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IMPACT OF HIGH YIELDING VARIETIES ON PADDY PRODUCTION IN MUDA AGRICULTURAL DEVELOPMENT AUTHORITY AREAS, MALAYSIA

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By

ABIOLA OLAPEJU ADEDOYIN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

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DEDICATION

This thesis is especially dedicated to my husband, Mr. Adeyemi Adeshola Samuel and my lovely child. At all times, worst and best, they stood by me. I really appreciate my husband so much, though not all husbands are ready to fulfil their responsibilities but you are such a rare gem for sponsoring me. His affection, prayers and encouragement most especially when I felt I was left with nothing in this world are really commendable.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the Degree of Master of Science

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Worldwide, technological change in paddy production has given in an era of agricultural development and increased productivity performance. However, such performance appears to be unevenly distributed among farmers. Though, with new technologies introduced in Malaysia, development is premised on the recognition that low productivity is a major cause of the lack of advancement in the paddy sector. Hence, in order to ensure self-sufficiency in paddy production, the use of high-yielding varieties of paddy seed has been a strategic way for increasing paddy yields.

This study, therefore, investigated the impacts of high yielding varieties on paddy production in Muda Agricultural Development Authority, (MADA) Areas. Specifically, the study established whether the new high-yielding varieties have significant effects on paddy yield. The study also examined the magnitude of paddy production due to the shift from old to new HYVs of paddy seed. Furthermore, the study analyzed socio-economic factors influencing the adoption of new high yielding varieties as well as the optimum efficiency of resource used in paddy production.

The data were collected through a well-structured questionnaire. The study sampled 396 paddy farmers using multistage sampling technique. The independent samples t-tests, F-test, Cobb-Douglas production, Ordinary Least Square analysis technique and (binary) logit regression analysis were used to analyse the data. The estimated results of all the inputs used on per hectare had positive signs and conformed to a *prior* expectation. All the five inputs used, seed, fertilizer, labour, pesticides, and herbicides influence paddy yield in MADA, areas. The paddy farms were found to exhibit increasing return to scale. This shows that, the paddy farms have characteristics of stage one of production. It means that, if the farm increased all inputs by 1 per cent, production will give 1.07 per cent. This result obtained suggested that there is every possibility to increase paddy production by improving the use of those inputs.

The findings re-affirmed the claim that socio-economic factors such as education level, farming experience, gender, training and farm size were the factors influencing the adoption of new high yielding varieties in MADA, areas. Estimated results on the effect of high-yielding varieties indicated that the use of the new high yielding varieties had a positive significant effect on paddy yield at 1 per cent. The result revealed 42 per cent more on average paddy yield by giving 1.5 times more yield compared to old varieties. There exists an upward neutral shift in production function curve. More so, since the coefficient of dummy is positively significant with a much smaller standard error of 0.02, the intercept of new high-yielding varieties is known to be higher than the old varieties which signify a shift in production function.

Based on the estimated results on the optimum resource efficiency used in paddy production, it was revealed that all inputs employed, seed input, fertilizer application, pesticides, herbicide and labour inputs were under-utilized as their ratios were greater than unity. Therefore, maximum optimal resource achievement is possible by re-organizing input utilization allocation on paddy farms. The enhancement in the resource among the farmers is the work of the individual farmers, government and research institutions. It is therefore the responsibility of the extension agents to raise efficient and knowledge based paddy farmers through specific farm management training, which train the paddy farmers on the efficient use of available resources. This would help the farmers in allocating the inputs effectively. Extension agents in the study area as a whole also need to be improved on various ways used in disseminating new high yielding varieties to farmers. The strategies for paddy technology transfer to farmers should be specially packaged.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

IMPAK HASIL TINGGI KEPELBAGAIAN TERHADAP PENGELUARAN PADI DI KAWASAN MUDA AGRICULTURAL DEVELOPMENT AUTHORITY, MALAYSIA

Oleh

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Di seluruh dunia, perubahan teknologi dalam pengeluaran beras telah berlaku dalam era pembangunan pertanian dan prestasi produktiviti meningkat. Bagaimanapun, prestasi itu nampaknya tidak sekata dalam kalangan petani. Walaubagaimanapun, dengan teknologi baru diperkenalkan di Malaysia, pembangunan adalah berasaskan kepada pengiktirafan bahawa produktiviti yang rendah adalah punca utama kekurangan kemajuan dalam sektor padi. Oleh itu, dalam memastikan sara diri dalam pengeluaran beras, mencukupi penggunaan pelbagai jenis padi yang berhasil tinggi adalah kaedah strategik dalam meningkatkan pengeluaran padi. Oleh itu, kajian ini adalah untuk mengkaji kesan jenis hasil tinggi pada padi di kawasan Lembaga Kemajuan Pertanian Muda, kawasan. Khususnya, kajian ini ditubuhkan untuk mengetahui sama ada jenis yang berhasil tinggi baru mempunyai kesan yang besar ke atas hasil padi. La juga untuk mengkaji magnitud pengeluaran padi disebabkan oleh peralihan dari lama kepada HYVs baru benih padi. Tambahan pula, kajian ini menganalisis faktor sosio ekonomi yang mempengaruhi penggunaan jenis berhasil tinggi yang baru dan menganalisis sumber yang optimum digunakan dalam pengeluaran padi.

Data yang dikumpul adalah melalui soal selidik berstruktur. Kajian sampel adalah seramai 396 pesawah dengan menggunakan teknik persampelan berbilang. Sampel bebas Ujian-t, F-ujian, pengeluaran Cobb-Douglas, Square Ordinary Least analisis regresi dan (binari) logit telah digunakan untuk menganalisis data. Anggaran keputusan semua input yang digunakan pada setiap hektar mempunyai tanda-tanda positif dan serupa dengan jangkaan sebelumnya.

Kesemua lima input yang digunakan, benih, baja , buruh , racun perosak, dan racun herba mempengaruhi hasil padi di MADA, kawasan. Ladang padi didapati menunjukkan skala peningkatan pulangan. Hai ini menunjukkan bahawa , ladang padi

mempunyai ciri-ciri peringkat pertama pengeluaran. Hai ini bermakna jika ladang meningkat semua input dengan 1 peratus, pengeluaran akan memberikan 1.07 peratus. Keputusan yang diperolehi mencadangkan bahawa terdapat setiap kemungkinan untuk meningkatkan pengeluaran padi dengan meningkatkan penggunaan mereka input.

Hasil kajian mengesahkan bahawa faktor-faktor sosio -ekonomi seperti tahap pendidikan, pengalaman pertanian, jantina, latihan dan saiz ladang adalah faktor yang boleh mempengaruhi pelbagai berhasil tinggi baru di MADA, kawasan. Anggaran hasil terhadap kesan jenis berhasil tinggi menunjukkan bahawa penggunaan satu jenis variasi berhasil tinggi yang baru telah memberi kesan positif kepada hasil padi pada 1 peratus. Keputusan menunjukkan 42 peratus lebih pada hasil padi purata dengan lebih hasil 1.5 kali tua jenis. Terdapat peningkatan dalam fungsi pengeluaran. Oleh kerana, pekali dummy adalah positif dengan ralat yang lebih kecil piawai 0.02, dari memintas HYV adalah diketahui lebih tinggi daripada varisi tua yang menunjukkan perubahan dalam fungsi pengeluaran.

Berdasarkan keputusan anggaran yang dibuat kecekapan sumber optimun yang digunakan dalam pengeluaran padi, hal ini telah mendedahkan bahawa semua input seperti benih, baja, racun perosak, racun herba dan buruh adalah kurang digunakan kerana nisbah mereka adalah lebih besar daripada perpaduan. Oleh itu, pencapaian sumber optimum maksimum adalah mungkin dengan menganjurkan semula peruntukan penggunaan input di ladang padi. Peningkatan sumber dalam kalangan petani adalah tanggungjawab institusi petani kerajaan dan penyelidikan individu. Oleh itu, adalah menjadi tanggungjawab ejen pengembangan untuk meningkatkan kecekapan dan pengetahuan berasaskan padi petani melalui pendidikan pengurusan ladang tertentu, yang melatih petani menjadi cekap untuk menggunakan sumber yang ada. Ini akan membantu petani memperuntukkan input secara berkesan. Ejen pengembangan di kawasan kajian sebagai satu keperluan keseluruhan untuk menambah baik dan membantu menyebarkan baik hasil yang tinggi varieti kepada petani. Strategi-strategi bagi pemindahan teknologi padi kepada petani perlu disusun atur khas untuk mereka.

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LIST OF ABBREVIATIONS

CLRM	Classical Linear Regression Model
DID	Department of Irrigation and Drainage
DOA	Department of Agriculture
DEA	Data Envelopment Analysis
FAO	Food and Agricultural Organization
FAOSTAT	Food and Agricultural Organization Statistics
HYV	High Yielding Varieties
IADPs	Integrated Agricultural Development Projects
IPM	Integrated Pest Management
LV	Local Varieties
KADA	Kemubu Agricultural Development Authority
MADA	Muda Agricultural Development Authority
MARDI	Malaysian Agriculture Research and Development Institute
ML	Maximum Likelihood
MOA	Ministry of Agriculture and Agro Based Industry
OLS	Ordinary Least Square
RM	Ringgit Malaysia
SFA	Stochastic Frontier Analysis
SRI	System of Rice Intensification
SSL	Self Sufficiency Level
TE	Technical Efficiency
TFP	Total Factor Productivity
USDA	United State Department of Agriculture

CHAPTER 1

INTRODUCTION

Among the hierarchy of food crops in Malaysia, paddy is probably the most important and paddy self-sufficiency is a prerequisite for food security (Zainal, 2012). However, all attempt made to attain self-sufficiency in paddy production despite the use of new technologies and optimum input used still premised on the recognition that low productivity is the major cause of lack of advancement in the sector. This might be due to the fact that Malaysia paddy production is characterized by low yield per hectare, a multitude of small scale farmers of 2 hectares per farm land, weedy rice infestation, old working age factor in the field, low capitalization, poor technology adoption and excessive use of input. (Tawang *et al*, 2002; Angin, 2004; Wong *et al*., 2010; Zainal, 2012; Dos, 2013; Lira *et al*., 2014).

There was no significant advancement in yield as the mean yield is at 3.9 tons per hectare while the actual paddy farm yields varies from 3-5 tons per hectare below the neighbouring countries such as Vietnam and Indonesian at 5.5 tons per hectare and 4.9 tons per hectare respectively (Dos, 2013). The shifting from transplanting to direct seeding technology of planting of paddy have been reported to increased weedy paddy infestations resulting to crop loss per year at RM 180 million (Angin, 2004).

