



REVIEW ARTICLE

Methods of Rice Technology Adoption Studies in the Philippines and Other Asian Countries: A Systematic Review

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Abstract: Agricultural researchers in developing countries were not able to give much attention on the adoption studies of agricultural technologies until the period of Green Revolution. These technologies are disseminated in rural farming community by agricultural extension professionals to boost farm efficiencies and productivity. This paper presents the systematic review of methods employed by previous researchers in studying agricultural technology adoption with special reference to rice. The review focuses on the study of rice technologies adoption in the Philippines and other related studies conducted by a Filipino author in other countries in the Asian Region. From 391 adoption studies identified, 22 papers were selected and included in the review. These papers were retrieved from Scopus database. This review revealed that papers focused on studying the adoption of rice cultivation practices employed quantitative techniques. Institutional factors were found to critically influence the decision-making of the farmers to adopt production technologies.

Keywords: Adoption studies; Agricultural extension; Rice; Technology dissemination; Philippines

1. Introduction

Agricultural research institutions develop new technologies which are disseminated through effective extension and mass media channels. Moreover, these technologies must reach the farms for effective adoption to realize desired benefits^[1]. Nevertheless, adoption rate of technologies related to agriculture is very low in developing countries despite the availability of numerous public interventions^[2]. The low uptake of technology among small-

holder farmers is due to lack of information and credit^[3] while the lack of knowledge explains low adoption rate of technologies^[4]. This implies that lack of knowledge critically explains low adoption rate of profitable technologies among the farmers^[2]. Similarly, adoption is not abrupt due to the presence of significant gap between the market promotion of technology and the actual use of the farmers^[5]. Rural farmers decide on the sustainability of their business and their complex decision-making process is influenced by the existence of agricultural operational methods

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and technologies ^[6]. Hence, measuring and interpreting its impact is difficult ^[7].

Awareness is an important prerequisite for adoption, however, exposure to technology is usually not random and is prone to selection bias. The exposure of an individual to technology may be due to the result of the researchers' or extension workers' selection with high possibility of being biased ^[8]. Likewise, there exists a lot of scientific researches aimed at addressing determinants of adoption of agricultural technologies. However, the way these researches are carried out is indefinite and non-cohesive ^[6]. Nevertheless, studies conducted in different countries and cultures are the same and they only vary on complexity and number of variables studied ^[5]. Therefore, this review aims to explore the different methods used by previous authors to study the adoption of various technologies for rice. Specifically, this review wants to determine the type of technologies studied by agricultural researchers, their method of analyses, and their major findings of their papers.

2. Methods

2.1 Selection of Studies for Review

The systematic review of papers related to the farmers' adoption of rice technologies is focused on agricultural practices regardless of its type. Journal articles published and indexed at Scopus database were searched using the key words that include "farmers' adoption of rice technologies" limited to year of publication, subject area, and language.

The combination of the key words such as "farmers' adoption of rice technologies and rice innovations" were used to obtain an array of information about adoption of agricultural innovations but is limited only to rice as the main subject of interest. Initially, the database has generated 391 documents that were subjected to screening.

2.2 Screening of Papers

The systematic review of agricultural technologies for

rice is in accordance with the inclusion criteria set such as: 1) The research focus on rice production intervention and technology between 2010-2018 authored by at least one Filipino researcher (if there is co-authorship) or done in the Philippines, 2) Focus on the adoption of rice technology by farmers or farming households; or technology/knowledge transferred to farming communities, 3) Research methods such as qualitative, quantitative or mixed in English language published as primary journal article in the database of Scopus Elsevier, 4) The research paper reports innovation in rice production and post-harvest activity with clear methodology and analytical procedure, 5) The study is focused on the adoption of agricultural practices or technologies for rice.

