EUROPEAN ACADEMIC RESEARCH
Vol. VII, Issue 1/ April 2019

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

ISSN 2286-4822
www.euacademic.org

Impact of Rural Infrastructure on Rice Productivity in Kano State, Nigeria

YUSUF TANKO[1]
OYA Graduate School Business
School of Economics, Finance and Banking, Universiti Utara
Malaysia, Sintok, Kedah, Malaysia
CHEAH YONG KANG
School of Economics, Finance and Banking, COB
Universiti Utara Malaysia, Sintok, Kedah, Malaysia
RABIUL ISLAM
[c]School of International Studies, COLGIS
Universiti Utara Malaysia, Sintok, Kedah, Malaysia

Abstract

The paper presents a conceptual framework on the impact of rural infrastructure on rice productivity in Kano state, Nigeria. There are 9 out of 44 local governments in the state that are producing rice with 17 rice clusters. Questionnaire will be used to collect data from the respondents in the study area. A random sample of 768 rice farmers will be selected from 9 rice clusters that have a population of 135,895 rice farmers, using the multistage and purposive sampling. Literature has shown that rural infrastructures are key aspect that facilitates increase in the productivity of a farmer. Thus, for this study, infrastructure is conceptualised as physical and institutional. Also, included in the study is improved rice seed as an input and climate change awareness as a proxy. Further, the study intends to use the Cobb-Douglas stochastic frontier model in identifying the impact of rural infrastructure on rice productivity as well as the productivity level of rice the farmers in the study area.

[1] Corresponding authors emails: ytanko64@gmail.com; yong@uum.edu.my; rabiul@uum.edu.my

Keywords: Physical Infrastructure, Institutional Infrastructure, Productivity, Rice, Kano state.

1 INTRODUCTION

The estimated land potential in paddy rice production in Nigeria is 4.9m/h for self-sufficiency and export (Kim, Elisha, Lawrence, & Moses, 2017). Unfortunately, the production of paddy rice in the country is yet to keep pace with the rising demand (Macauley, 2015). Further, estimates show that paddy rice production has never been made in relation to the demand in Nigeria from 1980 to 2018. As the demand for rice increases, local production decreases relative to population growth, which led to an annual import of 4.2 m/t of paddy rice to bridge the gap, which the country cannot stand being a mono-economy. This led to the scarcity of rice at an exorbitant price. Further, despite a substantial increase in world rice production, the rate of growth is less than the population growth (Maraseni, Deo, Qu, Gentle, & Neupane, 2018). Likewise, global empirical studies show some element of inefficiency in rice productivity, though the level differs among countries. Thus, the need for a study with a view to increasing rice productivity in Nigeria.

One of the most important food crops consumed by more than half of the world population in the 21st century is rice (Oryza sativa) (Antle, Zhang, Mu, Abatzoglou, & Stöckle, 2018; Zhang et al., 2018). The global estimate indicates that the size of land put to rice farming is over 100 million hectares (Xue et al., 2017). Rice is the 3rd most important food crop in the West African countries after maize and sorghum, and the rate of growth of rice consumption is growing at a faster rate more than any other vital food, due to the growth of the population (Macauley, 2015). Estimates show that world rice production is 78.23% (Maraseni et al., 2018).

Rice is a major staple food, a source of energy and a vital nutrient in Nigeria. The average annual rice consumption in

Nigeria increases at 10.3% (Maji, Bashir, Oduba, Gbanguba, & Audu, 2015). The increase is induced by population growth, changes in job structures, changes in taste and people's dietary needs, urbanization, and partly due to rise in income following the discovery of crude oil in Nigeria (Tanaka et al., 2017; Uduma, Samson, & Mure, 2016). Rice farming is an important sector in the Nigerian economy, providing job opportunities, poverty alleviation, food production, and contributes to the development of the economy. Despite these, however, rice farming in Nigeria is still characterised by low level of inputs, low yields, and limited areas under rice cultivation. Food is necessary for energy thus, security in food production becomes a main concern of every government in supporting the livelihood of the population (Islam, Siwar, & Bhuiyan, 2012).

Productivity is partial when the contribution of an individual input is measured in relation to the growth of total output. While, the total factor productivity measured the total contribution of the inputs, in relation to the growth of total output. The best productivity is one in which output increases without an increase in the inputs. Therefore, the aim of this study is to identify the impact of rural infrastructure on rice productivity, the causes of low productivity, as well as the level productivity in the study area.

2 LITERATURE REVIEW

A summary of literature review on the infrastructure affecting the productivity of paddy rice in the study is presented below.

2.1 Rural road networks

Rural roads linked rural farmers with inputs and outputs markets hence, creating a convenient access to farmland, inputs, and output. Gibbons, Lyytikäinen, Overman, and Sanchis-Guarner (2019) reported that linked roads significantly increase output per worker, Lin (2017) high speed railway

expands market access. Binswanger, Khandker, and Rosenzweig (1993) reported that road contribution to agricultural growth is 7% leading to expansion of banks. Also, Dercon, Gilligan, Hoddinott, and Woldehanna (2009) indicate that rural roads reduced poverty by 6.9% in rural areas. Thus, Demenge et al. (2015) stress the need for a multifunctional scheme to rural road networks. Though, Baum-Snow, Henderson, Turner, Zhang, and Brandt (2018) pointed out that averagely, roads that improves access to local markets have a slight or adverse effect on a state economic activity, and Stenico de Campos, Simon, and de Campos Martins (2019) pointed out that truck fleets negatively affect crop production by causing climate change.

2.2 Farm size

Bigger farmlands are expected to yield higher output as reported by Akudugu, (2016) and Tashikalma, Giroh, and Ugbeshe (2014) that farm size has a significant impact on rice yield. Also, a study by Osanyinlusi and Adenegan (2016) shows farm size has a positive and significant impact on rice efficiency. The reports are buttressed by Ragasa & Chapoto (2017) showing 6% of the 7.5% increase in rice productivity was accounted for by expansion in the land area. While, Wang, Chen, Gupta, and Huang (2015) report that yield increases in China with the size of the farm while in India, yield decreases due to land fragmentation. Also, Bhattacharyya and Mandal (2016) show a decline in technical efficiency of rice farming owing to land fragmentation. Further, Chang, Takahashi, and Yang (2017) affirm more profits efficiency was realised by big firms compared to smaller ones, due to the ability of bigger firms to expand production by acquiring more farmland.