Even with the vital use of paddy crop in the country, the increase in paddy production threatened by farm size expansion is quite challenging. The overall number of paddy farm size is not more than 0.7millions hectares with average growth of about 0.27 per cent per year for the last two decades (Wong *et a*l., 2010). Majority of the paddy farmers' were cultivating on a small farm size ranging from 2.2 to 4 hectares (Normiyah *et al*, 1997). Presently, constraints of suitable soil fertility, competition with industrial, housing and domestic needs have been major factors threatening land expansion in Malaysia. Furthermore, paddy farm has been characterized to be inefficient as a result of old age factor working in the field. Majority of the farmers were above 60 years of age (Chan *et al*., 2012).

Excessive use of inputs such as chemical fertilizers and pesticides, above a given recommendations has caused a lot of problems in padding farming. This has caused soil degradation, water pollution and an increased number of pests, which are resistant to the application of pesticides. The level of financial constraint of farmer's in using sophisticated machinery that can help in boosting paddy yield is worsened. All these occurrences have negative effects that threaten the level of productivity, technology transfer process and cannot in any way guarantee self-sufficiency in paddy production. Thus, in order to correct those problems, this study was carried out to determine the impact of HYVs on paddy production, to examine the socio-economic factors influencing the adoption of new high yielding varieties and to analyze the optimum resource efficiency used in paddy production as raising paddy production has been identified as very crucial as reflected in the new Malaysian economic transformation programme.

1.1 Paddy Production in Malaysia

Malaysia is one of the highest 25 paddy producing countries in the world with annual production of 2.51 million metric tons (FAOSTAT, 2009). The annual consumption of paddy in the country was estimated to be 2.69 million tons which was only able to meet 68.5 per cent of production (Dos, 2013). The total population of 28.96 million Malaysian people were estimated in the country and only 296,000 were found to be total paddy growers (Zainal, 2012). The paddy industry in Malaysia has played an important role in agricultural diversification. Currently, paddy was position as the most essential food crop for ensuring the nation's food security. In Malaysian economy, the industries have improved the social-economic and political importance such as poverty eradication and ever since then farmer's livelihood have changed and are better-off.

Paddy is growned in eight granary areas of Peninsular Malaysia covering an area of 209,300 hectare (Azmi and Mashhor, 1995). The total area of paddy production as at year 2006 was about 645 hectare (USDA, 2008). The two main paddy producing areas in the country were Muda Agriculture Development Authority (MADA) and Kemubu Agriculture Development Authority (KADA). There are wet paddy areas having 85 per cent of the total paddy field and remaining 15 per cent were made up of hill paddy areas. Irrigated paddy field constituting of 321,696 hectare and out of these irrigated paddy fields were approximately 217,053 hectare to granary areas and 28,441 hectare was in non-granary areas which were divided as mini granary areas or secondary. The four main paddy areas in Malaysia are classified as irrigated, rain-fed, lowland and upland. Irrigated and lowland farming environments predominate in Peninsular Malaysia while rain-fed and upland farms are more common in Sabah and Sarawak.

1.1.1 Technology in Malaysia Paddy Production

The recent achievements in the 'green revolution' was the advancement of paddy farming technologies in Peninsular Malaysia as the country depends on 70 per cent local consumption while 30 per cent of paddy were been imported from neighbouring countries annually (Akinbile, 2001). The country in 1970's was comparatively progressed in paddy sector among the Southeast Asian countries through the introduction of modern technologies. Among the new technologies introduced in Malaysia paddy production were HYVs of seeds, irrigation systems, chemical fertilizers, improved agronomic practices, pesticides, herbicides, labour-saving technologies such as farm mechanization and capital-intensive technology that includes the use of tractors, ploughs, weeders, broadcaster, transplanter, row seeder, point seeder and combine harvester's over traditional way of paddy production. (Suswanto *et al.*, 2007Zainal, 2012; Chan *et al.*, 2012 and Raudah *et al.*, 2014)

Ever since then, agricultural sectors have turn into a better situation, though not sufficient for paddy production in the country. In 1970's, there were 131,700 hectares of paddy land in Peninsular Malaysia, which were improved through irrigation facilities, of which 110,563 were given in double-cropping areas. The government committed and execute the development projects both for water resources and infrastructures (irrigation and drainage) in a way to encourage paddy double cropping. Irrigation facilities were built in the paddy bowl areas in order to boost paddy production as its production largely depends on availability of water. The provision of adequate irrigation and drainage facilities in the eight granary areas had encourage paddy double cropping which enabled the achievement of a mean cropping intensity of more than 180 per cent in the areas. Paddy areas in Malaysia supplied with good irrigation and drainage system were located at;

1. Muda Agricultural Development Authority (MADA),
2. Kemubu Agricultural Development Authority (KADA), and
3. Integrated Agricultural Development Projects (IADPs) in six areas – Barat Laut (Selangor state), Seberang (Perak state), Pulau Pinang, Kerian-Sungai Manik, Kemasin-Semerak, and Trengganu Utara (KETARA).

More so, farm mechanization has gain popularity but not all farmers have full access to all these machines as a result of financial constraints. Basically, there is no domestic agricultural engineering industry. Malaysia relied mostly on imported agricultural machinery from Europe, especially Germany. The industry is confined to testing and adoption of imported machinery. Although, severals measure have been introduced by the government to motivate personal ownership of small and medium machinery. Such measures are tax exemption by enjoying 100 per cent on imported machineries, government grants to farmers' organization without interest and matching agents to assist farmers acquire small and medium farm machinery.

Table1.1. Machinery Ownership Status (2012)

No	Type of machinery	Government agency/PPT Units	%	Public Sector Units	%	Total Units
1	4 wheeled tractor	249	7.78	2951	92.22	3200
2	Combined harvester	92	7.31	1166	92.69	1258
3	2 Wheeled tractor	0	0	7000	100	7000

Source: Chan *et al*, 2012.

The use of farm chemicals has increased tremendously over the years. Pesticides as one of the green revolution have make pests becoming resistant to chemicals as farmer's used it above the recommended rate. The farmer's had to try different combinations of chemicals to curb the problem but still persisted. Though, the use of varieties of seed that are resistant to pest and diseases are now in use to reduce the infestations (Zainal, 2012). New fertilizers as one of the technology revolution, have been made available for the paddy farmer's in a subsidized rate. The subsidy was only giving to paddy farmer's with 10 hectares and below. All registered paddy farmer's were supplied with 240 kg ha^{-1} mixed fertilizer, 80 kg ha^{-1} for organic fertilizer and 75 kg ha^{-1} as well as RM 200/ha/ season subsidy for pesticides control and additional fertilizer at RM 140/ha /season (Vengedasalam *et al.*, 2011).

Table 1.2 Fertilizer Subsidy, Malaysia (2009)

Number	Incentives	Fertilizer type	Bag	Price (RM/bag)
1	Fertilizer subsidy scheme	Compound	12(20kg/bag)	RM29.97/bag
		Urea	4(20kg/bag)	RM25.75/bag
2	Food security incentives	NPK	3(25kg/bag)	RM89/bag

Source: Ministry of Agriculture and Agro-Based Industry (2009).

1.1.2 Development of Paddy Varieties in Malaysia

The termed 'Green Revolution' is known to be a technology transformation which has been based on high-yielding varieties in increasing cereals crop yields since 1960's (Dana, 1978). Though, fertilizer and irrigation helped raise cereals yields but their impact was fully revealed after the release of high-yielding varieties.

Majorly, the importance of introducing new paddy varieties in Malaysia is to improve the country's paddy production as the major staple food and to increase the level of productivity as land is becoming challenging. Introduction of high-yielding varieties is one of the steps initiated for agricultural development in Malaysia paddy production. HYVs breeding technology is considered as a revolutionary change from the age-old tradition to contemporary innovation in the practice of agriculture. Under the green revolution technology, HYVs are the major input of agricultural production. The introduction was in the late 1960s and has tripled Asian paddy production from 200 million tons in 1960 to more than 600 million tons in 2010 with the help of irrigation and subsidized inputs such as pesticides and fertilizer (Ricepedia, 2013). Its adoption level in Asia was only about 40 per cent total cereals area in 1980's and increased to about 80 per cent of the cropped area in year 2000 (Ricepedia, 2013).

The first high-yielding varieties named IRRI-8 was released in 1966 while other ten varieties were developed in 1975 (Dana, 1978; Ricepedia, 2013). Though, more generation varieties with high-yielding potentials and resistance to pest and diseases have been developed due to the fact that the seed variety produced are susceptible to pest and diseases. These varieties are characterized to have a shorter maturity days, good grain quality, higher yield potentials, resistance to pest and diseases, improve lodging resistance and tolerance to soil problems. It helps particularly to use the land for double cropping and multiple cropping resulting in high productivity and its land saves. The seeds are developed to get higher yielding and better quality yielding compared to the yield of traditional seeds. It is a type of seed that gives higher yield under irrigated conditions and the crop should be irrigated at the right time of schedule time. The use of high-yielding varieties of rice have reported to increase the average yield in last 25-50 years of irrigated rice from 2-3 to 5-6 ton per hectare and minimized crop period from about 140 days to 110 days (Bouman and Tuong, 2001).

Earlier in Malaysia, varieties under these categories are; IR 8, MR 71, MR 232, MR 219, and MR 220. Among these HYVs, only MR 219 and MR 220 has been the most common varieties planted by Malaysian paddy farmers' in more than 90 per cent granary areas (Suswanto et al., 2007; Raudah et al, 2014). It has been used by farmers for 12 years and has contributed significantly to increase production and food security requirements (MARDI, 2011). However, in recent time, the performance of both varieties decreased due to prevalence of weedy, pest and diseases infestations in the granary areas. To avoid the loss of farmers' MR 220CL1, MR 220CL2, MR 263 and MR 269 was launched as an alternative use to MR 219 and MR 220 because how can high yield be obtained when paddy seed is been faced with weedy, pest and diseases.

