighted that, paddy farms might be attacked by series of weeds from seeds previously left in paddy soils. These insects cause loss of income to the paddy farmers by directly affecting productivity (Haque et al., 2021). Some of these insects are also vectors that transfer disease to the paddy plant (Pathak & Khan, 1994).

Savary et al. (2000) emphasized that just like insects, pests, and diseases, weeds are also major constraints in achieving high paddy productivity. In Southeast Asia a number of these insects represent major causes of paddy productivity losses (Sardesai et al., 2001). According to Dass (2017), weeds has a strong effect of productivity especially the direct-seeded rice. Weaver and Ivany (1998), also showed that the losses in paddy productivity for most field are result of weeds infestation. Mondal et al., (2017) highlighted that, uncontrolled weed growth may cause damages or loss of between 44 to 96% paddy productivity.

Having examined literature across other regions of the world, an assessment of relevant extant studies in the context of Malaysia is also presented. In this context, a few studies had delve into assessment of specific factors responsible for productivity growth. First, in relation to management practices, Anisuzzaman, et al. (2021) studied the effect of inorganic fertilizer on productivity in Malaysia. Also, Maikol et al., (2021) examined the effects of application of chicken litter biochar on selected chemical properties of a tropical acid soil under MR219 rice cultivation in Malaysia.

Also, in Malaysia, Din et al. (2015) evaluated the effect of the rice blast disease on paddy productivity in Terengganu. The study assessed the adoption of PUTRA 1 technology as an effective against the disease. The results showed that four factors; attitude, subjective norms, knowledge and perceived behavioural control significantly affect farmers' intention to adopt Putra 1. Also in Malaysia, Houma et al. (2021) used the field experimental approach to examine challenges of weed infestation and water stress in paddy field under three climate change scenarios (RCP4.5, RCP6.0 and RCP8.5 emission scenario). Results indicated positive effect on productivity with no water stress and weed attack. However, if water stress is introduced with weed control, then the productivity could decline by 65%. In a deviation, Rehan et al., (2019) extended the effect of flood on farm infrastructures such as dams, irrigation facilities, building and most importantly productivity in Malaysia.

Another environmental factor examined by Duasa and Mohd-Radzman (2021) in the context of Malaysia is CO2 emission based on ARDL and OLS techniques. ARDL result revealed that the CO2 has no significant effect on rice productivity in the shortrun, however it was positively significant in the longrun. While OLS regression confirmed CO2 to have a negative effect. Similarly, Firdaus et al., (2020) examined both increasing trends in both temperature and rainfall in the granary areas in Malaysia and effect on paddy productivity. The findings signified that climate change poses a severe threat to paddy production, which eventually will affect food security as they are highly interrelated. Also in Malaysia, How et al. (2022) employed an alternative measure for environmental factors using heat exposure potential and farmers health which have direct impact on productivity of conventional rice farmers. The study shows that there is a significant difference between HSI, blood pressure, and blood glucose levels among organic and conventional farmers.

Several studies across regions have examined factors associated with paddy productivity performance (notably, Kim, Jang, Hwang, & Jeong, 2021; Li, Nanseki, Chomei & Fukuhura, 2018; Todd et al., 2018). However, it is evident that different measures were used in assessing environmental, biotic and management practices across the extant studies. This makes it a difficulty or even impossible to compare studies across regions or even sub national levels. Furthermore, existing literature have argued on the effect of farmers management practice on productivity (Kaya-Altop et al., 2019; Cesari et al., 2017). There is scarcely any study that explicitly examined the effect of farmer's compliance or non-compliance to paddy management schedule on productivity. While the dynamics of climate change demands that farmers follow or adjust specific management practices to ensure adaptability and better productivity.

On the basis of the highlighted limitations of the extant literature, and the limited attempts made within the paddy sector of Malaysia. This study is conceived to address the limitations through an in depth assessment of the paddy sector of Malaysia with focus on farmer's socio-demographics, specific biotics, environmental threats and adopted management practices. The study rely on data from both CCS and NKEA to achieve the study objectives. To achieve this, the following objectives are defined for this study, first, to analyse the different types of socio-demographics of farmers, environmental factors, biotic factors and management practices that threatens paddy productivity at the MADA granary area; to analyse how this factors varies across the four MADA regions; then to determine the significant factors impacting paddy productivity. Thus the study contributes generally to the existing body of knowledge and specifically the effort to boost paddy productivity in MADA, Malaysia.