2.3 Irrigation facilities

Irrigation reduces the growth of weed in grain fields, prevent the consolidation of soil, facilitate the growth of crops,

revegetate upset soil during the dry season or when faced with insufficient rainfall. Ahmed, Xu, Yu, and Wang (2017) report that an increase in rice yield can be achieved by providing irrigation facilities to the farmers. Also, Ragasa and Chapoto (2017) state that expansion in irrigated land led to a rise in rice productivity. Further, rice yield rises from 8.2% to 42.7% due to improvement in irrigation facilities (Chun et al., 2016). While, Kim et al. (2017) report that low rice productivity is due to poor motivation to irrigated rice farmers also, Uduma et al. (2016) ascertained that Nigeria's irrigated potentials in rice farming were not fully harnessed.

2.4 Electricity supply

Electrification in the rural areas promotes their productive activities because the cost of backup and maintenance will be low (Narula & Bhattacharyya, 2017). Barnes and Binswanger (1986) state that private rural electrification has a significant impact on agricultural productivity. Also, Binswanger et al. (1993) report electrification of pump increase irrigation investment by 28% and output by 2%. While Bhattacharyya and Ganguly (2017) report that removal of electricity subsidy will lead to food inflation. The absence of electricity in rural areas distorts rural dwellers' productive activities (Narula & Bhattacharyya, 2017). Thus, Langarita, Chóliz, Sarasa, Duarte, and Jiménez (2015) suggest a low tariff supply of electricity to rural farmers.

2.5 Communication networks

Communication is an important tool used by farmers, Elly and Silayo (2013) report that farmers use traditional means of communication to source agricultural data. In modern time, the services of mobile-enabled information lessen the dominant info anomalies, lessen the gap between accessibility and conveyance of agricultural inputs and outputs. Similarly, the increase in mobile phone coverage in the emerging nations, offer an

exclusive chance to ease technology adoption, through information and computer technology based agricultural extension programs. Kirui, Okello, Nyikal, and Njiraini (2013) report that annually, MMT services increase commercial agriculture by 37%. Thus, modern communications technology is used to edify farmers on sustainable agricultural practices, to be robust to shocks, and responsive to market signals.

2.6 Fertilizer access

Fertilizer is a modern mechanism of increasing crop productivity as reported by Tashikalma et al. (2014) and Zhu and Chen (2002) that chemical fertilizer has a positive impact on crop production. Further, Stewart, Dibb, Johnston, and Smyth (2005) report that fertilizer nutrients increase crop yield from 30% to 50%. Also, Osanyinlusi and Adenegan (2016) and Mandal, Patra, Singh, Swarup, and Masto (2007) states that fertilizer usage and quantity used has a positive impact on farmers' productivity. Furthermore, a virtual study by Ahmed et al. (2017) shows that rice yield can be increased in Hainan, China and Niger, Nigeria using fertilizer. Also, Zhang et al. (2017) reports nitrogen usage significantly increase rice yield and improve crop growth rate. Proper use of fertilizer by farmers increases crop return seasonally by 35% and 69% annually (Duflo, Kremer, & Robinson, 2008). Thus, Ajani and Ugwu (2008) suggest providing fertilizer to farmers at the right time and place.

2.7 Improved rice seed access

Modern rice varieties significantly increase rice production as reported by Ahmed et al. (2017) and Xue et al. (2017) that modern varieties significantly increase crop productivity. This is because treated seeds increased germination by 93.33% (Anupama, Murali, Jogaiah, & Amruthesh, 2014). Societies, where most farmers adopt improved seeds, realises better price for farmers and consumers (Minten & Barrett, 2008). Also,

Thirtle, Beyers, Ismael, and Piesse (2003) report 88% efficiency by adopters of pest-resistant cotton seed and non-adopters are 66% efficient while, in lower yield period adopters are 74% and non-adopters are 44% efficient. Further, Zhou et al. (2017) report improved rice can cope with deficit soil water, guarantee an increase in rice yield, and efficiency in water use. Also, Qaim and Zilberman (2003) report genetically modified seed significantly reduces pest damage and increase output, and Shiferaw, Kebede, and You (2008) report an increase in returns of 30% for guaranteeing farmers access to improve seeds.

2.8 Storage facility

Storage includes handling and processing of goods, from production to consumption periods. The development in technology provides facilities for storage, processing, and farm produce handling. Gajigo and Lukoma (2011) state that poor storage facilities put farmers at risk of pests and weather deterioration. While Kaminski and Christiaensen (2014) report improved storage facilities lower post-harvest losses. Also, Sheng et al. (2017) indicate that citrate content can be improved for post-harvest maintenance and improves storage performance in citrus production. Improves bread storage and onion storage (Licciardello et al., 2017; Petropoulos, Ntatsi, & Ferreira, 2016). Further, Pandino et al. (2017) reported that storage enables artichoke slices maintained high nutritional quality. Storage facility maintains colour parameters for seven days of milk storage (Milkovska-Stamenova & Hoffmann, 2017). Furthermore, the storage facility maintains the quality of carrot (Behsnilian & Mayer-Miebach, 2017; Du, Angers, Ren, Zhang, & Li, 2017).

2.9 Credit facility

A study by Ojochenemi, Gabriel, and Ogwuche (2017) reported that inadequate finance is the major constraint to rice productivity. While Nonvide, Sarpong, Kwadzo, Anim-Somuah

and Gero (2017) state that credit facility increases farmers productivity. Akudugu (2016) report formal and informal credit positively and significantly affect agricultural productivity. Binswanger et al. (1993) report fast growth of banks, leads to a rise in the demand for fertilizer by 23%, increase investment in pumps by 41% and in tractors by 13%, and an increase in aggregate crop harvest by 3%. Regrettably, most banks are shining away from rural areas due to the risks involved in rural banking, as reported by Ijaiya, Abdulraheem, and Abdullahi (2017) that banks dodge businesses that involve high risks, especially in rural areas. Also, Binswanger et al. (1993) report that most banks prefer branches in areas with good infrastructure and relatively fewer risks in agriculture.