MR 220CL1 and MR 220CL2 was developed by Malaysia Agriculture Research and Development Institute (MARDI) to solve the problem of wild and weedy paddy infestations which approximately 10 per cent of granaries areas are facing. It is a breed of paddy that can withstand pest and diseases like weedy paddy. Both Varieties were developed by breeding local varieties, MR 220 and MR 219 with an American paddy variety. The other new varieties MR 263 and MR 269 were also released by MARDI with varieties that have a tolerant level of panicle blast, sheat blight, and moderate resistance level with Tungro, brownplant hopper and leaf blast. It is a variety against pest and diseases. The utilization of all these new varieties have not been widely used by all farmers, though used by some of the farmers' in granaries areas instead the old varieties MR 219 and MR 220 were still in vogue. Majorly, there are eight varieties of paddy growned in Malaysia, MR 220, MR 219, MR 263, MR 230, MR 185, MR 211, MR 220CL1 and MR 220CL2 with maturity days ranging between 105 and 120 days. In Peninsular Malaysia, thirty eight (38) paddy varieties with their yields have been recorded thus far by MARDI till date as listed in Table 1.3 and 1.4 below.

Table1.3. Lists of Released Paddy Seed Varieties in Malaysia (1974-2013)

Names	Year Released
S.MALAYSIA 1	1974
S.MALAYSIA 2	1974
P.MALAYSIA 1	1979
SETANJUNG	1979
SEKEN CANG	1979
SEKEM BANG	1981
KADARIA	1981
P.SIDING	1981
MANIK	1984
MUDA	1984
SEBERANG	1984
MAKMUR	1985
MR 84	1986
MR 81	1988
MR 103	1990
MR 106	1990
P.HITAM 9	1990
MR 123	1991
MR 127	1991
MR 159	1995
MR 167	1995
MR 185	1997
MR 211	1999
MRQ 50	1999
MR 219	2001
MR 220	2003
MRQ 74	2005
MR 232	2006
MR 220CL1	2010
MR 220CL2	2010
MR 253	2011
MR 263	2011
MRQ 76	2012
MR 269	2012
MRIA	2013

Source: Zainal (2012)

Potential yield of Malaysian paddy varieties is presented in the Table 1.4 below.

Table 1.4 Malaysian Paddy Seed Varieties (1973-2010)

Names	Yield (kg/hectare)	Year Released
JAYA	3500-5000	1973
MR1 (SETANJUNG)	4100-6000	1979
KADARIA	2900-5000	1981
MR 52(Manik)	4000-5000	1984
MR 71(MUDA)	5000-5500	1984
MR 77(SEBERANG)	5000-5500	1984
MR 73(MAKMUR)	5500-6500	1985
MR 84	4057-6235	1986
MR 81	4200-6000	1989
MR 106	4500-7100	1990
PH 9 (PULUT HITAM)	3800-4700	1990
MR 127	4831-7245	1991
MR 159	3500-5400	1995
MR 167	4000-6000	1995
MR 211	6000-9000	1999
MRQ 50	3500-4500	1999
MR 219	7000-10000	2001
MR 220	7000-10000	2003
MRQ 74 (MASWANGI)	4500-5500	2005
MR 232	7000-10000	2006
MR 220 CL1	5740-9140	2009
MR 220 CL2	5840-9740	2009
MR 253	5600-7000	2010
MR 263	5500-7000	2010

Source: Salmah, (2014)

1.2. Paddy Production in MADA

MADA (Muda Agricultural Development Authority) is an established area in Malaysia order to boost paddy production. It is located along the coastal plain in the northern states of Kedah and Perlis in the peninsular Malaysia (Loh, 2011). There are four regions in MADA, namely Kangar region, Jitra region, Pendang region and Kota Sarang Semut region with population size of 45,800 paddy farmer's in the regions.

The total area was estimated to be 126, 155 hectares with total paddy area of 96,558 hectares, of which 80.66 per cent is located in the State of Kedah and 19.34 per cent located in the state of Perlis and about 40 per cent of national paddy production is being produced from the area (MADA, 2010; MADA, 2012). There are 40,000 hectares of paddy area of non-irrigated areas located outside the Muda Agricultural

Development Authority (MADA) and the Integrated Agricultural Development Project (IADPs). Farmers, who own less than one hectare, cultivates paddy once in every season, with production of 3 tons per hectare (Fauzi, 2013). There were about 55,130 paddy farmers in the area with an average size of 2.2 hectares with the sole-ownership status of land or rent. About 47 per cent of the farm families are owner-operators, 25 per cent are tenants, 17 per cent are owner-tenants, and 9 per cent are others each managing a farm.

It is a drought prone area with major water supply from 4 major sources. The sources are from direct rainfall on paddy fields, dam release, uncontrolled river flow and recycled drainage water. Despites the good irrigation infrastructure facilities, nearly 52 per cent of the total water supplies for paddy production are still from rainfall. The reservoirs (and dams) provide about 30 per cent, followed by rivers (13 per cent) and recycled water (5 per cent). This actual annual water supply from rain, uncontrolled flow and dam release is reported to be between 2.9m and 4.1m high and equal to at least 3,000 million cubic meters for the entire area (Tawang & Ahmad, 2003).

The low income areas among the granary areas were estimated to be MADA in the country. The per capita income is only about two-thirds of that of the national income. As an agricultural area, most of the low income population groups are directly related with economic activities in the agricultural sector. The average income for farmers was of RM1, 806 monthly, of which RM1, 267 per month comes from paddy cultivation. The average monthly expenses were RM1, 575 per month indicating that the income for paddy cultivation was unable to cover farmer monthly expenses (Mohd, 2013).

Most of the paddy farmers work on rented paddy fields or leased from other owners. A total of 78 per cent work full time as paddy cultivators, with 56 per cent of farmers' have been in this field for more than 11 years. Almost all farmers' get subsidized fertilizer and pesticides from the government but not many farmers' receive assistance in terms of machinery (Fauzi, 2013).

MADA contributes more to national paddy production with an average yield of 5 tons per ha per season, higher than the national average of 3.74 (MADA, 2010). Table 1.5 shows the contribution of paddy in MADA to national paddy production as at year 2010.

Table 1.5 MADA Contributions to National Rice Production (2010)

Granary Area	Area (HA)	% Area	Contribution To National Production (Metric Tonne					
			2008	%	2009	%	2010[A]	%
MADA	**96,558**	**23.22**	**887,992**	**37.74**	**976,192**	**38.88**	**912,321**	**37.01**
KADA	32,167	7.74	179,048	7.61	209,950	8.36	201,135	8.16
IADAK.S MANIK	27,829	6.69	169,753	7.21	187,117	7.45	184,563	7.08
IADA BL S"GOR	18,814	4.52	174,247	7.41	202,633	8.07	210,292	8.53
IADA P.PINANG	10,305	2.48	98,436	4.18	107,285	4.27	115,189	4.67
IADASBG PERAK	8,529	2.05	62,076	2.64	70,294	2.80	70,814	2.84
IADA KETARA	5,156	1.24	46,097	1.96	49,082	1.95	52,711	2.14
IADA K.SEMERAK	5,220	1.26	14,757	0.63	16,853	0.67	20,550	0.83
TOTAL GRANAR	**204,578**	**49.20**	**1,632,406**	**69.38**	**1,819,206**	**72.46**	**1,757,575**	**71.31**
TOTAL NON-GRANARY	**211,213**	**50.80**	**720,626**	**30.63**	**691,637**	**27.54**	**707,256**	**28.69**

Source**:** Early Reports Paddy Production Survey Study off Season 2010 Issue of Secretariat National Survey of Rice Production, Department of Agriculture, Accountants. [A] Preliminary Data

Although it is the largest granary area, it lacks large industrial-scale growers, small-scale farmers' with average farm size of 2 hectares and most of the production is by traditional methods. Majority of the paddy farmers' in MADA were old with an average age of 60 years & above (MARDI, 1984; Normiyah & Chang, 1997).

Table 1.6 Farmers Age Pattern in MADA Areas (2012)

Age of Farmers	Percentage %
< 35	1.9
35.1- 45	7.3
45.1- 55	24.8
55.1- 65	38.2
>65	27.8
Total	100

Source: Chan *et al.* (2012)

Farmers attained low level of education as two-thirds of the paddy farmers had a primary education, 16 per cent are found to have completed their secondary school, 8 per cent attended religious school while 12 per cent were found not to have any basic education (Normiyah *et al*; 1995).

Methods of paddy planting in MADA have changed from transplanting to direct seeding methods due to the drudgery involved in transplanting. Absence of labour and increase wage rate makes the majority of paddy farmers' changed to direct seeding system. Direct seeding is a method of planting crops directly into soil and it's of three types namely direct wet seeding, direct dry seeding and direct seeding in water. The common traditional practice for paddy cultivation is wet direct seeding, though mechanized transplanting is fast gaining popularity. The three methods of direct seeding are:

1. Direct Wet Seeding

A method where by paddy straw stubble is cut, disperse, leave for 2-5 days to be dry and it must be totally burn in order to destroy the weedy paddy seed. This is usually done followed by the first dry rotation after 7-14 days of burning straws while the second wet rotation is done when the soil is overrun by water. After which, pretilachlor is applied to the stagnant water (height between 5-10 cm) and leave it for 10 days. Then, the paddy seed is scattered when the soil is flattened and in damp condition.

2 Direct Dry Seeding

Direct dry seeding normally uses less water as compared to wet direct seeding. Direct dry seeding uses 5-10 per cent less water, whereas seeding in standing water uses 10 per cent less water as compared to wet direct seeding. Direct dry seeding paddy is a type of planting methods that has the potential in reducing water and labour use compared with farmers conventional transplanting giving an average of 67-104m of saving irrigation water in direct seeding paddy compared with transplanted paddy (Tabbal et al., 2002). Mostly, dry soil rotation is done in the first paddy-planting season, which is usually done in dry way. After the dry rotation, the soil is flattened with cam tractor and sowing on the dry surface of the paddy field follows this. Another rotation is done to mix the seed with the soil.

3 Direct Seeding in Water

This type of method follows the same way of direct wet seeding but glisofat or glufosinat weedicide application is added to subdue weed growth especially weedy paddy after the first rotation. This is followed by the second rotation (wet rotation), after which pretilachlor poison is applied to stagnant water (5-10 cm) for 10 days. Sowing is done in water logging paddy field; this is to reduce the infestation of weedy paddy. Other than direct seeding, planting method could also be used. This traditional planting method by hand is no longer in use but the jentanam method. This method might increase the planting time and also determine the consistent paddy seed numbers that have been planted. In addition, this method would be able to facilitate the pest control and disease that occur in the paddy field. Direct seeding method can either be done through broadcasting conventionally or in a mechanized way. This method can be highly mechanized to reduce labour-intensive planting and then transplanting seedlings by hand. Although there are seedling transplanting machines available, they are very expensive and thus not that widely used in many countries. The machines are very labor efficient but are not feasible to buy for many farmers since the price is so expensive. Most farmers rent the machines from other farmers, but the cost of renting can still be expensive since the farmers must pay for transportation of the machine as well as the human labor for use.