III.3. RESEARCH METHODOLOGY

3.1 Data and sample

The data used in this study is retrieved from the 2020 production data for CCS and NKEA paddy projects in MADA. As the largest paddy producing region, the data is considered to sufficiently represent the Malaysia's paddy production sector. This data is an annual data that covers the four MADA regions. The data comprises of socio-demography of the farmers, the level of input usage, the level of mechanisation at different production stages, management practices, compliance with schedules, the occurrence and percentage damage by specific environmental and biotic factors. and finally the outputs. Thus the dataset would allow this study to analyse at aggregate and sub-regional level of input usage, the differences in productivity, incidences of environmental and biotic threats, level of compliance and technology use. Additionally, the study could also compare between the different paddy groups (CCS and NKEA).

3.2 Analytical technique

The descriptive analysis (Percentages, frequencies, mean, and standard deviation) was used mainly to describe the socio-economics characteristics of the respondents and identify the technologies used in the different stages of paddy production. A comparison of the differences between regions and the two projects (CCS and NKEA is also presented).

IV. RESULTS AND DISCUSSIONS

The primary purpose of this study is to analyse first, the socio-economic factors of the MADA paddy farmers, the different types of environmental factors, biotic factors and management practices influencing paddy productivity at the MADA granary area. Then, to analyse how these factors vary across the four MADA regions. This is followed by determining the significant factors impacting paddy productivity. Consequently, the result is presented beginning with the description of the socio-demography of paddy farmers for the CCS group by region. This is then followed by a comparative assessment of productivity and input use between NKEA and CCS groups.

4.1 Socio-Demography of Paddy farmers for the CCS Paddy Group by Region

Table 1 presents the average productivity in kg/ha of each region across the four MADA for the CCS group. A comparison of the region shows that, Region 4 had the highest average productivity followed by Region 1. Whereas, Region 3 had the lowest average productivity among the four Regions. The minimum and maximum were 984 and 8953 kg/ha, which shows a wide gap between the highest and lowest in Region 4. This agrees with empirical literature (*Cicatiello et al., 2016;* Savary *et al., 1999*) which suggest that productivity varies across regions, the need for sub regional evaluation.

Table 1: *Average Productivity by Region (kg/ha) for CCS*

Statistics	*Region 1*	*Region 2*	*Region 3*	*Region 4*
N	*125*	*225*	*148*	*175*
Mean	*6080.09*	*5993.48*	*5695.25*	*6122.07*
Std. Deviation	*452.52*	*862.59*	*811.63*	*892.99*
Variance	*204770.43*	*744068.95*	*658750.93*	*797429.21*
Minimum	*4869.60*	*1708.50*	*3128.10*	*984.00*
Maximum	*7814.50*	*9533.30*	*7678.90*	*8953.00*

To examine which variety performed better in terms of productivity across the four MADA regions, nine major varieties of paddy seeds used by the regions were analysed. Table 2 presents the mean productivity in kg/ha of varieties across the four MADA regions for the CCS group. The varieties are; MARDI SEMPADAN 303, MARDI SEBERNAS 307, MR 219, MR 220 CL2, MR 263, MR 269, MR SIRAJ 297, UKMRC-8, and UKMRC-2. A comparison of the average productivity of varieties reveals that, in Region 1, MR 220 CL2 had average of 6441.7 kg/ha which is higher than all other varieties. For Region 2, MARDI SEMPADAN 303 was found to have the highest average productivity of 6248.30 kg/ha. In Region 3, MARDI SEBERNAS 307 had the highest average productivity of 5983.75 kg/ha. Whereas, in Region 4 the UKMRC-2 variety had the highest average productivity of 6954.0 kg/ha, which is also the highest compared to the average for the other regions.