Furthermore, poor awareness by farmers is a constraint to access credit facilities, for instance, Nyaga and Nzulwa (2017) report constraint to credit by farmers is caused by poor awareness of financial info and administrative skills. Thus, organized farmers have more access to formal support than un-organized farmers (Islam & Siwar, 2012). Further, Roberts, Otieno, and Nyikal (2017) report farmers with bank account have more access to formal credit facilities than those without a bank account and that, access to credit is negatively and significantly related to literacy, profession, and group membership. Further, Tran, Gan, and Hu (2016) report that female small-scale farmers sourced credits from the informal sector due to the absence of collateral security.

2.10 Access to Market

Improving access to a market is promising in increasing crop productivity (Koppmair, Kassie, & Qaim, 2016), and market facilities lessen the risk associated with post-harvest losses (Kaminski & Christiaensen, 2014). So, access to an enhanced market for rural household and supportive markets facilitate an increase in agricultural production. Thus, the need to have a conducive market for rural rice farmers (Uduma et al., 2016).

Therefore, Czyzewski and Majchrzak (2017) and Goto and Douangngeune (2017) suggest government to intervene in prospering markets. Because, organised markets lead to 87% growth rate, contributes 4% to agricultural produce and 17% to the demand for fertilizer, boost liquidity position of farmers, and reduce the costs of a deal for banks and farmers (Binswanger et al. 1993). While, the absence of a feasible market for rural farmers is a barrier to increase in rice productivity (Uduma et al., 2016). Though, Akudugu (2016) noted that access to the market is insignificant in determining agricultural productivity.

2.11 Education

Training of farmers improves their understanding of modern technology. Education of farmers leads to an improvement in productivity (Adekunle et al., 2004). Investment in human development upsurges access and adoption of improved varieties (Maredia, Byerlee, & Pee, 2000). Hence, the level of education affects the productivity of a farmer as it will ease extensions. Extensions are the advisory services offered to farmers by extension workers with a view to increasing productivity (Antle et al., 2018; Golan & Kohli, 2013). Extension through contact with farmers is more practical, through publications is appealing to farmers while through radio program have wider coverage and at times preferred in the physical absence of extension agent (Adekunle et al., 2004).

2.12 Access to Extension Services

A study by Binam, Tonyè, Wandji, Nyambi, and Akoa (2004) report that extensions offered increase the return of groundnut by 77%, maize by 73%, and groundnut and maize cropping by 75%. Also, Dercon et al. (2009) state that one extension visit reduces poverty by at least 9.8% and upsurge consumption by 7.1%, and Owens, Hoddinott, and Kinsey (2003) report one to two extension visits increase farm yield by 15%. Further, Alene

and Manyong (2007), Jin, Huang, Hu, and Rozelle (2002), Maffioli, Ubfal, Vazquez-Bare, and Cerdan-Infantes (2013), and Pender and Gebremedhin (2007) report that extensions significantly influence adoption of modern agriculture, and Berhanu and Poulton (2014) report investment in extension services is the most effective program to increase the productivity of peasant farmers. Also, Jin and Huffman (2016) report that investment in extension services yields a high return. Thus, Garnett et al. (2013) emphasised the need for extensions to support farmers to increase productivity, and Evenson (2001) affirmed that most of the research results on extensions show a more than 40% returns thus, concludes estimates were consistent that extensions increase agricultural productivity.

2.13 Awareness of Climate Change

The rate of rainfall and duration, humidity, temperature level, drought, flood, and extreme temperature are part of the environmental issues that affect rice output and are caused by climate change (Kim et al., 2017; Xue et al., 2017). Besides, Mrabet and Moussadek (2012) report a 90% human-induced climate change in the world, and Ozor, Umunakwe, Ani, and Nnadi (2015) specify that 40.6% of the farmers have little knowledge of climate change and 21.7% do not know climate change. Thus, the extent of adoption of climate change measures depends on the farmer's perception and awareness. Kim et al. (2017) report a direct relationship between the perception of climate change and adaptation measures and poor awareness is a barrier to adaptation strategies. For instance, a study by Huong, Shun Bo, and Fahad (2017) shows that most of the farmers who have a knowledge of climate change had adopted at least one measure to tackle the problem. Also, Okonya, Syndikus, and Kroschel (2013) indicates 99% of peasant farmers are aware of the effect of climate change and have taken measures. Li, Wang, and Chun (2017) report that

climate change will reduce rice yields by (3.5 - 23.2) % by 2020s and an increase in temperature by 10 will reduce rice output by 10.26% thus, concludes that by 2050 climate change will cause a significant reduction in rice yields if adaptation plans were not adopted.

Enete et al. (2011) state that 96% of the farmers are aware of climate change, 97% are aware of its effect through extension agents but, 52% do not believe their farming activities contribute to climate change. Also, Deressa, Hassan, and Ringler (2011) report 83% of the respondents are aware of climate change but only 58% adapt climate change measures and determinants of climate change adaptation are: educational level, family size, sex, ownership of livestock, extensions, access to credit facilities and temperature. Also, Joshi, Ji, and Joshi, (2017) report that factors affecting adaptation measures are socio-economic, geographical, ecological and institutional factors. Khanal, Wilson, Hoang, and Lee (2018) report farmers' education, access to credit, extension services, experience, information on climate change issues, and belief in climate change determines the decision to take measures.

3 METHODOLOGY

The primary source of data will be used for the study to collect the information from the respondents. Out of the 44 local governments in Kano state, 7 are cultivating rice with 17 rice clusters. Purposive sampling of 9 rice clusters will be selected and a random sample of 768 rice farmers will be selected from the population of 135 895 rice farmers using the multistage sampling (Dillman, 2000; Krejcie & Morgan, 1970). Research assistance in conjunction with extension workers in each cluster will be used in identifying and administering the questionnaire to the rice farmers. The extension workers are familiar and have a good understanding with the farmers thus, making them feel free in responding to the questionnaire.

Finally, the study will use the Cobb-Douglas Stochastic Frontier Model.