1.3 Problem Statement

Following the phenomenal success of the green revolution technologies, which were first initiated in Mexico in the 1940s, Malaysian government introduced these new technologies for paddy cultivation in MADA with the aim of increasing production. However, this aim was not attained due to poor technological adoption. High yielding varieties of paddy seed have been in existence in Asia and in Malaysia, in particular, since 1966. These varieties have a resistance to pest and diseases, tolerance to soil problems and higher yield potential, which can add to the improvement of the farmers income, agricultural growth, and economic development of rural communities. Extension workers and individual farmers have a role to play in bringing change in adoption of new high yielding varieties technology. However, due to the old age of working factor of farmers in the field, low education attained by the paddy farmers, low exposure of farmers to specific training programmes, small farm size and inadequate of effective farmers leaders to facilitate the dissemination of agricultural information to the farmers hindered the adoption level of the new high yielding varieties in the study area.

The level of education acquired by a farmer to a large extend determines the farmer’s adoption level of new technology without stress. It’s is expected that farmer’s with high level of education will adopt new innovations on their farms and used it effectively to increase productivity, income and subsequently the profit obtain by the farmers. Nevertheless, paddy farmers in MADA attained low level of education as majority had primary education level while minority had proceeded to university. This makes it less easily for the paddy farmers to adopt the new high yielding varieties.

Outmigration of young farmers is a serious problem among paddy farmers in the study area. Presently, majority of the paddy farmers in the study area were above 70 years of age. Farmers were classified as less active and unproductive due to old age working factor in the field. This makes the farmers less prone to changes and reluctant to adopt the new high yielding varieties due to risk and uncertainty which hindered technology transfer process and threaten the productivity level.

Leaders form a link connecting farmer’s and extension agents. They disseminate educational information and try to modify farmers perspective. Leadership has significant role in agricultural extension, as it deals with educating groups of farmer’s in the community. Yet, leaders in MADA are running into a few trials. One such problem is in the adoption of new high yielding varieties. The proportion of paddy farmer’s that are exposed to paddy cultivation training were far below farmers that do not attend any training on paddy production as a result of the absence of training made available by agencies to leaders and the absence of expertise. Hence, they often fail to transfer what they learn about new high yielding varieties to other farmers because of poor communication between the leaders' and farmer's and these will not facilitates the adoption of the new high yielding varieties as more training programmes brings about high adoption of technology.

Production threatening by land expansion is really threatening. MADA is lacking large, industrial growers as majority were cultivating on farm size of 2 hectares. The overall number of paddy area is not more than 0.7millions hectares with average growth of about 0.27 per cent per year for the last two decades. Though, constraints of suitable soil fertility, competition with industrial, housing and domestic needs have been major factors threatening land expansion in the study area.

Moreover, the current level of actual farm paddy yield is considered far below the potential yield as well as attainable yield that should be achieved by the paddy farmers. There was no significant improvement in production despite the adoption of chemical fertilizers, irrigation system and improved agronomic practises. The average paddy yield is still at 3.9 tons per hectare while the actual paddy farm yields vary from 3-5 tons per hectare below that of neighbouring countries such as Vietnam and Indonesian at 5.5 and 4.9 tons per hectare respectively.

There are no regulated standard procedures on farm machinery shifting thereby causing spreading of paddy plant diseases and paddy weed as transfering of field machineries and equipment from one area to another without control and preventive measures resulted in spread of diseases. Moreso, shifting from transplanting to direct seeding technology of cultivating paddy due to the drudgery involved in paddy cultivation has caused a high prevalence of weedy paddy infestations resulting to crop loss per year at RM 180 million. Due to these problem, excessive use of inputs such as chemical fertilizers and pesticides, above a given recommendations were been used by the farmers' to curb the infestations. This has caused soil degradation, water and air pollution and has increased numbers of pest that are resistance to application of pesticides.

All these circumstances cannot in any way guarantee self-sufficiency in paddy production. Thus, to correct these problems, the use of HYVs of paddy seed have been a strategic way of increasing paddy production as raising paddy production has being identified as very crucial as reflected in the new Malaysian economic transformation programme.

1.4 Research Questions

The issues aforementioned in this study's problem statement warrant the following questions:

1. What are the socio-economic factors influencing the adoption of the new high yielding varieties of paddy seed?

2. Does a new high yielding variety have a significant impact on paddy yield?
3. Are resources optimally utilized in paddy production?

1.5 Objectives of the Study

The general objective of the study is to assess the impacts of high yielding varieties on paddy production in MADA. To achieve this, the specific objectives outlined for this study are;

1. To examine the socio-economic factors influencing the adoption of new high yielding varieties;
2. To determine the effect of new high-yielding varieties on paddy yield;
3. To analyse the optimum efficiency of resource used in paddy production.

1.6 Hypothesis

The following hypotheses are postulated for testing:

Ho: There is no significant effect of new HYVs on Paddy yield;
Ha: There is a significant effect of new HYVs on paddy yield.
Ho: There is no significance difference between the regression models;
Ha: There is significant difference between the two regression models.

1.7 Significance of the Study

Countries that have experience growth in agricultural productivity to a higher level used improved agricultural inputs. As Malaysia's paddy production pattern, which is currently faced with infestation of weedy, pests and diseases, smallholders and difficulties in land expansion, giving a threat to productivity level, the strategic way to boost paddy production is to focus on adoption of technology that can in turn increase paddy yield in order to meet self-sufficiency at 100 per cent in respective of shortage in land use. This paper aims to contribute in two ways; theoretically the study added to existing body of literature by providing a micro perspective on the effect of agricultural technology in increasing crop production. Practically, the study provides feedback in guiding government policy makers, researchers, extension agents and those involved in technology transfer to have a better understanding on how technology adoption help in increasing crop production.

1.8 Scope of the Study

The study was carried out in MADA (state of Kedah and Perlis). The research was limited to paddy-based farmer's in MADA, Malaysia. The choice of the study area for this research was due to the fact that the state of MADA has the largest paddy farming area among other state in Malaysia. It is an area where paddy-based crop is predominantly grown in Malaysia. The study was conducted within three years being the time frame for the research programme and relied on memory recalled data by the paddy farmers for its analysis.

19 Organization of the Thesis.

This thesis is arranged in five chapters. Chapter 1 discussed Malaysian paddy production, technology use for paddy production in MADA, and Malaysia. Research problem, objectives and the significant of the study is further discussed in the chapter.

Chapter 2 discussed the definitions, concept and measurement of technological change, related past studies to the research topic and methodological issues related to the study using paddy and other cereals crops for reviewing.

Chapter 3 focused on the conceptual frameworks, data collection, sampling techniques, basic model and analytical techniques used to estimate the objectives in the study.

Chapter 4 stated the results of the study, comprising of descriptive analysis to examine the socio-economic characteristics of paddy farmers in the study area, logit regression analysis to examine the socio-economic factors influencing adoption of HYVs, production function analysis for estimating the effect of new high yielding varieties on paddy yield as well as return to scale, upward shift in production function as a results of adopting new technology, optimum resource used in paddy production was also discussed.

Chapter 5 presents the concluding parts of the research study in line with the objectives and from the research findings. However, policy implication and recommendations are further discussed in the later chapter.

REFERENCES

Abdulai, A., & Huffman, W. (2000a). Structural Adjustment and Economic Efficiency of Rice Farmers' in Northern Ghana. Economic Development and Cultural Change, 504-519.

Abdulai, A., & Huffman, W. (2000b). Structural Adjustment and Economic Efficiency of Rice Farmers' in Northern Ghana. Economic Development and Cultural Change, 48(3):503-520.

Abel, Kwaku. K, Bruce, & Samuel, A., (2014). Improved Rice Variety Adoption and Its Effect on Farmers' Output in Ghana. Department of agriculture and Resource Economics, Faculty of Agribusiness and Communication Sciences, University of Communication Studies, Tamale Ghana. *Journal of Development and Agricultural Economics*, 6 (6), 242-248.

Abhilasha, Tiwari, .M.S. (2014). Compare the Yield of Wheat Varieties Provided under NAIP (National Agricultural Innovation Project) through IARI in Dhar district of Madhya Pradesh, India. *Indian Agricultural Research Institute*, 7(8), 37- 40. www.iosrjournals.org.

Adedeji, T. O. (2013). Adoption of New Rice for Africa (NERICA) Technology in Ogun State, Nigeria. *Journal of Development and Agricultural Economics,* 5(9), 365-371. http://www.academicjournals.org/JDAE.

Adegbola, P.Y., Arouna, A., Diagne A., & Souléïmane, A .A (2006). Assessing the Economic Impact of New NERICA Rice Varieties in Benin: Evidence with Models Based on the Approach against Factual. Paper presented at the first Africa Rice Congress, Salaam, Tanzania.

Adesina, A. A. and Seidi, S. (1995). Farmers' Prescription and Adoption of New Agricultural Technologies: Analysis of Modern Mangrove Rice Varieties in Guinea Bissau. *Quarterly Journal of International Agriculture*, 34, 358-385.

Aigner, D.J, Lovell, C.A.K, & Schmidt, P. (1977). Formulation and Estimation of Stochastic Frontier Production Function Models. *Journal of Econometrics*, 6, 21-37.

Ainembabazi, J. H., Bashaasha, B., Mugisha, J., Pender, J. & Hyuha, T. S. (2005). Technological Change in Sorghum Production in Eastern Uganda. African Crop Science Conference Proceedings, African Crop Science Society, Printed in Uganda 7, 947-954.

Alias, Bin Radam, & Ismail, Bin Latiff, (1996). Estimating Economic Efficiency in Paddy Farms: A Case of Northwest Selangor IADP. *Journal of Social Science. 4(1): 77-82.*

Akinbile, C.O, Abd El-Latif, .K.M, Rozi Abdullah & Yusoff, M.S. (2001). Rice Production and Water use Efficiency for Self-Sufficiency in Malaysia: *A Review Trends in Applied Sciences Research*, 6: 1127-1140.

Akinola, A. A. (1987). An Application of Tobit Analysis to the Adoption of Tractor Hiring Services Scheme in Nigeria. Oxford Agriculture Studies, 16, 70 - 82.