Also, the most frequently used varieties across the four regions are also indicated in Table 2. That is, Table 2 indicated the frequency (N) number of people using the different varieties across the regions. Across the four regions, the most frequently used variety was the same, that is the most number of farmers used the MR SIRAJ 297. The total number of people that used the MR SIRAJ 297 variety for each region are; in Region1, a total of 71 people out of 125. Region 2, a total of 121 people out of 225 while inn Region 3, it is a total of 100 people out of 148. Whereas, in Region 4 a total of 87 out of 175. This indicates that majority of the farmers across the regions uses the MR SIRAJ 297 variety.

Table 2: Varieties used and Average Productivity by Region (Kg/Ha) for CCS

Variety		Region 1	Region 2	Region 3	Region 4
MARDI SEMPADAN 303	**N**	**9.00**	**3.00**	**2.00**	**7.00**
	Mean	**5721.28 (468.09)**	**6248.30 (390.28)**	**5614.60 (226.42)**	**6335.29 (1169.19)**
MARDI SEBERNAS 307	**N**	**0.00**	**1.00**	**2.00**	**1.00**
	Mean	**0.00 (0.00)**	**5882.40 (0.00)**	**5983.75 (376.53)**	**6906.00 (0.00)**
MR 219	**N**	**17.00**	**15.00**	**7.00**	**7.00**
	Mean	**6055.25 (319.67)**	**5813.17 (695.83)**	**5362.67 (1221.46)**	**5622.86 (1261.27)**
MR 220 CL2	**N**	**15.00**	**82.00**	**31.00**	**65.00**
	Mean	**6441.66 (398.41)**	**6047.35 (621.58)**	**5952.11 (710.22)**	**5954.89 (1044.11)**
MR 263	**N**	**0.00**	**1.00**	**0.00**	**0.00**
	Mean	**0.00 (0.00)**	**5434.00 (0.00)**	**0.00 (0.00)**	**0.00 (0.00)**
MR 269	**N**	**9.00**	**0.00**	**0.00**	**0.00**
	Mean	**5708.50 (468.7)**	**0.00 (121)**	**0.00 (100)**	**0.00 (87)**
	Std. Deviation	**468.70**	**0.00**	**0.00**	**0.00**
MR SIRAJ 297	**N**	**71.00**	**121.00**	**100.00**	**87.00**
	Mean	**6089.50 (436.12)**	**5977.14 (1026.58)**	**5633.30 (833.07)**	**6273.79 (684.15)**
UKMRC-8	**N**	**1.00**	**2.00**	**2.00**	**7.00**
	Mean	**6352.90 (0.00)**	**6079.20 (732.56)**	**5421.80 (189.22)**	**5844.00 (736.26)**
	Std. Deviation	**0.00**	**732.56**	**189.22**	**736.26**
UKMRC-2	**N**	**3.00**	**0.00**	**4.00**	**1.00**
	Mean	**6290.57 (248.34)**	**0.00 (0.00)**	**5868.20 (234.43)**	**6954.00 (0.00)**

Standard deviation in parenthesis ()

Table 3 indicates the mean input usage by MADA regions for CCS group. In descending order, the mean land area are 1.17 ha (Region 2), 1.08 ha (Region 2), 1.02 ha (Region 4) and 0.88 ha (Region 3). Also, in terms of fertilizer usage, there are three different types of fertilizers used which are SEBATIAN, NPK1 and NPK2. For SEBATIAN fertilizer, the mean values in descending order are 244.04kg (Region 2), 222.42kg (Region 1), 207.77kg (Region 4) and 183.99kg (Region 3). This implies, Region 3 used the lowest mean value of SEBATIAN fertilizer. In terms of NPK1, the mean values in descending order are 77.02kg (Region 1), 71.72kg (Region 2), 66.91kg (Region 4) and 60.88kg (Region 3). This again indicates that Region 3 used the lowest mean value of NPK1 fertilizer. For the case of NPK2, the mean values in descending order are 203.76kg (Region 2), 185.72kg (Region 1), 176.54kg (Region 4) and 152.20 kg (Region 3). This implies that Region 3 used the lowest mean value of NPK1 fertilizer. With respect to the length of time used daily on the farm, the mean values for each region in descending order are 2.01 hours (Region 3), 1.83 hours (Region 2), 1.79 hours (Region 4) and 1.39 kg (Region 1). Thus, the Region that spends the least mean value of time on the farm is Region 1.