3.1 Theoretical Framework

The productivity or efficiency of a farmer can be measured by the microeconomic theory of production (Farrell, 1957). The performance of each variable inputs can be identified using the theory. Thus, efficient utilization of the variable inputs in production will positively affect productivity. Different variable inputs are used in the production process and each input is associated with a problem, in relation to its efficient utilization. While deviating from underutilization of the variable inputs will lead to efficiency in production. The selection among the alternative input's possibilities in relation to their availability and optimal utilization led to the development of an activity analysis model by Koopmans (1951) and Debreu (1951). The stage of efficiency in production indicates the level of productivity, as efficiency in production is the success attained in producing the maximum possible output from a set of combination of variable inputs (Mendola, 2007). The mathematical expression of the production function is expressed as:

$$Q = f(X_1, X_2, X_3, \ldots\ldots\ldots\ldots\ldots X_n) \quad (1)$$

Where Q is the output and X_1, X_2, X_3, ……., X_n are the variable inputs.

Since this study is on productivity, then the mathematical function will now be;

$$Rp = \frac{Q}{X1, X2, X3, \ldots\ldots Xn} \quad (2)$$

Where, Rp = productivity, Q = output produced, and $X1, X2, X3, \ldots\ldots Xn$ = are the inputs used in the production.

Mathematically, the production function shows the maximum output that can be produced from a given set of inputs. While

Figure 1 is the theoretical model of the production function. The model shows that inputs are used to produce an output.

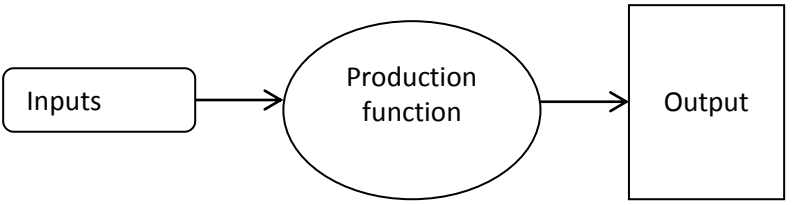

Figure 1: ***Theoretical Framework***

3.2 Conceptual Framework

3.2.1 Dependent Variable: The rice farmer aims at the maximization of output subject to inputs availability and utilization. A rational farmer can increase productivity by technically allocating the variable inputs efficiently in the production process thus, the dependent variable is productivity. However, Pieri (2010) opined that the theory of production alone is insufficient to explain the behaviour of increasing productivity, in which some infrastructures are inadequate.

3.2.2 Independent Variables: The independent variables are institutional and physical infrastructures. The physical infrastructures are access road, farm size, irrigation, electricity, and communication networks. While, the institutional infrastructures are fertilizer, storage, markets, credit, extensions, and education. The conceptual model of rural infrastructure affecting rice productivity is adapted from Narayanamoorthy and Hanjra (2006) that used electricity, irrigation, and roads as physical infrastructure and educational level as institutional infrastructure, and Zhang and Fan (2004) used communication, roads, and irrigation were used as physical infrastructure and education and extensions as institutional infrastructure. Here, extensions and

communication expand institutional and physical infrastructures.

Economic, institutional, and social were used as infrastructure by Manjunath and Kannan (2015). The economic infrastructures are communication, road, irrigation, and electricity. Institutional infrastructures are markets and credits while, education was used as social infrastructure. Also, communication expands physical while credits and markets expand institutional infrastructures. Further, roads, electricity, credits, farm size, communication, markets, education, and fertilizer, are used as infrastructure by Segun, Omotesho, Bello, and Dayo (2008). Variables such as fertilizer and farm size expand the adapted concept of infrastructure. While, improved rice seed is adapted from Guodaar, Asante, and Eshun (2017) and Tanaka et al. (2017) as an input, and a proxy climate change awareness from Kim et al. (2017). Below is the conceptual model.

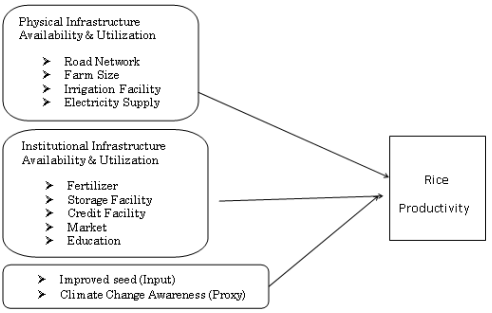

Figure 2: ***The conceptual model for the research***

4. DISCUSSION

Literature has shown that rural infrastructure played a significant role in increasing agricultural productivity thus, the need to provide a qualitative infrastructure in the rural areas. Physical and institutional rural infrastructure, improved rice seeds, as well as climate change awareness, will increase rice productivity in Kano state. A qualitative rural infrastructure connects farmers and buyers thereby, increases access to inputs

and outputs, increase yield, reduces price distortions, as well as making a domestic market well-functioning. Further, rural infrastructure has a direct impact on productivity by providing rice farmers with feasible choices for rice production, milling, marketing, and distribution, provides an opening for banks to offer credit to remote rural areas, unlocked farmlands, improve convenience, adds value to output, and reduce wastes.

Furthermore, rural infrastructure eases extension workers to support farmers, eases contact between farmers, buyers, and extension workers, and reduces movements and its cost. Climate change has exposed rice farmers to hazardous risks thus, reduced their productivity. While the development and adoption of improved rice variety and climate change awareness has a significant impact on rice productivity. Lack of formal education resulted in poor adoption of improved rice seed, poor awareness to climate change, and led to improper utilization of fertilizer. Furthermore, socioeconomic characteristics of rural farmer led to poor adoption of modern farming techniques.

5. CONCLUSION

It is hope that the study will be a source of reference to the government in talking the problem of infrastructure dwindling the productivity of paddy rice in Nigeria. The private sector can benefit from the result of the study by having an idea of profitable investment in the required rice inputs and output. While, paddy rice farmers can explore the study to identify feasible means of increasing their productivity so that profit can be maximized and minimized inefficiencies related to rice production in Kano state and Nigeria. Furthermore, the result can serve as reference for researchers for furture studies.