Amos, T.T. (2007). An Analysis of Productivity and Technical Efficiency of Small Holder Cocoa Farmers in Nigeria. *Journal of Social science* 15(2): 127-133.

Angelsen, A. A., Van Soest, D., Kaimowitz, D., Bulte, E. (2001). Technological change and deforestation: A theoretical review in Agricultural technologies and tropical deforestation in New York, NY: CABI Publishing, 19-34.

Angin, (2004): Manual Control Technology of Rice.

Anthony, Panin (1994). Empirical Evidence of Mechanization Effects on Smallholder Crop Production Systems in Botswana. Agricultural Systems Elsevier Science Limited Printed in Great Britain, 41, 99-210.

Anthony, Ojonimi Onoja, Nua Janet Deedam, & Anthonia Ifeyinwa Achike (2012). Profitability and Yield Determinants in Nigerian Cocoa Farms: Evidence from Ondo State. *Journal of Sustainable Development in Africa*, 14 (4), 1520-5509.

Aphiphan, Pookpakdi (1992). Sustainable Agriculture for Small-Scale Farmers: A Farming Systems Perspective. Department of Agronomy Faculty of Agriculture Kasetsart University, Bangkok, Thailand, 12-01.

Atala, S. (2002). Agricultural Business Today: Dependable Food and Agriculture News. 1(7): 16.

Audibert, Martine. (1997). Technical Inefficiency Effects among Paddy Farmers' in the Villages of the office Du Niger, Mali, and West Africa. *Journal of Productivity Analysis*, 8(4), 379-394.

Awoniyi, O. A., & Awoyinka, Y. A. (2007). Economic Analysis of the Impact of Improved Yam Variety on Farm Income of Farming Households in Guinea Savanna, Nigeria. African Crop Science Conference Proceedings, African Crop Science Society. Printed in El-Minia Egypt, 8, 1363-1368.

Azmi, M. & Mashhor, M. (1995). Weed Succession from Transplanting To Direct-Seeding Method in Kemubu Rice Area. Malay, *Journal. Biological-science*., 6: 143-154.

Badal, P. S. &. Singh, R. P. (2001). Technological Change in Maize Production: A Case Study of Bihar. *Indian J. Agri. Economics*., 56(2), 211-219.

Bartsch, William H. (1977). Employment and Technology Choices in Asian Agriculture. New York, London: Preager Publishers.

Basak, K.C., & Choudhary, B. K. (1957). Studies in the Economics of Farm Management in West Bengal. Reports for the year, Directorate of Economics and Statistics, Ministry of Food and Agriculture, New Delhi.

Basavaraja, H, Mahajanashetti, S. B & Sivanagaraju, P. (2008). Technological Change in Paddy Production: A Comparative Analysis of Traditional and SRI Methods of Cultivation. *Indian J. Agric. Econ*., 63(4), 629-640.

Berihun Kassa Hailu, Bihon, K. A, & Kibrom, A. W. (2014). Adoption and Impact of Agricultural Technologies on Farm Income: Evidence from Southern Tigray, Northern Ethiopia. *International Journal of Food and Agricultural Economics,* 2(4), 91-106.

Bingxin, Yu & Shenggen Fan, (2009). Rice Production Response in Cambodia Development Strategy and Governance Division International Food Policy Research Institute, 2033 K ST NW, Washington DC 20006 USA.

Bisaliah, S. (1977). Decomposition Analysis of Output Change under New Production of Technology in Wheat Farming: Some Implication to Returns on Investment. Indian *Journal of Agricultural Economics,* 32(4), 193-201.

Boserup, Ester. (1965). The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure. Chicago and George Allen and Unwin Ltd: Aldine Publishing Company.

Bouman, B.A.M & Tuong, T.P. (2001). Field Water Managements to Save and Increase its Productivity in Irrigated Low Land Rice. *Journal Agricultural Water Management*, 49:11-30.

Bourdillon, M, Hebinck P, Hoddinott J, Kinsey B, Marondo J, Mudege N & Owens T. (2002). Assessing the Impact of HYVs Maize in Resettlement Areas of Zimbabwe. Discussion Paper International Food Policy Research Institute, Washington, DC. 161.

Budiono, Sri Handoko Gillian Hart, Gustav F., & Papanek Ace Partadiredja, (1982). Technological Change, Productivity and Employment in Indonesian Agriculture. An Analysis of the Annual Agricultural Surveys of the Central Statistical Office with regard to Rice Agriculture, Particularly in Java/Bali.

Busari, A.O & Alabi, K. M. (2010). Measurement of Technological Change among Rice Farmers in the Derived Savanna Zone in Oyo State of Nigeria. *Journal of Agriculture & Social Sciences*, 7: 35-37. Http://Www.Fspublishers.Org

Capps, O. & Crammer, R. (1985). Analysis of Food Stamp Participation Using Qualitative Choice Model. American *Journal of Agricultural Economics*, 67, 49-59.

Cardenas, G., Vedenov, D, & Houston, J. (2002). Analysis of Production Efficiency of Mexican Coffee in Producing Districts. Department of Agricultural and Applied Economics, University of Georgia, USA.

Chan, C .S, Mohd Zainal, .I. & Abu Hassan, D. (2012). Agricultural Machinery and Mechanization Situation in Malaysia. Naresuan University, Thailand.

Coelli, J. F. & Battese, G. E. (1996). Model for Technical Inefficiency Effect in a Stochastic Frontier Production Function and the Efficiencies of India Farm

Using Panel Data from Krizatis Village Level Studies. *Journal of Quantitative Economics*, 5, 185-208.

Coelli, T.J., Rao, D.S.P., Donnell C.J., & Battese, G.E. (2005). An Introduction to Efficiency and Productivity Analysis. Springer Science and Business Media, New York.

Dana, .G. Dalrymple. (1978). Development and Spread of High Yielding Varieties of Wheat and Rice in the Less Developed Nations. Foreign Agricultural Economic Report, 95.

Dauda, Solomon Musa (2012). Mechanization Effect on Farm Practices in Kwara State, North Central Nigeria. *IOSR Journal of Engineering* (IOSRJEN), 2, (10), 79-84. www.iosrjen.org

David Boansi (2014).Yield Response of Rice in Nigeria: A Co-Integration Analysis. *American Journal of Agriculture and Forestry*, 2(2), 15-24.

David Terfa Akighir & Terwase Shabu, (2011). Efficiency of Resource use in Rice Farming Enterprise in Kwande Local Government Area of Benue State, Nigeria. International *Journal of Humanities and Social Science*,1(3). www.ijhssnet.com

Debashis, Sarkar & Jiban Kumar Ghosh, (2013). Spread of New Varieties of Hybrid Rice and their Impact on the Overall Production and Productivity in West Bengal. AER, Visva -Bharati University, 176.

De Groote, H., G. Owuor, C. Doss, J. Ouma, L. Muhammad, K. & Danda (2005). The Maize Green Revolution in Kenya, *E-Jounal of Agricultural and Development Economics*, 2(1): 32-49.

De Koeijer, T.J., Wossink, G.A.A., Struik, P. C & Renkema, J.A. (2002). Measuring Agricultural Sustainability in Terms of Efficiency: The Case of Dutch Sugar Beet Growers. *Journal of Environmental Management*, 66:9-17.

Department of Agriculture Malaysia, (2013). Statistics on Paddy Productions.

Diagne, A. (2006): Diffusion and Adoption of NERICA Rice Varieties in Cote d'Ivoire. The Development Economics, 44(2):208-231.

Dibba, L, A. Diagne, F. Simtowe, Sogbossi .M. J & Mendy .M (2008a). Diffusion and Adoption of NERICA in Gambia, Mimeo, WARDA.

Dibba, L, A. Diagne, F. Simtowe, M .J. Sogbossi & Mendy. M (2008b). The Impacts of NERICA Adoption on Yield in Gambia, Mimeo, WARDA.

Dixon, J., b Gulliver, A., & Gibbon, D. (2001). Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World. Rome, Italy.

DOS, (2013). Department of Statistics Malaysia, 99-102.http://www.statictics.gov.my/portal/download_economics/files/DATA_SE

RIES/2011/pdf/08pad.pdf.

Easter, K.W., (1977). Improving Village Irrigation Systems: An Example from India. Land Econ., 53: 56-66.

Edward Tsinigo (2014). Economics of Technological Change in Rice Production in the Ejura-Sekyedumase and Atebubu-Amantin Districts, Ghana. M.Sc., Philosophy in Agricultural Economics Faculty of Agriculture College of Agriculture and Renewable Natural Resources.

Ellis, Frank. (1993). Peasant Economics: Farm Households and Agrarian Development. Cambridge: Cambridge University Press.

Elodie Blanc Aurelia Lepine Eric Strobl (2014). Determinants of Crop Yield and Profit of Family Farms: Evidence from the Senegal River Valley, Working Paper, 596.

FAOSTAT, (2012a). FAOSTAT Online Statistics Service, Food and Agriculture Organization of the United Nation (FAO), Rome, Italy.

Food and Agriculture Organization, (2012b). FAO Rice Price. Retrieved on 12 February from http: www.fao.Org/.../rice-publication/the-fao-rice-price-update/en

Färe, Rolf .Grosskopf, Shawna, Norris, Mary, & Zhang, Zhongyang, (1994). Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries. *The American Economic Review*, 66-83.

Farrell, M.J. (1957). The Measurements of Productive Efficiency. Journal of statistics society, 120, (3), 253-290.

Fasoranti Olayiwola Olujenyo (2008). The Determinants of Agricultural Production and Profitability in Akoko Land, Ondo-State, Nigeria. *Journal of Social Sciences* 4 (1): 37-41.

Fauzi Hussin A.B. Wahab (2013). Socio-Economic Level of Paddy Farmers' under the Management of MADA: A Case Study in the Pendang District, Kedah, Journal of Governance and Development, 9, 79-92.

Feder, Gershon, Dina .L. & Umali (1993). Adoption of Agricultural Innovations in Developing Countries: A Survey. Technological Forecasting and Social Change, 43:215-239.

Food and Agriculture Organization, (2009). FAOSTAT Database, FAO, Rome, Itally.www.faostat.fao.org (accessed June 2010).

Gafsi S. (1976). Green Revolution: The Tunisian Experiment- Abriged by CIMMYT, Centro International Dc Mejoramiento de maiz Y Trigo, Mexico City.

Gajja, B.L, Khem Chand, Bhagwan Singh, R.S. Mertia & Shalander Kumar (2014). Impact Assessment of New Pearl Millet Technology in Arid Rajasthan.