Rice production and post-harvest practices being studied are the agricultural innovations which are regarded as modern technologies that aim to improve farm productivity and farmer socio-economics to alleviate poverty and hunger among rice farmers. Papers that deal with traditional farm practices without innovative components were not included in the systematic review. The systematic review looks at the studies only focused on innovative agricultural practices but excluded impact and adoption intensity ^[9]. From the total of 391 documents initially obtained, 166 papers were removed following the restrictions on the year of publication and is furthered narrowed down to 157 after removing duplicates. Moreover, only 126 papers are published as primary journal article in which 26 are either authored by at least one Filipino researcher or the researches were conducted in the Philippines. The remaining 26 articles were screened and evaluated if they qualify for review. Finally, another four articles were excluded following the Population, Intervention, Comparator, Outcome and Study Design (PICOS) format ^[9] (see Table 1). A total of 22 articles were used in the systematic review following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta- Analyses) 2009 flow diagram ^[10] (Figure 1).

Table 1. Inclusion and exclusion criteria for the systematic review.

PICOS	Inclusion criteria	Exclusion criteria
Population	Rice farmers/Rice farming households	Consumers, Traders, Agents, Processors, Extension workers
Intervention	Innovative rice practices/technologies/interventions at farm level	Off-farm/Non-farm level interventions (i.e. marketing and off-farm processing)
Comparator	Traditional practices/Indigenous Knowledge	None
Outcome	Adoption rate, Productivity, Yield	None
Study Design	Statistical techniques/models in assessing adoption and its determinants	None

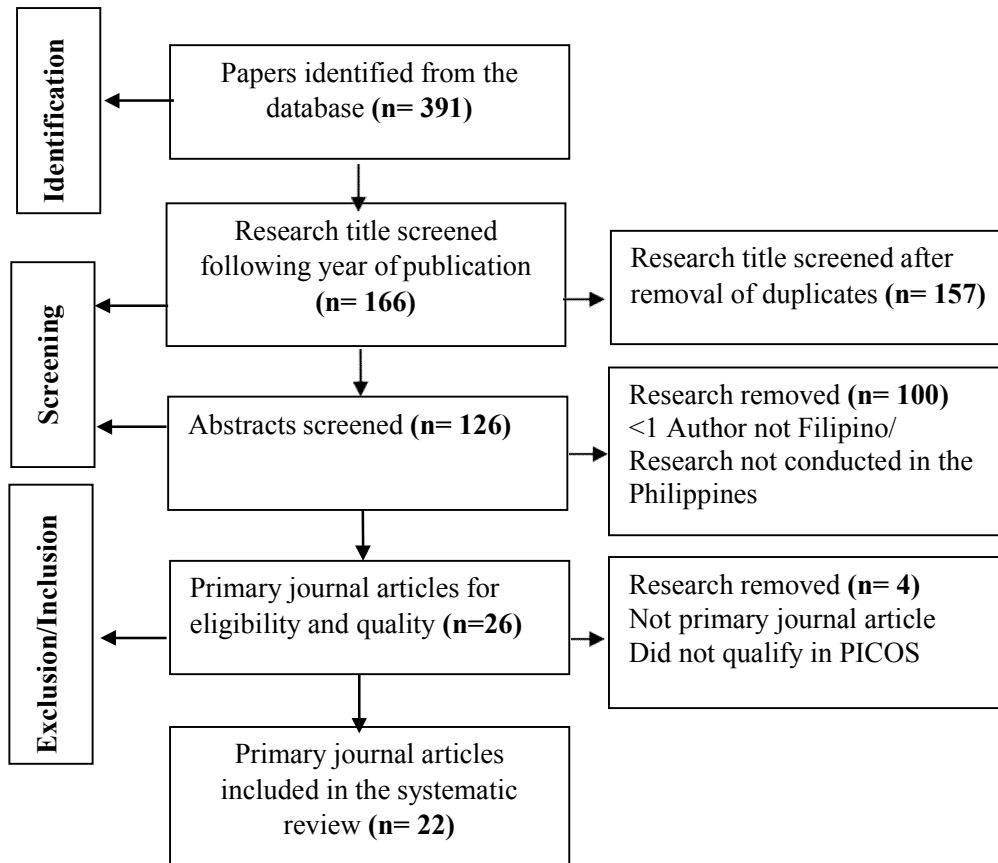


Figure 1. Process of paper screening using PRISMA.