REFERENCES

1. Adekunle, A. A., Onyibe, J. E., Ogunyinka, O. M., Omenesa, Z. E., Auta, S. J., & Kuyello, A. U. (2004). Agricultural information dissemination: An audience survey in Kano State. *International Institute of Tropical Agriculture*, (April), 1–20.
2. Ahmed, A., Xu, S., Yu, W., & Wang, Y. (2017). Comparative Study on Factors Influencing Rice Yield in Niger State of Nigeria and Hainan of China. *International Journal of Agricultural and Food Research [IJAFR]*, *6*(1), 15–25.
3. Ajani, O. I. Y., & Ugwu, P. C. (2008). Trend in agricultural economics. *Asian Network for Scientific Information*, *1*(1), 1–7.
4. Akudugu, A. M. (2016). Agricultural productivity, credit and farm size nexus in Africa: A case study of Ghana. *Agricultural Finance Review*, *76*(2), 288–308. http://doi.org/10.1108/09574090910954864
5. Alene, A. D., & Manyong, V. M. (2007). The effects of education on agricultural productivity under traditional and improved technology in Northern Nigeria: An endogenous switching regression analysis. *Empirical Economics*, *32*(1), 141–159. http://doi.org/10.1007/s00181-006-0076-3
6. Antle, J. M., Zhang, H., Mu, J. E., Abatzoglou, J., & Stöckle, C. (2018). Methods to assess between-system adaptations to climate change: Dryland wheat systems in the Pacific Northwest United States. *Agriculture, Ecosystems and Environment*, *253*, 195–207. http://doi.org/10.1016/j.agee.2017.03.017
7. Anupama, N., Murali, M., Jogaiah, S., & Amruthesh, K. N. (2014). Crude oligosaccharides from alternaria solani with bachilus subtlis enhenc defense activity and inudce resistance against early blight disease of tomato. *Asian Journal of Science and Technology*, *5*(7), 412–416.
8. Barnes, D. F., & Binswanger, H. P. (1986). Impact of rural electrification and Infrastructure and Agricultural Changes, 1966-1980. *Economic And Political Weekly*, *21*(1), 26–34.
9. Baum-Snow, N., Henderson, J. V., Turner, M. A., Zhang, Q., & Brandt, L. (2018). Does investment in national highways help

or hurt hinterland city growth? *Journal of Urban Economics*. http://doi.org/10.1016/j.jue.2018.05.001

10. Behsnilian, D., & Mayer-Miebach, E. (2017). Impact of blanching, freezing and frozen storage on the carotenoid profile of carrot slices (Daucus carota L. cv. Nutri Red). *Food Control*, *73*, 761–767. http://doi.org/10.1016/j.foodcont.2016.09.045
11. Berhanu, K., & Poulton, C. (2014). The political economy of agricultural extension in Ethiopia: Economic growth and political control. *Development Policy Review*, *32*(2), 197–213. http://doi.org/10.1111/dpr.12082
12. Bhattacharyya, A., & Mandal, R. (2016). A generalised stochastic production frontier analysis of technical efficiency of rice farming: A case study from Assam, India. *Indian Growth and Development*, *9*(2), 114–128.
13. Bhattacharyya, R., & Ganguly, A. (2017). Cross subsidy removal in electricity pricing in India. *Energy Policy*, *100*(October 2016), 181–190. http://doi.org/10.1016/j.enpol.2016.10.024
14. Binam, J. N., Tonyè, J., Wandji, N., Nyambi, G., & Akoa, M. (2004). Factors affecting the technical efficiency among smallholder farmers in the slash and burn agriculture zone of Cameroon. *Food Policy*, *29*(5), 531–545. http://doi.org/10.1016/j.foodpol.2004.07.013
15. Binswanger, H. P., Khandker, R. S., & Rosenzweig, R. M. (1993). How infrastructure and financial institutions affect agricultural output and investment in India. *Journal of Development Economics*, *41*, 337–366.
16. Chang, T., Takahashi, D., & Yang, C.-K. (2017). Profit efficiency analysis of rice production in Taiwan. *China Agricultural Economic Review*, *9*(1), 32–47.
17. Chun, J. A., Li, S., Wang, Q., Lee, W. S., Lee, E. J., Horstmann, N., … Vang, S. (2016). Assessing rice productivity and adaptation strategies for Southeast Asia under climate change through multi-scale crop modeling. *Agricultural Systems*, *143*, 14–21. http://doi.org/10.1016/j.agsy.2015.12.001
18. Czyzewski, B., & Majchrzak, A. (2017). Market versus agriculture in Poland: Macroeconomic relations of incomes, prices and productivity in terms of the sustainable

development paradigm. *Technological and Economic Development of Economy*, *4913*, 1–17. http://doi.org/10.3846/20294913.2016.1212743

19. Debreu, G. (1951). The coefficient of resource utilization. *The Econometric Society*, *19*(3), 273–292. Retrieved from http://www.jstor.org/stable/1906814
20. Demenge, J., Alba, R., Welle, K., Manjur, K., Addisu, A., Mehta, L., & Woldearegay, K. (2015). Multifunctional roads: The potential effects of combined roads and water harvesting infrastructure on livelihoods and poverty in Ethiopia. *Journal of Infrastructure Development*, *7*(2), 165–180. http://doi.org/10.1177/0974930615609482
21. Dercon, S., Gilligan, D. O., Hoddinott, J., & Woldehanna, T. (2009). The impact of agricultural extension and roads on poverty and consumption growth in fifteen Ethiopian villages. *American Journal of Agricultural Economics*, *91*(4), 1007–1021. http://doi.org/10.1111/j.1467-8276.2009.01325.x
22. Deressa, T., Hassan, R. M., & Ringler, C. (2011). Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *Journal of Agricultural Science*, *149*, 23–31. http://doi.org/10.1017/S0021859610000687
23. Dillman, D. A. (2000). *Mail and internet surveys: The tailored design method* (2nd ed.). New York: John Wiley and sons.
24. Du, Z., Angers, D. A., Ren, T., Zhang, Q., & Li, G. (2017). The effect of no-till on organic C storage in Chinese soils should not be overemphasized: A meta-analysis. *Agriculture, Ecosystems and Environment*, *236*, 1–11. http://doi.org/10.1016/j.agee.2016.11.007
25. Duflo, E., Kremer, M., & Robinson, J. (2008). How high are rates of return to fertilizer? Evidence from field experiments in Kenya. *Quarterly Journal of Econom*, *121*(2), 635–672. Retrieved from http://www.jstor.org/stable/29730068
26. Elly, T., & Silayo, E. E. (2013). Agricultural information needs and Sources of the rural farmers in Tanzania: A case of Iringa rural district. *Journal of Library Review*, *60*(5), 383–395. http://doi.org/10.1108/S1479-3563(2012)000012B005
27. Enete, A. A., Madu, I. I., Mojekwu, J. C., Onyekuru, A. N., Onwubuya, E. A., & Eze, F. (2011). Indigenous agricultural

adaptation to climate change : Study of southeast Nigeria. Nairobi, Kenya: African Technology Policy Studies Network.