Agricultural Economics Research Review, 27 (1), 133-137.

Godoy, Ricardo, Jeffrey R. Franks & Mario, Alvarado Claudio, (1998). Adoption of Modern Agricultural Technologies by Lowland Indigenous Groups in Bolivia: The Role of Households, Villages, Ethnicity, and Markets. Human Ecology 26(3):351-69.

Green, W.H (1980a). On Estimation of a Flexible Frontier Production Model, *Journal of Econometrics.* 13:101-116.

Green, W. H, (1980b). LIMDEPversion7.0. Econosoft: New York.

Gujarati, D.N., (1995). Basic Econometrics, Third Edition. McGraw-Hill, Singapore.

Gujarati, D. N. (2004). Basic Econometrics: fourth edition. Tata McGraw-Hill Publishing Company Limited. New Delhi, India, 580-625.

Gundu, Rao, Bisalaiah D.S., S. & Krishnaswamy H.S. (1985). Technical Change and Efficiency Gain in Dry land Agriculture: An Econometric Study, Margin, NCAER, 37-38.

Haneishi, Y., Maruyama, A., Asea, G., Okello, S. E., Tsuboi, T., Takagaki, M., & Kikuchi. M. (2011b). Exploration of Rainfed Rice Farming In Uganda Based On A Nationwide Survey: Regionality, Varieties and Yield. An internal report of NaCRRI-JICA NERICA Project Namulonge, Uganda.

Harrod, R. (1961): The Neutrality of Improvements, *Journals of Economics*, 71:300-04.

Hassan, Ishtiaq & Khuda Bakhsh,. (2005). Impact Assessment of Zero-Tillage Technology in Rice-Wheat System Pakistani Punjab. Electronic *Journal of Environmental*, *Agriculture and Food Chemistry*, 4(6) 1132-1137.

Hayami, Y. & Ruttan, V.W. (1971). Agricultural Development; an International Perspectives. The Johns Hopkins Press, Baltimore.

Hicks, J. R. (1932). The Theory of Wages: McMillan and Company Ltd., London.

Huang, M.Y., & Huang, C. J (2002). Cultivation Arrangements and Cost Efficiency of Rice Farming in Taiwan. *Journals of Productivity Analysis*, 18, 223-239.

Hughes, A. (2201). Guide to Economic Performance Measurement for General Government Sector Agencies, Office of Financial Management of the New South Wales Treasury.

Hussain, I. & Perera, I. R. (2004). Improving Agricultural Productivity through Integrated Service Provision with Public and Private-Sector Partnership in Columbia Sri Lanka. International Water Management Institute Working Paper, 66.Jay, Atkinson .J, David .E. & Kunkel (1976). High-Yielding Varieties of Rice in the Philippines (Progress of the Seed-Fertilizer Revolution). *Economic Research Service U.S. Department of Agriculture (C) Washington, D.C. 20250.*

Idumah, .F. O, Owombo, P. T., & Ighodaro.U.B. (2014). Economics of Yam Production under Agroforestry System in Sapoba Forest Area, Edo State, Nigeria. *International Journal of Agriculture and Forestry*, 4(6): 440-445.

Iqbal Muhammad, Arsheed Bashir & Umar, Farooq, (1999). Factors Affecting the Adoption of Hybrid Maize Varieties in the Irrigated Punjab. International *Journal of Agricultural Biology*, 1(3).

Jay, Atkinson .J, David .E. & Kunkel (1976). High-Yielding Varieties of Rice in Philippines. Economics Research Service, Department of Agriculture U.S. Washington, D.C.

Johnny, Mugisha & Gracious Diiro. (2010). Explaining the Adoption of Improved Maize Varieties and its Effects on Yields among Smallholder Maize Farmers in Eastern and Central Uganda. *Middle-East Journal of Scientific Research,* 5 (1): 06-13.

Johl, .S, (1970). Grains of the Green Revolution: how they have been shred in Punjab. *Journal of Development Studies*, 11(3): 178-189.

Jonathan, Reuben & Anthony Danlami Barau, (2012). Resource Use Efficiency in Yam Production in Taraba State, Nigeria. *Journal of Agricultural Science,* 3(2): 71-77.

Joyotee, Smith & Gascon, F.E. (1979). The Effect of New Rice Technology on Family Labor Utilization in Laguna. IRRI, Research Paper Series, 42.

Kadiri, F. A. Eze .C. C; Orebiyi .J.S; & Onyeagocha .S.U.O. (2014). Resource-Use and Allocative Efficiency of Paddy Rice Production in Niger Delta Region of Nigeria. *Global Journal of Agricultural Research*, 2,(4):11-18. www.eajournals.org.

Kallika, Taraka, Ismail Abdul Latif & Mad Nasir Shamsudin. (2010). A Non-Parametric Approach to Evaluate Technical Efficiency of Rice Farms in Central Thailand. *Chulalongkorn Journal of Economics*, 22: 1-14.

Karki, B.B. (1981). The Impacts of Modern Varieties of Rice on Farm Income and Income Distribution in Eastern Nepal. Project on Training Nepalese in Agricultural Research and Development Planning, Research Paper Series, 12.

Ketut, .I. & Kariyasa. (2014). Economic Impact Assessment of Integrated Crop Management Farmer Field School Programs on Corn Production in Indonesia. *International Journal of Food and Agricultural Economics*, 2 (4):13-26.

Key, N. & Mcbride, W. (2003). Production Contract and Productivity in the US Hog Sector. *American Journal of Agricultural Economics,* (85), 121-133.

Khanna, G. (2006). Technical Efficiency in Production and Resources use in Sugarcane. A Stochastic Production Function Analysis. Graduate Institute of International Studies HEI Working Paper No: 15.

Kisho Miyamoto (2012): NERICA Cultivation and its Yield Determinants: The Case of Upland Rice Farmers in Namulonge, Central Uganda. *Journal of Agricultural Science*; 4,(6).

Kumbhakar, S.C (1997). Modelling Allocative Inefficiency in a Translog Cost Functions and Cost Share Equations an Exact Relationship. .*Journal of Econometrics*, 76: 351-356.

Kumbhakar, S.C., & Lovell, C. A. K. (2002). Stochastic Frontier Analysis, Cambridge University Press.

Kumar, Singh, W. (1999). An Attempt to Evaluate the Effect of Change in Rice Production Technology in Manipur. *Indian J. of Agril. Econ*., 54(2): 220-227.

Kunnal, L. B., Gaddi .G. M, Olekar, .J. N, Dabali .S .D & Shreepad .P.V. (2002). Impact of New Technology in Bengal Gram Production in Karnataka', *Indian journal of agricultural Economics*, 57(2): 247-250.

Kurkalova, L.A., & Jensen, H. H. (1998). Technical Efficiency of Grain Production in Ukraine. Paper Presented at the American Agricultural Economics Association, Salt Lake City, Utah.

Lira Mailena, Mad, Nasir. Shamsudin, Alias, Radam & Ismail Latif, (2014). Rice Farms Efficiency and Factors Affecting the Efficiency in MADA, Malaysia. *Journal of Applied Sciences*, 14: 2177-2182.

Lira. Mailena Shamsudin, M. N., Radam, A., & Mohamed, Z. (2014). Optimality of Input Used, Input Demand and Supply Response of Rice Production: Experience in MADA, Malaysia. *Journal of Economics and Sustainable Development*, 4, (18).

Loh, Kim Mon (2011). Water and Land Productivity in Paddy Cultivation: Concepts, Indices, Targets and Challenges in Iran. International Congress on Irrigation and Drainage, 15-23.

MADA. (2010). How much MADA Contributes in the Total Domestic Rice Production. http://www.mada.gov.my/web/guest/soalanlazim

Mahmudul, Alam M. D, Chamhuri Siwar, & Wahid Murad. (2010). Socioeconomic Profile of Farmer in Malaysia: Study on Integrated Agricultural Development Area in North-West Selangor, Agricultural Economics and Rural Development, New Series, 7(2): 249-265.

Malaysia Department of Statistics, (2011). Malaysia economics statistics-2011 series: Paddy.http://www.statistics.gov.my/portal/download_Economics/files/DATA_SERIES/2011/pdf/08Padi.pdf

MARDI. (1984). Practical Guide Requirements and Recommendations For Direct Seeding of Rice and Paddy Change, Serdang, Malaysia, 21.

MARDI. (2011). Malaysian Agricultural Research and Development Institute

(MARDI), Malaysia. 1432H | 2011G.

Mattigatti, R.M., Geetha Devi .R .J & Datta .R.K (2002). Technological Change in the Management of Small Scale to Large Scale Irrigated Sericulture Farming, Advances in Indian Sericultural Research. Proceedings of the National Conference on Strategies for Research and Development, 476-479.

Mathur, S.C., & Balishter. (1973). Impact of HYVs of Crops on Farm Labour Use - A Case Study of Wheat and Paddy Cultivation in Barava Village in Agra District. *Man power Journal*, 8(4): 18-38.

Maurice, D.C, & Amaza, P. (2005). Identification of Factors that Influence Technical Efficiency in Rice-Based Production System in Nigeria: Paper Presented At Workshop on Policies And Strategies For Promoting Rice Production and Food Security in Sub-Saharan Africa.

Mbugua, Felistus (2009). An Analysis of Factors Influencing Adoption of The Recommended Maize Technology's Package. Published M.Sc. Thesis. School of Humanities and Social Sciences, Kenya.

Meeusen, W., & Broeck, J.V.D. (1977). Efficiency Estimation from Cobb-Douglas Production Function with Composed Error. *International Economic Review*, 5: 257-264.

Ministry of Agriculture & Agro-Based Industry (2009). Lists, Subsidies and Incentives Industry Padi and Rice Year. [Online.] Accessed http://www.moa.gov.my/web/guest/insentif_padi_n_beras on 22 September 2010.

Ministry of Agriculture and Agro-Based Industry, various issues, Agric Statistics Handbook, Putrajaya, (1980-2007).

Mohan. P. H. (2009). Impact of IPM Technology on Cotton and Paddy Production in Haveri District. An Economic Analysis, University of Agricultural Sciences, Dharwad.

Mohd Rashid Rabu (2013). Food and livelihood Security of the Malaysian Paddy farmers. Economic and technology Management Review, 8:59-69.

Mohd, Mansor. Ismail, Nurjihan Idris & Behrooz Hassanpour (2013). Technical Efficiency Estimates of Paddy Farming In Peninsular Malaysia: A Comparative Analysis. Scholars Research Library Annals of Biological Research, 4 (5):114-11.