2.3 Acquisition of Data

From the screened papers used in the systematic review, important data were obtained from each journal articles consistent with the purpose of the review. These data include the type of technology or intervention, the method of research and statistical analysis or model and the major findings of the research paper.

2.4 Attributes of the Pre-selected Papers in the Review

The succeeding tables present the attributes of 391 papers that were pre-selected for systematic review. Following the format provided by the Elsevier’s Scopus database, documents were categorized in terms of access type, year of publication, subject area, document type, source type, origin, and language. From Table 2, majority of the papers (88.49%) searched from the data base are not open access and require permission or payment. From these selections, most (42.45%) of the papers were published prior to the year 2010 as presented in Table 3. In terms of subject area, majority or 65.73% belong to the discipline of Agricultural and Biological Sciences. In the

data base, it is possible for a document to have duplicates wherein one research paper is categorized to multiple disciplines or subject area (Table 4). Majority of the papers’ document and source type are articles (81.33%) from journals (88.75%) (Table 5). Moreover, Table 6 shows that majority of these publications are journal that may consist of original articles or reviews. In Table 7, the origin of the papers was identified according to the country or territory where it was published. Based on the result of pre-selection, most of the documents were published in India and the Philippines (24.04 percent and 17.14 percent, respectively). With that, it can be inferred that most adoption studies in rice technologies originate from these countries given also that their economies are dependent to agriculture, specifically in rice production. Finally, majority (97.70%) the documents searched from the data base were written and published in English language (Table 8).

Table 2. Access type of pre-selected papers.

Access Type	Number of Documents	Percentage
Open Access	45	11.51
Other	346	88.49

Table 3. Year of publication of pre-selected papers.

Year of Publication	Number of Documents	Percentage
2018	39	9.97
2017	35	8.95
2016	40	10.23
2015	24	6.14
2014	13	3.32
2013	15	3.84
2012	23	5.88
2011	20	5.12
2010	16	4.09
Prior to 2010	166	42.45

Table 4. Subject area of pre-selected papers.

Subject Area	Number of Documents	Percentage
Agricultural and Biological Sciences	257	65.73
Social Sciences	110	28.13
Environmental Science	99	25.32
Econometrics, Economics and Finance	51	13.04
Earth and Planetary Sciences	28	7.16
Biochemistry, Genetics and Molecular Biology	22	5.63
Engineering	16	4.09
Business, Management and Accounting	11	2.81
Energy	11	2.81
Arts and Humanities	6	1.53

Table 5. Document type of pre-selected papers.

Document Type	Number of Documents	Percentage
Article	318	81.33
Review	25	6.39
Book Chapter	24	6.14
Conference Paper	19	4.86
Short Survey	2	0.51
Book	1	0.26
Article in Press	1	0.26
Note	1	0.26

Table 6. Source type of pre-selected papers.

Source Type	Number of Documents	Percentage
Journals	347	88.75
Books	27	6.91
Book Series	12	3.07
Conference Proceedings	3	0.77
Trade Publications	2	0.51

Table 7. Origin of pre-selected papers.

Country/Territory	Number of Documents	Percentage
India	94	24.04
Philippines	67	17.14
United States	50	12.79
Australia	32	8.18
Japan	31	7.93
Netherlands	21	5.37
Nigeria	21	5.37
China	20	5.12
United Kingdom	19	4.86
Indonesia	16	4.09
Others	20	5.12

Table 8. Language of pre-selected papers.