Table 3: *Mean Inputs use by Regions for CCS*

Inputs	Region 1	Region 2	Region 3	Region 4
Descriptive Statistics	**Mean**	**Mean**	**Mean**	**Mean**
Land Area (Ha)	**1.08 (0.81)**	**1.17 (0.71)**	**0.88 (0.65)**	**1.02 (0.65)**
Quantity of Fertilizer at Stage 1 (SEBATIAN)	**222.42 (164.81)**	**244.04 (146.01)**	**183.99 (134.65)**	**207.77 (133.49)**
Quantity of Fertilizer at Stage 2 (NPK1)	**77.02 (54.69)**	**71.72 (52.46)**	**60.88 (44.58)**	**66.91 (45.68)**
Quantity of Fertilizer at Stage 3 (NPK2)	**185.72 (140.41)**	**203.76 (121.95)**	**152.20 (111.92)**	**176.54 (112.82)**
Time in Field (Daily)	**1.39 (0.49)**	**1.85 (0.35)**	**2.01 (0.08)**	**1.79 (0.45)**
N	**125**	**225**	**148**	**175**

Standard deviation in parenthesis ()

4.1.1 Extent of Damage from Environmental and Biotic Factors

This section presents the results of the descriptive analysis of the environmental and biological constraints experienced by the CCS MADA paddy farmers and the percentages of the damage resulting from the incidence.

Table 4 *Percentage of damage by Biotic and Environmental Factors*

Regions	Statistics	Animals %	Snail %	Insects %	Diseases %	Wind paddy %	Weeds %	Flood %	Drought %
Region 1	**N**	**125.0**	**125.0**	**125.0**	**125.0**	**125.0**	**125.0**	**125.0**	**125.0**
	Mean	**0.4**	**2.5**	**2.6**	**2.3**	**1.6**	**2.4**	**0.0**	**0.0**
	Min	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

	Max	**5.0**	**5.0**	**5.0**	**5.0**	**10.0**	**5.0**	**5.0**	**0.0**
Region 2	**N**	**225.0**	**225.0**	**225.0**	**225.0**	**225.0**	**225.0**	**225.0**	**225.0**
	Mean	**0.3**	**0.6**	**8.5**	**1.7**	**3.3**	**2.1**	**0.0**	**0.0**
	Min	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	Max	**10.0**	**10.0**	**50.0**	**20.0**	**30.0**	**10.0**	**5.0**	**0.0**
Region 3	**N**	**148.0**	**148.0**	**148.0**	**148.0**	**148.0**	**148.0**	**148.0**	**148.0**
	Mean	**0.1**	**1.1**	**5.1**	**2.4**	**2.5**	**3.2**	**0.2**	**0.0**
	Min	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	Max	**5.0**	**5.0**	**20.0**	**50.0**	**5.0**	**15.0**	**10.0**	**0.0**
Region 4	**N**	**175.0**	**175.0**	**175.0**	**175.0**	**175.0**	**175.0**	**175.0**	**175.0**
	Mean	**0.3**	**0.9**	**4.2**	**2.7**	**3.5**	**3.1**	**0.1**	**0.1**
	Min	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	Max	**10.0**	**5.0**	**10.0**	**10.0**	**10.0**	**5.0**	**15.0**	**10.0**

Table 4 provided the analysis of different biotic and environmental factors (animals, snail, insects, diseases, wind paddy, weeds, flood and drought) affecting paddy productivity on the field. The result indicates that, the mean loss from animals in Region 1 is 0.4%. This is higher than that of any other region. Similarly, the maximum recorded loss from animals are highest for Regions 2 and 4 which is 10%. Comparing the mean loss from snails showed that, Region 1 experienced the highest mean loss of 2.5%. While the overall maximum loss of 10% from snails was recorded in Region 2. In the case of insects, the highest mean loss of 8.5% was recorded from Region 2. While the maximum loss of 50% was also recorded in Region 2. Also, on the issue of disease attack, loses incurred showed the highest mean value of 2.7% in Region 4. While the maximum loss of 50% was recorded in Region 3. The case of wind paddy which represent the amount of empty rice seeds is another threat to productivity. The highest mean of the incidence of wind paddy was found to be 3.5% in Region 4. Also, the maximum of 30% loss from wind paddy was incurred in Region 2. Importantly again, weed attack was another issue among the paddy regions. Region 3 incurred a mean loss of 3.2% which is higher than the mean for other three regions. The maximum loss of 15% was attributed to weed occurred also in Region 3. These findings is supported by literature that emphasized significant productivity damage occur from biotic attacks in rice fields biotic (examples are, Asghar et al., 2013; Thongphak et al., 2012).