Morris, M.L., Tripp .R. & Dankyi .A. A. (1999). Adoption and Impacts of Improved Maize Production Technology: A Case Study of the Ghana Grains Development Project, Economics Program Paper, 99-01.

Muhkerjee, C., White, H. & Wuyts .M. (1998). Econometrics and Data Analysis for Developing Countries. London, Routledge.

Mustafa .k. & Mujari. (1991). Impacts of High Yielding Varieties Technology on Rice Production Variability and Yield in Bangladesh. *The Pakistan Development Review,* 30(1):63-81.

Muthamia, J.G.N, Musembi F, Maina J.M, Okuro J.O, & Amboga .S. (2001). Participatory On-Farm Trials on Weed Control in Smallholder Farms in Maize-Based Cropping Systems. Proceedings of Seventh Eastern and South Africa Regional Maize Conference, 468-473.

Maikasuwa M., A., & Ala, A.L, (2013). Determination of Profitability and Resource-Use Efficiency of Yam Production by Women in Bosso Local Government Area of Niger State, Nigeria. E*uropean Scientific Journal,* 9(16).

Maikasuwa M., A., Ala, A.L, Baba M.D. (2014). Inputs Acquisition and Utilization by Turkey Producers in Zuru Emirate Kebbi State, Nigeria. *International Journal of Modern Research and Reviews,* 2 (7): 235-240.

Nair, K.N.S (1980).Technological Changes in Agriculture: Impact on Productivity and Employment. Birla Institute of Scientific Economic Research Division, Vision Books.

Nandi, J. A., Haruna, S. K. & Abudu, S. (2012). Analysis of Socio-Economic Factors Influencing Farmers' Adoption of Rice Varieties with High Yielding And Weed Suppressing Abilities In Kano River Irrigation Project (Krip). *Journal of Agriculture, Forestry and the Social Sciences* (JOAFSS), 10(1).

Ndaghu, Ndonkeu Nathanel, Zakari Abdulsalam, Shehu Abdul Rahman, & Tahirou Abdoulaye, (2015). Socio-Economic Factors Affecting Adoption Of Early Maturing Maize Varieties By Small Scale Farmers in Safana Local Government Area of Katsina State, Nigeria. *Journal of Development and Agricultural Economic*s, 7(8): 273-281.

Narayani Shrivastava (1988). Sustainability through Technological Change in Agriculture with Special Reference to Chhattigarh, India. narayanijohny@rediffmail.com.

Nimoh, .F, Tham-Agyekum, E. K & Nyarko, P.K. (2012). Resource Use Efficiency in Rice Production: The Case of Kpong Irrigation Project in the Dangume West District of Ghana. *International of Journal Agriculture and Forestry,* 2(1): 35-40.

Normiyah, R, Chang, P. M, Azmi, M, & Aznan, A. (1995). Pests Management Practices of Rice Farmers in the Muda Irrigation Scheme, Malaysia.

Normiyah, .R, & Chang, P.M. (1997). Pests Management Practices of Rice Farmers in the Muda and Kemubu Irrigation Schemes in Peninsular Malaysia. Pest Management of Rice Farmers in Asia, 115-127.

Norgaard, R. & Howarth, R. (1991). Sustainability and Discounting the Future in Costanza, Ecological Economics: The Science and Management of Sustainability, New York: Columbia University Press, 88–101.

OECD, (2001). Measuring Productivity: Measurement of Aggregate and Industry Level. OECD Manual. Available at: www.sourceOECD.org

Ojiako, I. A., Manyong, U. M. & Ikpi, A. E. (2007). Determinants of Rural Farmers' Improved Soybean Adoption Decisions in Northern Nigeria. *Journal of Food, Agriculture and Environment.* Vol. 5, No. 2 Pp. 215- 223. www.world-food.net

Okoye, B. C., Onyenweaku C.E, Ukoha O.O, Asumugha .O.C & Aniedu.(2008). Determinants of Labour Productivity on Small-holder Cocoyam Farms in Anambra State, Nigeria. *Academic Journal of Science,* 3: 559-561.

Okunade, E. O. (2006). Factor Influencing Adoption of Improved Farm Practices among Women Farmers in Osun State, Nigeria. *Journal of Human Ecology,* 19(1): 45-49.

Oladele, O. I. & Fawole, O. P., (2007). Farmers' Perception of the Relevance of Agricultural Technologies in South-Western, Nigeria. *Journal of Human Ecology,* 21(3):191-194.

Oladeebo, J.O & Fajuyigbe, A .A (2007). Technical Efficiency of Men and Women Upland Rice Farmers in Osun State Nigeria. *Journal of Human Ecology,* 22(2): 93-100.

Olarinde, L.O. & Ajetomobi, J.O. (2000). Economic Efficiency of Homestead Fish Farmers in Ejigbo, Area of Osun-State. Nigerian Agricultural Development Studies, 1 (2): 20-26.

Olayide, S.O. (1980). Nigeria Small Farmers' Problems and Process in Integrated Rural Development; Center for Agriculture and Rural Development (CARD) University Ibadan, Nigeria, 20-22.

Olayide, S. O. & Heady, E. O. (1982). Introduction to Agricultural Production Economics. Ibadan University Press Publishing House, University of Ibadan, Nigeria, 319.

Olukosi, M. & Ogungbile .P. (1998a). Efficiency of Resource use in Tomato Enterprise in Tarka Local Government Area, Benue state, Nigeria. *Journal of economic and social research,* 3(1): 1-12.

Olukosi, J.O. & Ogungbile A.O, (1989b). Introduction to Agricultural Production Economics; Principles and Applications. Zaria, Agitab Publishers Limited.

Olusegun Ayodeji Fadare, Dare Akerele & Begho Toritseju (2010). Factors Influencing Adoption Decisions Of Maize Farmers In Nigeria. *International Journal of Food and Agricultural Economics,* 2(3): 45-54.

Oniah M.O, Kuye O.O & Idiong .I.C (2008). Efficiency of Resource use in Small Scale Swamp Rice Production in Obubra Local Government Area of Cross River State, Nigeria. *Middle-East Journal of Scientific Research,* 3 (3): 145-148.

Onyenweaku, C.E. (1994). Economics of Irrigation in Crop Production in Nigeria. African Social Science Research Networks Issues in African Rural Development, Winrock. International Institute for Agricultural Development, 129 138.

Onyenweaku, C. E. & Effiong, E.O. (2005). Technical Efficiency on Pig Production in Akwa Ibom State, Nigeria. Nigeria *International Journal of Agric Rural Development*, 6:51-57.

Onuk, E.G.1., Ogara I. M. 1, Yahaya H1 & Nannim .N. (2010). Economic Analysis of Maize Production in Mangu Local Government Area of Plateau State, Nigeria. Publication of Nasarawa State University, Keffi. www.patnsukjournal.net/currentissue/

Owombo P.T, Akinola A.A, Ayodele O.O, Koledoye G.F (2012). Economic Impact of Agricultural Mechanization Adoption: Evidence from Maize Farmers in Ondo State, Nigeria. *Journal of Agriculture and Biodiversity Research*, 1(2): 25-32.

Parashar, Bhakta Malla. (1982). Economics of rice farming in Nepal: Production and Technology Adoption, Department of Resource Economics and Agribusiness.

Parikh, & Shah, (1994). Stochastic Frontier and Technical Efficiency of Farms Irrigated Areas of Pakistan's Punjab. *Pakistan Institute of Development Economics Journal*, 37: 275-291.

Peng, C.Y. J., Lee, K. L. & Ingersoll, G. M. (2002). An Introduction to Logistic Regression Analysis and Reporting. *The Journal of Educational Research*, 96(1):3-15.

Prasad, V. (1973). Resource use Efficiency and Level of Production in Multiple Cropping in Farrukhabad District in U.P. An unpublished Ph.D. Thesis, C.S. Azad University, Manpet.

Rabu, Mohd Rashid, & Shah, Mohd Dainuri Mohd. (2013). Food and Livelihood Security of the Malaysian Paddy Farmers'.

Rafael, N. & Uaiene (2004). Maize and Sorghum Technologies and the Effects of Marketing Strategies on Farmers' Income in Mozambique.

Rahman, K.M.M. (2002). Measuring Efficiency of Producing Rice in Bangladesh: A Stochastic Frontier Analysis. Wissenschaftsverlag Vauk Kiel KG.

Rahman, S. (2007). Adoption of Improved Technologies by Farmers' of Aizawl District of Mizoram, India. Livestock Research for Rural Development.19 (5).http://www.cipav.org.co/lrrd/lrrd19/1/rahm19005.ht.

Rao, C.H. & Hanumantha (1986). Technological Changes and Distribution of Gains in Indian Agriculture Macmillan, Delhi.

Rauniyar, Ganesh .P, Frank M. & Goode, (1996). Managing Green Revolution Technology: An Analysis of a Differential Practice Combination in Swaziland. Economic Development and Cultural Change, 44(2):413-37.

Raudah, B.T, Talib Zainal Abidin, & Kadir, B. (2014). Situation Breeding and Production of Rice in Malaysia.

Reddy, Rampuram Jayapal, & Shenoy, Sandhya (2013). Impact of SRI Technology on Rice Cultivation and the Cost of Cultivation in Mahabubnagar District of Andhra, Pradesh. International Journal of scientific and Research Publications, 268.

Ricepedia, (2013). Research Program on Rice, 4th Global Rice Science Partnership Edition, Rice, Almanac. www.ricepedia.org

Rogers, Everett .M. (1960). Social Change in Rural Society: A Textbook in Rural Sociology. New York: Appleton-Century-Crofts, INC.

Rogers, E. M. (2003). Diffusion of Innovations. 5th Edition. New York: The Free Press.

Ruttan, V.W. (1960). Research on the Economics of Technological Change in American Agriculture, *J. Farm Econ*, 42(4), 735-754.

Sadiq, M.S., Singh, I.P., Kolo, M. D., Maude, A. M & Kudu, M. A, (2015). Resource Optimization in Sorghum Production in Niger State, Nigeria. *International Journal of Advanced Multidisciplinary Research* (IJAMR), 2(2):53–59. www.ijarm.com.

Sadoulet, E., & Janvy, D. (1995). Quantitative Development Policy Analysis. Baltimore: John-Hopking, University Press.

Saka .J.O & Lawal, B.O (2005). Determinants of Adoption and Productivity of Improved Rice Varieties in South Western Nigeria. *African journal of biotechnology*, 8 (19): 4923-4932.