Language	Number of Documents	Percentage
English	382	97.70
Chinese	3	0.77
Japanese	2	0.51
French	1	0.26
Portuguese	1	0.26
Spanish	1	0.26
Thai	1	0.26

2.5 Attributes of Included Papers in the Review

Out of 391 primary documents compiled for review, only 22 primary journal articles that reported rice technologies and rice innovations adoption conform with the

inclusion criteria. Table 9 summarizes the journal articles included in the systematic review. After the selection of articles for the systematic review, the type of technologies studied, and the method of analyses were evaluated.

Table 9. Journal articles subjected to systematic review.

Document Title	Author/s	Year	Source
On-farm assessment of different rice crop management practices in the Mekong Delta, Vietnam, using sustainability performance indicators	Stuart, A.M., Devkota, K.P., Sato, T., (...), Beebout, S., Singleton, G.R.	2018	Field Crops Research 229, pp. 103-114
Is farmer-to-farmer extension effective? The impact of training on technology adoption and rice farming productivity in Tanzania	Nakano, Y., Tsusaka, T.W., Aida, T., Pedo, V.O.	2018	World Development 105, pp. 336-351
The application of best management practices increases the profitability and sustainability of rice farming in the central plains of Thailand	Stuart, A.M., Pame, A.R.P., Vithoonjit, D., (...), Singleton, G.R., Lampayan, R.M.	2018	Field Crops Research 220, pp. 78-87
On-farm assessment of a new early-maturing drought-tolerant rice cultivar for dry direct seeding in rainfed lowlands	Ohno, H., Banayo, N.P.M.C., Bueno, C., (...), Garcia, R., Kato, Y.	2018	Field Crops Research 219, pp. 222-228
Recognizing farmers' practices and constraints for intensifying rice production at Riparian Wetlands in Indonesia	Lakitan, B., Hadi, B., Herlinda, S., (...), Yundiyawati, Y., Meihana, M.	2018	NJAS - Wageningen Journal of Life Sciences 85, pp. 10-20