Environmental threats are a common occurrence, across the paddy fields especially with the advent of climate change. This demand management practices that ensures resilience and better productivity, especially, as there is variations in the nature and severity across region. Two major environmental factors (flood and drought) were highlighted as a threat across the paddy regions. The descriptive analysis of the impact indicates that Region 3 has the mean loss of 0.2% which is the highest compared to other regions. However, the maximum loss of 15% from flood was recorded in Region 4. The second environmental factor was the incidence of drought. Also, Region 4 have the highest mean and maximum loss of 0.1% respectively from flood is Region 4. Although, there were incidence of drought across, the low effect may be attributable to existing effective irrigation system at MADA. These findings is supported by literature that emphasized significant productivity damage occur from environmental stress (Duasa and Mohd-Radzman 2021;

Houma et al., 2021; Kaya-Altop et al., 2019; Cesari et al., 2017)

4.2 Comparison of Average Productivity of Paddy between CCS and NKEA

Figure 1 shows the distribution of paddy farmers across the MADA regions for CSS and NKEA. For the CCS, the distribution shows that, Region 2 has the highest percentage (33.43%) of the farmers, Region 4 is the second highest with 26.00%, Region 3 has 21.99% of the farmers in CSS then, Region 1 has about 18.57% of the farmers in CSS. While for NKEA, Region 4 has the highest percentage (30.37%) of farmers. This is followed by region 2 with 27.41% of the paddy farmers under in NKEA. Region 3 composed of 23.70% and Region 1 composed of 18.52% representing the third and fourth groups respectively.

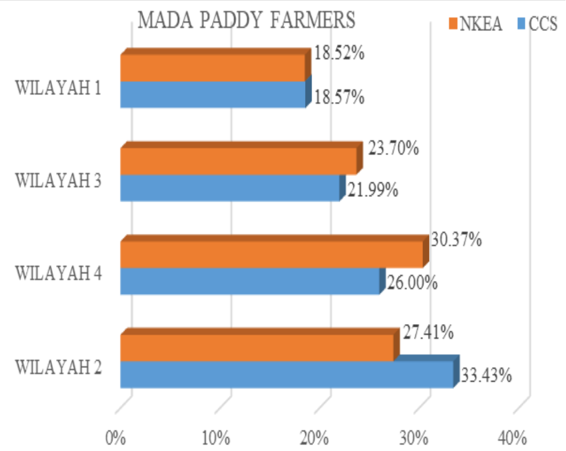

Figure 1: *Distribution of Paddy farmers across the MADA Regions for CSS and NKEA*

4.2.1 Comparison of Average Productivity of Paddy between CCS and NKEA

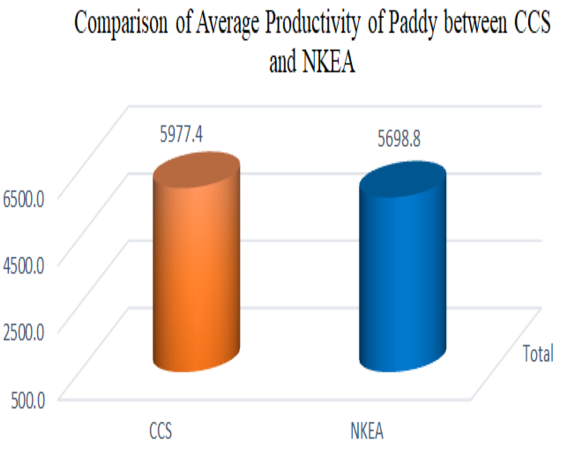

Figure 2: *Average Productivity of Paddy between CCS and NKEA*

In Figure 2, the result of the mean productivity between the two paddy groups showed that NKEA has a mean value of 5698.8kg/ha, this is slightly lower than the CCS which has a mean productivity of 5977.4kg/ha. This implies that, on average, the CCS paddy farmers outperformed the NKEA group. Thus a further assessment of how the productivity varies according to the four regions is presented in Figure 3.