28. Evenson, R. E., & Gollin, D. (2003). Assessing the impact of the green revolution, 1960 to 2000. *American Association for the Advancement of Science*, *300*(5620), 758–762. http://doi.org/10.1126/science.1078710
29. Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society. Series A (General)*, *120*(3), 253. http://doi.org/10.2307/2343100
30. Gajigo, O., & Lukoma, A. (2011). *Infrastructure and agricultural productivity in Africa*. Retrieved from www.adb.org
31. Garnett, T., Appleby, M. C., Balmford, A., Bateman, I. J., Benton, T. G., Bloomer, P., … Godfray, H. C. J. (2013). Sustainable intensification in agriculture: Premises and policies. *Science Magazine*, *341*(July), 33–34. http://doi.org/10.1126/science.1234485
32. Gibbons, S., Lyytikäinen, T., Overman, H. G., & Sanchis-Guarner, R. (2019). New road infrastructure: The effects on firms. *Journal of Urban Economics*, *110*, 35–50. http://doi.org/10.1016/j.jue.2019.01.002
33. Golan, A., & Kohli, H. (2013). Asean dynamism: Agricultural transformation and food security. *Global Journal of Emerging Market Economies*, *5*(1), 3–21. http://doi.org/10.1177/0974910112469267
34. Goto, K., & Douangngeune, B. (2017). Agricultural modernisation and rural livelihood strategies: the case of rice farming in Laos. *Canadian Journal of Development Studies*, *5189*, 1–20. http://doi.org/10.1080/02255189.2017.1263553
35. Guodaar, L., Asante, F., & Eshun, G. (2017). Analysing the nexus between climate variability and tomato (Lycopersicon esculentum) production in the Offinso North District, Ghana. *Journal of Experimental Agriculture International*, *15*(1), 1–13. http://doi.org/10.9734/JEAI/2017/30688
36. Huong, T. L. N., Shun Bo, Y., & Fahad, S. (2017). Farmers' perception, awareness and adaptation to climate change: Evidence from Northwest Vietnam. *International Journal of Climate Change Strategies and Management*. http://doi.org/10.1108/17568690910955603

37. Ijaiya, M. A., Abdulraheem, A., & Abdullahi, I. B. (2017). Agricultural credit guarantee scheme and food security in Nigeria. *Ethiopian Journal of Environmental Studies and Management.*, *10*(2), 208–218.
38. Islam, R., & Siwar, C. (2012). The analysis of urban agriculture development in Malaysia. *Journal of Advances in Environmental Biology*, *6*(3), 1068–1078.
39. Islam, R., Siwar, C., & Bhuiyan, A. H. (2012). The role of water, food security and poverty alleviation in the context of sustainable livelihoods. *OIDA International Journal of Sustainable Development*, *3*(8), 101/106.
40. Jin, S., Huang, J., Hu, R., & Rozelle, S. (2002). The creation and spread of technology and total factor productivity in China's agriculture. *American Journal of Agricultural Economics*, *84*(4), 916–930.
41. Jin, Y., & Huffman, W. E. (2016). Measuring public agricultural research and extension and Estimating their impacts on agricultural productivity: New insights from US evidence. *Agricultural Economics (United Kingdom)*, *47*(1), 15–31. http://doi.org/10.1111/agec.12206
42. Joshi, B., Ji, We., & Joshi, B. N. (2017). Farm households' perception on climate change and adaptation practices: A case study from mountain district of Nepal. *International Journal of Climate Change Strategies and Management*. http://doi.org/10.1108/17568690910955603
43. Kaminski, J., & Christiaensen, L. (2014). Post-harvest loss in Sub-Saharan Africa: What do farmers say? *Global Food Security*, *3*(3–4), 149–158. http://doi.org/10.1016/j.gfs.2014.10.002
44. Khanal, U., Wilson, C., Hoang, V. N., & Lee, B. (2018). Farmers' adaptation to climate change, its determinants and impacts on rice yield in Nepal. *Ecological Economics*, *144*(July 2017), 139–147. http://doi.org/10.1016/j.ecolecon.2017.08.006
45. Kim, I., Elisha, I., Lawrence, E., & Moses, M. (2017). Farmers adaptation strategies to the effect of climate variation on rice production: A case study in Ekiti State, Nigeria. *Environmental and Ecology Research*, *5*(4), 289–301. http://doi.org/10.13189/eer.2017.050406

46. Kirui, O. K., Okello, J. J., Nyikal, R. A., & Njiraini, G. W. (2013). Impact of mobile phone-based money transfer services in agriculture: Evidence from Kenya. *Quarterly Journal of International Agriculture*, *52*(2), 141–162. http://doi.org/10.4018/jictrda.2012010101
47. Koopmans, T. C. (1951). Activity analysis of production and allocation. *An Analysis of Production as an Efficiency Combination of Activities*. New York and London: Johnson Wiley & sons Inc., New York Chapman & Hall, Limited, London. http://doi.org/10.2307/2226909
48. Koppmair, S., Kassie, M., & Qaim, M. (2016). Farm production, market access and dietary diversity in Malawi. *Public Health Nutrition*, *20*(02), 325–335. http://doi.org/10.1017/S1368980016002135
49. Krejcie, R. V, & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*, *38*(1), 607–610. http://doi.org/10.1177/001316447003000308
50. Langarita, R., Chóliz, S. J., Sarasa, C., Duarte, R., & Jiménez, S. (2015). Electricity costs in irrigated agriculture: A case study for an irrigation scheme in Spain. *Renewable and Sustainable Energy Reviews*, 1–12. http://doi.org/10.1016/j.rser.2016.05.075
51. Li, S., Wang, Q., & Chun, J. A. (2017). Impact assessment of climate change on rice productivity in the Indochinese Peninsula using a regional-scale crop model. *International Journal of Climatology*. http://doi.org/10.1002/joc.5072
52. Licciardello, F., Giannone, V., Del Nobile, M. A., Muratore, G., Summo, C., Giarnetti, M., … Pasqualone, A. (2017). Shelf life assessment of industrial durum wheat bread as a function of packaging system. *Food Chemistry*, *224*, 181–190. http://doi.org/10.1016/j.foodchem.2016.12.080
53. Lin, Y. (2017). Travel costs and urban specialization patterns: Evidence from China's high speed railway system. *Journal of Urban Economics*, *98*, 98–123. http://doi.org/10.1016/j.jue.2016.11.002
54. Macauley, H. (2015). *Cereal crops: Rice, Maize, Millet, Sorghum, Wheat*. *Feeding Africa: An action plan for African Agricultural transformation*.