Table 9 continued

Receiving information about rice seeds on mobile phones in eastern India	Pede, V., Yamano, T., Chellattanveetil, P., Gupta, I.	2018	Development in Practice 28(1), pp. 95-106
Incorporating gender into low-emission development: A case study from Vietnam	Farnworth, C.R., Ha, T.T., Sander, B.O., (...), De Haan, N.C., McGuire, S.	2017	Gender, Technology and Development 21(1-2), pp. 5-30
A multi-stakeholder partnership for the dissemination of alternate wetting and drying water-saving technology for rice farmers in the Philippines	Palis, F.G., Lampayan, R.M., Flor, R.J., Sibayan, E.	2017	AIMS Agriculture and Food 2(3), pp. 290-309
Yield and income effects of rice varieties with tolerance of multiple abiotic stresses: The case of green super rice (GSR) and flooding in the Philippines	Yorobe, J.M., Ali, J., Pede, V.O., (...), Velarde, O.P., Wang, H.	2016	Agricultural Economics (United Kingdom) 47(3), pp. 261-271
Farmers, institutions and technology in agricultural change processes: outcomes from Adaptive Research on rice production in Sulawesi, Indonesia	Flor, R.J., Singleton, G., Casimero, M., (...), Maat, H., Leeuwis, C.	2016	International Journal of Agricultural Sustainability 14(2), pp. 166-186
Indigenous knowledge and practices for the sustainable management of Ifugao forests in Cordillera, Philippines	Camacho, L.D., Gevaña, D.T., Carandang, A.P., Camacho, S.C.	2016	International Journal of Biodiversity Science, Ecosystem Services and Management 12(1-2), pp. 5-13
Development and evaluation of the Turbo Happy Seeder for sowing wheat into heavy rice residues in NW India	Sidhu, H.S., Singh, M., Singh, Y., (...), Singh, V., Singh, S.	2015	Field Crops Research 184, pp. 201-212
Dissemination of Natural Resource Management technology for irrigated rice in the Philippines: On-farm validation to national extension	Corales, A.M., Sibayan, E.B., Palis, F.G.	2015	Pertanika Journal of Tropical Agricultural Science 38(2), pp. 219-233
Determinants of herbicide use in rice production in the Philippines	Beltran, J.C., White, B., Burton, M., Doole, G.J., Pannell, D.J.	2013	Agricultural Economics (United Kingdom) 44(1), pp. 45-55
Factors influencing farmers' adoption of modern rice technologies and good management practices in the Philippines	Mariano, M.J., Villano, R., Fleming, E.	2012	Agricultural Systems 110, pp. 41-53
Review and analysis of documented patterns of agricultural research impacts in Southeast Asia	Maredia, M.K., Raitzer, D.A.	2012	Agricultural Systems 106(1), pp. 46-58
Farmers' experiences with the use of location-specific technologies in Cabanatuan City, Nueva Ecija, Philippines	Pascual, J.V., Bumatay, E.L.	2012	Asia Life Sciences 21(1), pp. 299-315
Rice yields and yield gaps in Southeast Asia: Past trends and future outlook	Laborte, A.G., de Bie, K.C.A.J.M., Smaling, E.M.A., (...), Boling, A.A., Van Ittersum, M.K.	2012	European Journal of Agronomy 36(1), pp. 9-20
Can humans outsmart rodents? Learning to work collectively and strategically	Palis, F.G., Singleton, G.R., Brown, P.R., (...), Umali, C., Nga, N.T.D.	2011	Wildlife Research 38(7), pp. 568-578
Are irrigated farming ecosystems more productive than rainfed farming systems in rice production in the Philippines?	Mariano, M.J., Villano, R., Fleming, E.	2010	Agriculture, Ecosystems and Environment 139(4), pp. 603-610
Farmers' adoption of improved upland rice technologies for sustainable mountain development in Southern Yunnan	Wang, H., Pandey, S., Hu, F., (...), Ding, S., Tao, D.	2010	Mountain Research and Development 30(4), pp. 373-380
Assessing the impact of agricultural technology adoption on farmers' well-being using propensity-score matching analysis in rural china	Wu, H., Ding, S., Pandey, S., Tao, D.	2010	Asian Economic Journal 24(2), pp. 141-160

3. Results and Discussion

3.1 Type of Technology Studied

The papers included in the review mostly discussed on the rice cultivation technologies and practices (40.9%), irrigation and water technologies (27.27%), improved seed varieties (18.18%), and integrated pest management (IPM) (13.64%). The widespread progress of these technologies in the Philippines was prompted by the establishment of two rice research and development (R&D) institutions in the country namely Philippine Rice Research Institute (PhilRice) and the International Rice Research Institute (IRRI) ^[11-13].

3.2 Methods Used

Generally, the articles focused on the technologies for rice production specifically on crop management practices and have diversity in terms of the methods used. Majority or 54.54% applied quantitative methods specifically regression analysis, on-farm/field experiment, and technical efficiency and economic analyses. On the other hand, qualitative and mixed method both comprise the 22.72% of the papers. These studies mostly applied participatory action research (household surveys, focus group discus-

sions, key informant interview), case study, and impact assessment.

3.3 Major Findings

The result of the systematic review shows that rice technologies have mostly positive effects to farmers. Nevertheless, the systematic review reveals that the institutional factors are the most critical factors affecting farmer decisions to adopt which includes education, access to extension services, and access to technological information. Technology acceptance can be distressing to farmers especially when its relevance and expected outcomes are not properly demonstrated to them. Finally, low level of knowledge about the technology leads to resistance and poor decision-making. Below are the specific outcomes or impact of the adoption of rice cultivation practices and technology ranked according to their significance:

- 1) Improved crop management practices
- 2) Enhanced farmers' capacity and capability
- 3) Increased net income/profit and benefit-cost ratio
- 4) Addressed issues on food security and sustainable food production
- 5) Increased yield and productivity
- 6) Decreased production cost

Table 10. Type of technology, method, and major finding of rice technology adoption studies reviewed.