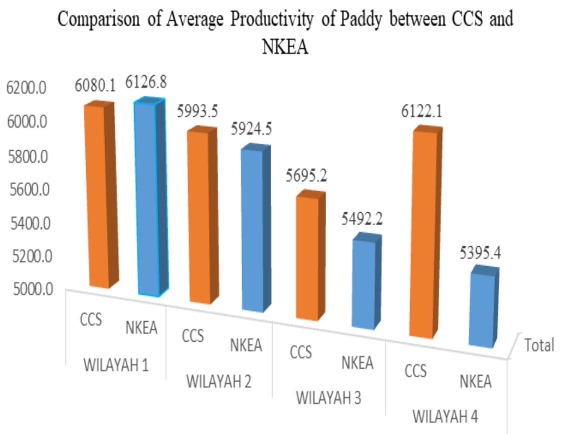

Figure 3: *Comparison of Average Productivity of Paddy between CCS and NKEA*

The productivity at Region 1 shows that NKEA project has a better mean productivity of 6126.8kg/ha compared to CCS group with 6080.1 kg/ha (see Figure 3). Whereas, in Region 2, the CCS group with 5993.5kg/ha was slightly higher than NKEA paddy project with a mean of 5924.5kg/ha. Similarly, at Region 3, the CCS with productivity of 5695.2 also outperformed the NKEA project with

5492.2kg/ha. This was also the case in Region 4 where the CCS with a productivity of 6122.1kg/ha outperformed the NKEA project with 5395.4kg/ha. Thus it can again be concluded that the CCS farmers have on average a better productivity compared to the NKEA. To comprehend the distribution of the productivity differences among the NKEA and CCS groups, a frequency distribution of the farmers are presented in Figure 4.

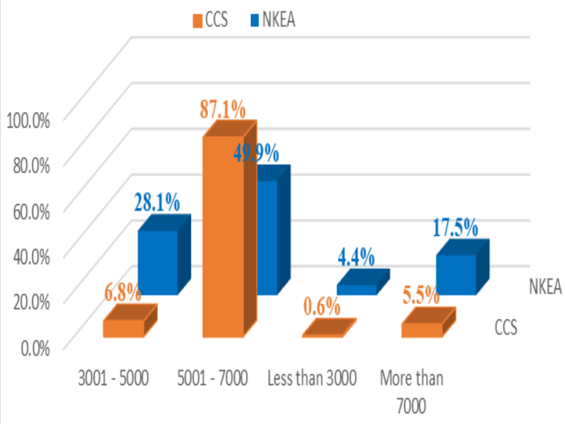

Figure 4: *Productivity distribution Between CCS and NKEA*

4.2.2 Productivity distribution between CCS and NKEA

Figure 4 shows the distribution of paddy productivity levels for CSS and NKEA. For the CCS, the distribution shows that, the highest percentage (87.1%%) of the farmers have productivity between 5001-7000. Similarly, for the NKEA group, the highest percentage (49.9%) of the farmers have productivity between 5001-7000. However, the second largest group of farmers, 6.8% and 28.1% for CCS and NKEA respectively. While 5.5% and 17.5% of farmers under the CCS and NKEA respectively have productivity more than 7000 kg/ha.