55. Maffioli, A., Ubfal, D., Vazquez-Bare, G., & Cerdan-Infantes, P. (2013). Improving technology adoption in agriculture through extension services: Evidence from Uruguay. *Journal of Development Effectiveness*, *5*(1), 64–81. http://doi.org/10.1080/19439342.2013.764917
56. Maji, A. T., Bashir, M., Oduba, A., Gbanguba, A. U., & Audu, S. D. (2015). Genotype X environment interaction and stability estimate forgGrain yield of upland rice genotypes in Nigeria. *Journal of Rice Research*, *03*(02), 1–5. http://doi.org/10.4172/2375-4338.1000136
57. Mandal, A., Patra, K. A., Singh, D., Swarup, A., & Masto, R. E. (2007). Effect of long-term application of manure and fertilizer on biological and biochemical activities in soil during crop development stages. *Bioresource Technology*, *98*(18), 3585–3592. http://doi.org/10.1016/j.biortech.2006.11.027
58. Manjunath, S., & Kannan, E. (2015). *Effect of rural infrastructure on agricultural development : District level analysis in Karnataka* (No. 345). Karnataka.
59. Maraseni, T. N., Deo, R. C., Qu, J., Gentle, P., & Neupane, P. R. (2018). An international comparison of rice consumption behaviours and greenhouse gas emissions from rice production. *Journal of Cleaner Production*, *xxx*, 1–13. http://doi.org/10.1016/j.jclepro.2017.11.182
60. Maredia, K. M., Byerlee, D., & Pee, P. (2000). Impacts of food crop improvement research: Evidence from sub-Saharan Africa. *Journal of Food Policy*, *25*(1), 531–559.
61. Mendola, M. (2007). Farm Households Production Theories: a Review of'Institutional'and'Behavioural'responses. *Asian Development Review*, *24*(1), 49–68. http://doi.org/10.2139/ssrn.661021
62. Milkovska-Stamenova, S., & Hoffmann, R. (2017). Influence of storage and heating on protein glycation levels of processed lactose-free and regular bovine milk products. *Food Chemistry*, *221*, 489–495. http://doi.org/10.1016/j.foodchem.2016.10.092
63. Minten, B., & Barrett, C. B. (2008). Agricultural technology, productivity, and poverty in Madagascar. *World Development*, *36*(5), 797–822. http://doi.org/10.1016/j.worlddev.2007.05.004

64. Mrabet, R., & Moussadek, R. (2012). Conservation agriculture in dry areas of Morocco: Rational for agricultural sustainability under climate and socio-economic change.
65. Narayanamoorthy, A., & Hanjra, M. A. (2006). Rural infrastructure and agricultural output linkages: A study of 256 Indian districts. *Indian Journal of Agricultural Economics*, *61*(3), 444–459.
66. Narula, S. A., & Bhattacharyya, S. (2017). Off-grid electricity interventions for cleaner livelihoods: A case study of value chain development in Dhenkanal district of Odisha. *Journal of Cleaner Production*, *142*, 191–202. http://doi.org/10.1016/j.jclepro.2016.07.176
67. Nonvide, G. M. A., Sarpong, D. B., Kwadzo, G. T. M., Anim-Somuah, H., & Gero, A. F. (2017). Farmers' perceptions of irrigation and constraints on rice production in Benin: a stakeholder consultation approach. *International Journal of Water Resources Development*, *0627*(May), 1–21. http://doi.org/10.1080/07900627.2017.1317631
68. Nyaga, J., & Nzulwa, J. (2017). Strategic factors affecting access to credit facilities by smallholder dairy farmers in. *Journal of Management*, *4*(2), 865–888.
69. Ojochenemi, P. A., Gabriel, R., & Ogwuche, J. (2017). An Analysis of Women Farmers in Rice Production in Donga Local Government Area of Taraba State. *International Journal of Emerging Trends in Social Sciences*, *1*(1), 16–21.
70. Okonya, J. S., Syndikus, K., & Kroschel, J. (2013). Farmers' perception of and coping strategies to climate change : Evidence from six agro-ecological zones of Uganda. *Journal of Agricultural Science*, *5*(8), 252–263. http://doi.org/10.5539/jas.v5n8p252
71. Osanyinlusi, O. I., & Adenegan, K. O. (2016). The determinants of rice farmers' productivity in Ekiti. *Greener Journal of Agricultural Sciences*, *6*(2), 049–058.
72. Owens, T., Hoddinott, J., & Kinsey, B. (2003). The impact of agricultural extension on farm production in resettlement areas of Zimbabwe. *Economic Development and Cultural Change*, *51*(2), 337–357. http://doi.org/10.1086/346113
73. Ozor, N., Umunakwe, P. C., Ani, A. O., & Nnadi, F. N. (2015). Perceived impacts of climate change among rural farmers in

Imo State , Nigeria. *African Journal of Agricultural Research*, *10*(14), 1756–1764. http://doi.org/10.5897/AJAR2015.9618