Author/s	Technology	Method	Major finding
Stuart et al., 2018	Good Agriculture Practice (GAP); Small Farmer, Large Field (SFLF)	Household survey Eight Sustainable Rice Platform (SRP) performance indicators, Bonferroni Test, Linear Regression	Mean total production cost per season decreased while mean net income and benefit-cost ratio increased. GAP and SFLF management approaches improved rice farming practices and was sustainable than conventional farmers.
Nakano et al., 2018	Farmer-to-farmer extension program on rice cultivation technologies	Panel survey Descriptive and Regression Analysis	New technologies were first adopted by the trained key and intermediate farmers thus, yield gap initially widened between the trained farmers and the non-trained ordinary famers.
Stuart et al., 2018	Cost Reduction Operating Principles (CROP), Alternate Wetting and Drying (AWD), Drum Seeder (DS) Technology	Farmer Participatory Field Trials, Experiment Linear Mixed Models with Maximum Likelihood Estimation, Rank Transformation, Bonferroni Test	Fertilizer, seed, and pesticide use can be reduced in intensive lowland irrigated rice growing areas by following best management practices with no yield penalty. The improved practices were found to reduce costs and increase profit.
Ohno et al., 2018	Dry direct seeding of rice (DDSR) in drought-prone lowland areas	On-farm Experiment T-test, ANOVA	Crop establishment using DDSR is affected by erratic rainfall at the onset of wet season followed by weed infestation. On the other hand, there is greater establishment rate for newly released drought-tolerant cultivar resulting to less weed infestation and higher yield.

Table 10 continued

Lakitan et al., 2018	Crop cultivation practices	Two-staged mixed qualitative method (Grounded theory and Questionnaire-guided Survey)	Technology development must be based on the needs, preference, and absorptive capacity of targeted smallholder farmers
Pede et al., 2018	Use mobile phones to obtain information about rice varieties	Quantitative Study Regression Analysis	Farmers located farther away from the market were more likely to pay for the calls. Paying charges to receive rice varietal information is associated with varietal replacement
Farnworth et al., 2017	Low-emission development (LED), Alternative Wetting and Drying (AWD) water-saving technology	Conceptual Model Development Case Study	Improved benefits for Overall contribution on GHG emission was lowered while improving farmer benefit. Women have higher access to AWD technology.
Palis et al., 2017	AWD Technology	Qualitative and Quantitative (FGD, KII, Survey) Descriptive Analysis	The adoption of AWD by farmers has not reduced their yields. Thus, it has implications on food security through addressing issues around water, while sustaining food production.
Yorobe et al., 2016	High-yielding Green Super Rice (GSR) cultivars	Matched samples from a propensity score matching method (two-year panel data) Ordinary least squares and DID fixed-effects regressions	Yield benefits from GSR varieties could improve rice food security and help alleviate poverty in the country
Flor et al., 2016	Adaptive Research (AR) project	Monitoring data examination Complementary qualitative analysis	New approaches in agricultural research require a different type of monitoring as a complement to conventional approaches that tend to favor a quantitative assessment of adoption and impact at the farm level.
Camacho et al., 2016	Indigenous knowledge and practices (<i>Muyong</i> system)	Focus group discussions (FGDs) and key informant interviews, Survey Mixed Method	The proliferation of inorganic farming technologies replaces the traditional ones, and the abandonment of rice fields and <i>muyongs</i> as farmers go elsewhere seeking other employment opportunities.
Sidhu et al., 2015	Rice-wheat (RW) cropping systems, Turbo Happy Seeder for sowing wheat into heavy rice residues	Development, Field Testing and Evaluation (Experiment) Quantitative Analysis	The Turbo Happy Seeder offers a practical and economic solution to the problem of rice straw burning in the rice-wheat systems.
Corales, Sibayan & Palis, 2015	Natural Resource Management (NRM) technologies, such as Site-Specific Nutrient Management (SSNM), Ecologically Based Rodent Management (EBRM) and Alternate Wetting and Drying (AWD)	On-farm evaluation Cost and yield analysis	PhilRice-IRRI partnership has been proven to be a powerful instrument in facilitating delivery and adoption of NRM technologies.
Beltran et al., 2013	Adoption of herbicides and the level of herbicide use	Panel Data Assessment Heckman's two-step method (estimation of a random-effects double-hurdle model for unbalanced panel data)	Determinants of both adoption and level are land ownership, farm area, and the method of crop establishment.