Table 5 *Regression Result*

Average Productiivty	Description	Coef.	Std.Error	t	P>|t|
Land Area	**Ha**	**-216.214**	**110.052**	**-1.960**	**0.050**
Seed Consumption	**Kg/ha**	**1.044**	**0.768**	**1.360**	**0.175**
Sebatian Fert	**Kg**	**-0.477**	**1.168**	**-0.410**	**0.683**
NPK fert 1	**Kg**	**-0.245**	**1.554**	**-0.160**	**0.875**
NKP fert 2	**Kg**	**0.014**	**1.381**	**0.010**	**0.992**
Compliance	**1=Complied, 0 =Not**	**346.910**	**134.227**	**2.580**	**0.010**
Occupation	**1= Paddy, 0=others**	**-390.880**	**127.890**	**-3.060**	**0.002**
Gender	**1= male, 0 = female**	**286.802**	**77.766**	**3.690**	**0.000**
Ethnicity	**1= Malay, 0 = Others**	**203.026**	**170.460**	**1.190**	**0.234**
Edu Status	**1 = degree, 0 = lower**	**115.859**	**40.194**	**2.880**	**0.004**
Drought	**1 = Yes, 0 = No**	**-315.809**	**802.222**	**-0.390**	**0.694**
Flood	**1 = Yes, 0 = No**	**266.174**	**287.355**	**0.930**	**0.355**
Farm Collapse	**1 = Yes, 0 = No**	**-28.325**	**68.643**	**-0.410**	**0.680**

Weeds	**1 = Yes, 0 = No**	**-56.765**	**63.494**	**-0.890**	**0.372**
Wind Paddy	**1 = Yes, 0 = No**	**-94.689**	**63.331**	**-1.500**	**0.135**
Diseases	**1 = Yes, 0 = No**	**-155.654**	**63.113**	**-2.470**	**0.014**
Insects	**1 = Yes, 0 = No**	**-53.907**	**49.680**	**-1.090**	**0.278**
Snails	**1 = Yes, 0 = No**	**-122.896**	**80.027**	**-1.540**	**0.125**
Animals	**1 = Yes, 0 = No**	**46.511**	**133.614**	**0.350**	**0.728**
Age	**1= Young, 0= old**	**-0.881**	**2.725**	**-0.320**	**0.747**
Constant		**6070.96**	**282.307**	**21.500**	**0.000**

The relationship between the level of input use, that Land Area, Seed Consumption, Sebatian Fert, NPK Fert 1 and NKP Fert 2, showed that only land area significantly affect rice productivity. However, compliance with standard management practices have been shown to have a positive significant effect on paddy productivity. Also, among the socio-demographic factors; education, primary occupation,gender, ethnicity, and education status are statistically significant. Education has a positively significant effect on paddy productivity, the non-paddy activities had better productivity, this could be due to the availability of extra income to purchase of adequate inputs and for timely application. Also the male gender has been shown to out-performed the female in terms of paddy productivity, this conforms to apriori expectation. While diseases also showed a negative and significant effect on rice productivity in MADA, this result aligns with Asghar et al., 2013; Thongphak et al., 2012; Kaya-Altop et al., 2019, as they emphasized the role of biotic factors as major productivity limiting constraints.

V. CONCLUSIONS AND RECOMMENDATIONS

The primary purpose of this study is to evaluate how the different socio-demographic classifications of the paddy farmers, their choice of paddy management practices, the biotic and environmental constraints encountered collectively influences the productivity and the implications on four MADA paddy production and the food security of Malaysia. Thus, based on the result of the data analysis, this section discusses succinctly the differences in socio-demographic, paddy management practices, the biotic and environmental factors with respect to CCS and NKEA project at MADA paddy regions. The discussion of the results is divided into two parts to achieve the study objectives. The first sub-section presents the socio-demographic profiles of the MADA paddy farmers. The second sub-section present a comparative analysis of paddy productivity between CCS and NKEA in MADA regions. The factors affecting productivity at MADA includes, land area, primary occupation of farmers, gender, educational status, management compliance, and diseases. In is vital to address these factors if the goal of improving productivity is to be achieved.

The advent of the issues of climate change have necessitated the adjustment in management practices to ensure sustainability and adaptation. Thus, the closure of productivity gaps may require adoption of alternative crop management options, especially with the current changes in biophysical environments necessary for plant growth. As climate change is associated with issues of increased environmental issues and more threat from biotic factors such as insect pests attack, prevalence of weed damage. There is need for the use of improved or resistant rice varieties, with more capital investment in infrastructures such as irrigation and machineries.

VI. ACKNOWLEDGEMENTS

This research was supported by Ministry of Higher Education (MoHE) of Malaysia through Fundamental Research Grant Scheme (FRGS/1/2019/WAB01/UUM/02/2). We also want to thank Research and Innovation Management Centre (RIMC) Universiti Utara Malaysia, Kedah for the administration of this study.

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