Salmah, Binti Tajuddin (2014). Effect of Weedy Rice on the Yield of Cultivated Rice (Oryza Sativa L.) in Greenhouse and Field Environment.

Samuelson, Paul, A. & Nordhaus, Williams .A. (2005). Economics Tata Mc-Graw-Hill: New Delhi.

San, Nan Wutyi, Ismail Abdlatif & Zainal Abidin bin Mohamed (2013). Farm Efficiency and Socio-economic Determinants of Rain-Fed Rice Production in Myanmar: A Non-Parametric Approach, *Asian Journal of Empirical Research*, 3(11), 1401-1413.

Sani A, Yakubu, .A. A & Bello H.M (2010). Resource-Use Efficiency in Rice Production under Small Scale Irrigation in Bunkure Local Government Area of Kano State Nigerian Journal *of Basic and Applied Science* (2010), 18(2): 292-296. . http://ajol.info/index.php/njbas/index

Santhakumar, V & Rajagopalan .R. (2000). Green Revolution in Kerala: A Discourse on Technology and Nature.

Sarkar, Hiren & Early, O. Heady, (1979). Production Response of HYVs of Rice in Some less Development Countries. *Indian Journal of Agricultural Economics,* 34 (2):54-60.

Sasmal, J., (1993). Consideration of Risk in the Production of High-Yielding Variety Paddy: A Generalized Stochastic Formulation for Production Function Estimation. *Indian Journal Agricultural Economics*, 48: 694-701.

Schmookler, (1966). Invention and Economic Growths. Harvard University Press in Cambridge, United Kingdom.

Sharma, S.N. (1977). Study of Factors Affecting Adoption of High Yielding Varieties of Wheat by Small Farmers' in Jabalpur Districts. MSc. (Ag.) thesis (unpublished). College of Agriculture, Jabalpur pp: 60.

Shenggen, Fan (1999). Technological Change, Technical and Allocative Efficiency in Chinese Agriculture, the Case of Rice Production in Jiangsu. A discussion paper.

Sheikh, A. D.; Rehman, T.; Yates, C. M. (2003). Logit Models for Identifying Factors That Influence The Up-Take Of New No-Tillage Technologies By Farmers In Rice-Wheat And Cotton-Wheat Farming Systems of Pakistan Punjab. Agricultural system 75: 75-95.

Singh, W. K. (1999). Technological Change and Functional Income Distribution in Manipur, Agriculture Indian Journal of Agricultural Economics, 54, 2,220-227.

Singh, S.P & Gangwar, A.C, (1986). Trends and Variability in Area, Productions and Productivity of Coarse Grains and Pulses in Harayana. Agricultural Situation in India. 412, 81.

Solow, R.M. (1957). Technical Change and Aggregates Production Functions. Review of Economics and Statistics, 39(2), 57-69.

Sserunkuuma, D. (2005). The Adoption and Impacts of Improved Maize and Land Management Technology in Uganda. Electronic *Journal of Agricultural Development Economics*, 2(1): 67-84.

Suresh, A, Keshava, T. & Reddy. T. (2006). Resource-use Efficiency of Paddy Cultivation in Peechi Command Area of Thrissur District of Kerala: An Economic Analysis. *Agricultural Economics Research Review*, 19:159-171.

Suswanto, T., J. Shamshuddin, S.R. Syed Omar & P. Mat, (2007). Effects of Lime and Fertilizer Application in Combination With Water Management on Rice (Oryza Sativa) Cultivated On An Acid Sulfate Soil. Mediterranean *Journal of S Social Sciences*, 11: 1-16.

Suligavi, B.S & Shankar Murthy, .H.G. (1991).Impact of Technological Change on Employment and production Relationship in Cotton in Dharwad District, Karnataka. *Agric. Economic Res, Rev*, 4 (2):136-140.

Tabbal, D. F., Bauman, .B.A.M & Bhuiyan, S.I. (2002). On-Farm Strategies for Reducing Water Input in Irrigated Rice. Agric Water Management, 56:93-112.

Taiwo, B. A, Omolehi RA, Ibrahim U (2011). Efficiency of Resource use in Hybrid and Open-Pollinated Maize Production in Giwa Local Government Area of Kaduna State, Nigeria. *American J of Experimental Agric*, 1(3): 86-95.

Tawang, Ariffin, Ahmad, Tengku Mohd Ariff Tengku, & bin Abdullah, Mohd Yusof, (2002). Stabilization of Upland Agriculture under El Nino induced Climatic Risk: impact Assessment and Mitigation Measures in Malaysia.

Tawang, Ariffin, & Ahmad, Tengku Mohd Ariff Tengku. (2003). Stabilization of Upland Agriculture under El Nino induced Climatic Risk: Regional and Farm Level Risk Management and Coping Mechanisms in the Kedah-Perlis Region, Malaysia.

Terano, R., Zainalabidin, M., & Golnaz, R. (2013). Farm Management Analysis in Paddy Granary Areas in Enhancing On-Farm Income. AGRIS on-line Papers in Economics and Informatics, 5(1).

Thakur, J. & Sinha, D.K. (1994). An Empirical Analysis of Technological Change and Functional Income Distribution in Rice Production in Bihar. *Agric. Econ. Res. Rev.*, 7(1):47-55.

Tijjani, Adamu, Bakari, U .M & Giroh, D. Y. (2015). Analysis of the Technical Efficiency of Rain-Fed Rice Farmers in Taraba State, Nigeria. *Journal of Agriculture,* 2 (4).

Tijani, B. A. (2007). Comparative Economic Analysis of Weed Control Methods for Selected Crops in Marte Local Government Area of Borno State, Nigeria. Unpublished M.Sc Dissertation, Department of Agricultural Economics and Extension, University of Maiduguri, Nigeria, 93.

Tripathi, R.S. (1993). An Economic Analysis of High Yielding Wheat Cultivation in the Rainfed Conditions of Northern Central Himalaya, *Annals-of-Agricultural-Research,* 14 (2): 199-204.

Tripathi, R. S &Thimmappa .K. (2013). Impact of Zero Tillage on Economics of Wheat Production in Haryana, *Agricultural Economics Research Review*, 26 (1).

Uaiene, R.N, Amdt, C, Masters W.A (2009). Determinants of Agricultural Technology Adoption in Mozambique. Discussing paper, 67.

Umesh, K. B. & Bisaliah .S. (1987). An Econometric Analysis of Technical Change and Resource Saving in Paddy Production, Agric. Situ. India. 42(9): 695-700.

Upton, M (1979). The Unproductive Production Function, Journal of Agricultural Economics, 30: 179-194.

Ushaben, Sharma (1981). Contributions of Hyv's to Cereal Output, Yield and Area in Gujarat Indian. *Journal of Agricultural Economics,* 36(1):79-81.

USDA, (2008). World Rice Production, Consumption and Stocks, United States Department of Agriculture, Washington DC.

Van den Berg. J. (2013). Socio-Economic Factors Affecting Adoption of Improved Agricultural Practices by Small Scale Farmers in South Africa. African *Journal of Agricultural Research*. 8(35):4490-4500.

Vengedasalam, D., Michael .H. & Gordon .M. (2011). Malaysia Rice Trade and Government Intervention. Proceedings of the 55th Annual Conference of the Australian Agricultural and Resource Economics Society, Melbourne, Australia.

Venkataram, J.V. (1968). Economic Aspects of High yielding crops Hybrid Jowar. *Indian Journal of Agricultural Economics*, 23(4):134-138, 1968.

Wadud, A., & White. B. (2000). Farm household efficiency in Bangladesh: A comparison of stochastic frontier and DEA methods. Applied Economics, 32: 1665-1673.

Wiebe, K. D., Soule, M. J., & Schimmelpfennig, D. E. (2001). Agricultural Productivity for Sustainable Food Security in Sub-Saharan Africa. FAO, Corporate Document Repository, Economic and Social development Department.

Wilfred, Nyangena & Ogada, Maurice, Juma (2014). Impact of Improved Farm Technologies on Yields: The Case of Improved Maize Varieties and Inorganic Fertilizer in Kenya. Environment for Development Discussion Paper Series, EfD DP, 14-02.

Wikipedia, (2010). Agricultural Productivity: http://en.wikipedia.org/wiki/Agricultural.

Wiredu, A.N, Gyasi. K. O, Marfo .K .A,(2010). Impact of Improved Varieties on the Yield of Rice Producing Households in Ghana. Council for Scientific and Industrial Research-Crop Research Institute, Kumasi, Ghana. University of Ghana Accra, Ghana.

Wong, L. C. Y., Emrus. S. A, Bashir .B .M & Tey .J.Y.S (2010). Malaysian Padi and Rice Industry: Applications of Supply Chain Management Approach. Proceedings of the National Rice Conference Theme: Strengthening Food Security through Sustainable Rice Production, 1-17.

Wossink, A., & Denaux, Z.S (2006). Environmental and Cost Efficiency of Pesticide Use in Transgenic and Conventional Cotton Production. Agricultural Systems, 90:312-328.

Wu .Z. (2005). Does size matter in Chinese farm household production. Paper prepared for the Agricultural Economics Society Annual Conference, University of Nottingham, UK.

Yadav, R. N., & Gangwar, A.C. (1986). Economics of Technological Change in Rice Production. Economics Affairs, 31(3).

Yamane, Taro. (1967). Statistics: An Introductory Analysis, 2nd Edition., New York:

Harper and Row.

Yotopoulos, P. A. & Nugent, J.B. (1976). Economics of Development Empirical Investigations. Harper and Row Publish Inc., New York.

Yoko, Kijima, Keijiro Otsuka, & Dick Sserunkuuma. (2006). Determinants of Changing Behaviors of NERICA Adoption: An Analysis of Panel Data from Uganda. University of Tsukuba, Foundation for Advanced Studies on International Development, Makerere University, Kampala, Uganda.

Yoko Kijima, Yukinori Ito, & Keijiro, Otsuka. (2012). Assessing the Impact of Training on Lowland Rice Productivity in an African Setting: Evidence from Uganda. World Development, 40, (8): 1610-1618.

Yuko, Nakano & Kei Kajisa. (2012). How Does the Adoption of Modern Variety Increase Productivity and Income: A Case of the Rice Sector in Tanzania, International Rice Research Institute (IRRI).

Zainal, Abidin Bin Hassan. (2012). Issues and Challenges: Strategies to Sustain Rice Industry through R & D. Rice and Industrial Crops Research Centre, MARDI Serdang, Selangor.