74. Pandino, G., Barbagallo, R. N., Lombardo, S., Restuccia, C., Muratore, G., Licciardello, F., … Mauromicale, G. (2017). Quality traits of ready-to-use globe artichoke slices as affected by genotype, harvest time and storage time. Part I: Biochemical and physical aspects. *LWT - Food Science and Technology*, *76*, 181–189. http://doi.org/10.1016/j.lwt.2016.10.056
75. Pender, J., & Gebremedhin, B. (2007). Determinants of agricultural and land management practices and impacts on crop production and household income in the highlands of Tigray, Ethiopia. *Journal of African Economies*, *17*(3), 395–450. http://doi.org/10.1093/jae/ejm028
76. Petropoulos, S. A., Ntatsi, G., & Ferreira, I. C. F. R. (2016). Long-term storage of onion and the factors that affect its quality: A critical review. *Food Reviews International*, *9129*(January), 87559129.2015.1137312. http://doi.org/10.1080/87559129.2015.1137312
77. Pieri, F. (2010). *Essays on productivity and efficiency analysis*. *European Journal of Pharmaceutics and Biopharmaceutics*. http://doi.org/10.1016/S0939-6411(07)00045-8
78. Qaim, M., & Zilberman, D. (2003). Yield effects of genetically modified crops in developing countries. *Science*, *299*(5608), 900–902. http://doi.org/http://dx.doi.org/10.1126/science.1080609
79. Ragasa, C., & Chapoto, A. (2017). Limits to green revolution in rice in Africa: The case of Ghana. *Land Use Policy*, *66*(April), 304–321. http://doi.org/10.1016/j.landusepol.2017.04.052
80. Roberts, L. C., Otieno, D. J., & Nyikal, R. A. (2017). An analysis of determinants of access to and use of credit by smallholder farmers in Suakoko district , Liberia, *12*(24), 2093–2100. http://doi.org/10.5897/AJAR2017.12386
81. Segun, F. B., Omotesho, O. A., Bello, T. A., & Dayo, A. P. (2008). An economic survey of rural infrastructures and agricultural productivity profiles in Nigeria. *European Journal of Social Sciences*, *7*(2), 144–157. http://doi.org/Export Date 9 July 2012\nSource Scopus

82. Sheng, L., Shen, D., Luo, Y., Sun, X., Wang, J., Luo, T., … Cheng, Y. (2017). Exogenous y-aminobutyric acid treatment affects citrate and amino acid accumulation to improve fruit quality and storage performance of postharvest citrus fruit. *Food Chemistry*, *216*, 138–145. http://doi.org/10.1016/j.foodchem.2016.08.024
83. Shiferaw, B. A., Kebede, T. A., & You, L. (2008). Technology adoption under seed access constraints and the economic impacts of improved pigeonpea varieties in Tanzania. *Journal of Agricultural Economics*, *39*(3), 309–323. http://doi.org/10.1111/j.1574-0862.2008.00335.x
84. Stenico de Campos, R., Simon, A. T., & de Campos Martins, F. (2019). Assessing the impacts of road freight transport on sustainability: A case study in the sugar-energy sector. *Journal of Cleaner Production*. http://doi.org/10.1016/j.jclepro.2019.02.171
85. Stewart, W. M., Dibb, D. W., Johnston, A. E., & Smyth, T. J. (2005). The contribution of commercial fertilizer nutrients to food production. *Agronomy Journal*, *97*(1), 1–6. http://doi.org/10.2134/agronj2005.0001
86. Tanaka, A., Johnson, J. M., Senthilkumar, K., Akakpo, C., Segda, Z., Yameogo, L. P., … Saito, K. (2017). On-farm rice yield and its association with biophysical factors in sub-Saharan Africa. *European Journal of Agronomy*, *85*, 1–11. http://doi.org/10.1016/j.eja.2016.12.010
87. Tashikalma, A. K., Giroh, D. Y., & Ugbeshe, V. . (2014). Swamp rice production in Ogoja Local Government Area of Cross River State , Nigeria : An imperative for rice value chain of the agricultural transformation agenda. *International Journal of Agricultural Policy and Research*, *2*(August), 281–287.
88. Thirtle, C., Beyers, L., Ismael, Y., & Piesse, J. (2003). Can GM-technologies help the Poor? The impact of bt cotton in makhathini flats, KwaZulu-Natal. *World Development*, *31*(4), 717–732. http://doi.org/10.1016/S0305-750X(03)00004-4
89. Tran, C. M., Gan, E. C. C., & Hu, B. (2016). Credit constraints and their impact on farm household welfare. *Iternational Journal of Social Economics*, *43*(8), 782–803. http://doi.org/10.1108/09574090910954864

90. Uduma, B. U., Samson, O. A., & Mure, U. A. (2016). Irrigation potentials and rice self-sufficiency in Nigeria: A review. *African Journal of Agricultural Research*, *11*(5), 298–309. http://doi.org/10.5897/AJAR2015.10284
91. Wang, J., Chen, Z. K., Gupta, D. S., & Huang, Z. (2015). "'Is small still beautiful? A comparative study of rice farm size and productivity in China and India.'" *China Agricultural Economic Review*, *7*(3), 484–509.
92. Xue, W., Lindner, S., Dubbert, M., Otieno, D., Ko, J., Muraoka, H., … Tenhunen, J. (2017). Supplement understanding of the relative importance of biophysical factors in determination of photosynthetic capacity and photosynthetic productivity in rice ecosystems. *Agricultural and Forest Meteorology*, *232*, 550–565. http://doi.org/10.1016/j.agrformet.2016.10.009
93. Zhang, H., Yu, C., Kong, X., Hou, D., Gu, J., Liu, L., … Yang, J. (2018). Progressive integrative crop managements increase grain yield, nitrogen use efficiency and irrigation water productivity in rice. *Field Crops Research*, *215*, 1–11. http://doi.org/10.1016/j.fcr.2017.09.034
94. Zhang, T., Chen, A., Liu, J., Liu, H., Lei, B., Zhai, L., … Wang, H. (2017). Cropping systems affect paddy soil organic carbon and total nitrogen stocks (in rice-garlic and rice-fava systems) in temperate region of southern China. *Science of the Total Environment*, *609*, 1640–1649. http://doi.org/10.1016/j.scitotenv.2017.06.226
95. Zhang, X., & Fan, S. (2004). How productive is infrastructure? A new approach and evidence from rural India. *American Journal of Agricultural Economics*, *86*(May), 492–501.
96. Zhou, Q., Ju, C. xin, Wang, Z. qin, Zhang, H., Liu, L. jun, Yang, J. chang, & Zhang, J. hua. (2017). Grain yield and water use efficiency of super rice under soil water deficit and alternate wetting and drying irrigation. *Journal of Integrative Agriculture*, *16*(5), 1028–1043. http://doi.org/10.1016/S2095-3119(16)61506-X
97. Zhu, Z. L., & Chen, D. L. (2002). Nitrogen fertilizer use in China contributions to food production, impacts on the environment and best management strategies. *Nutrient Cycling in Agroecosystems*, *63*(2), 117–127.