Table 10 continued

Mariano, Villano & Fleming, 2012	Certified Seed Technology (CSs) and Integrated Crop Management Practices (ICMPs)	Probabilistic Binary logit and Poisson model	Extension-related variables have the most significant impact on technology adoption. On-farm demonstration trials has the highest effect on the adoption of certified seeds technology. However, constraints to the adoption of CSs and ICMPs are soil and nutrient deficiencies.
Maredia & Raitzer, 2012	Impact of Agricultural research	Comprehensive search and review of the literature, In-depth review, and analysis of documented impacts of agricultural research Systematic- Quantitative Analysis	Evidence of impacts in other areas and other commodities is minor. Impacts of research on long-term developmental goals remain undocumented. There is declining trend in total documented net benefits from agricultural research.
Pascual & Bumatay, 2012	Location-Specific Technology Development (LSTD)	Impact Assessment Case Study	LSTD Project was found effective in technology transfer process as manifested by the adoption of the technology by the farmer- participants. All the interventions were effective.
Laborte et al., 2012	Production technology (cultivars)	Yield-Gap analysis method Trend Analysis	Best-yielding farmers were generally more educated than average farmers and they used production inputs more efficiently than average farmers.
Palis et al., 2011	Ecologically Based Rodent Management (EBRM)	Participatory action research (household surveys, focus group discussions and key informant interviews) Quantitative- Qualitative	The adoption of EBRM meant better rice yields, higher economic returns for farmers, and reduced human health and environmental risks
Mariano, Villano & Fleming, 2010	Irrigated farming ecosystems and Rainfed farming systems in rice production	Stochastic meta- frontier Productivity-Technical Efficiency Analysis	Farms in the rainfed farming ecosystem achieve productivity levels only slightly different from those of farms in the irrigated farming ecosystem. Some farms in both ecosystems were able to achieve the highest possible output with respect to the meta-frontier in all the seasons studied.
Wang et al., 2010	Improved upland rice varieties and terraces	Household Survey Case Study	Farmers who have adopted both technology components have been able to increase the upland rice yield substantially. Income from rice production was similarly found to be higher for adopters than for nonadopters.
Wu et al., 2010	Improved upland rice technology	Impact Assessment Propensity score matching analysis	Improved upland rice technology has a robust and positive effect on farmers' well-being, as measured by income levels and the incidence of poverty

4. Conclusions

This paper reports the systematic review on the methods used by agricultural researchers in studying rice technology adoption in the Philippines and other Asian countries. It focused on the specific type of technology studied, the method of analyses, and the major findings of the researches. Papers were focused on studying the adoption of rice cultivation practices and technologies us-

ing quantitative method. The review highlights the role of institutional factors which is found to mostly influence the decision-making of the farmers to adopt technology. Hence, the findings of this review can serve as the basis of agricultural extension professionals in the academe, local government, and the private sector to strengthen the strategies of technology dissemination to the rural rice farmers. Rice cultivation technologies and practices are

the most studied research topics using applied quantitative methods. The adoption of these technologies mainly improved crop management practices and farmers' capacity and capability which led to increased net income or profit and benefit-cost-ratio. Since institutional factors were found to be critical in farmer decision-making, education, access to extension services, and access to technological information related to rice cultivation practices and technologies can be further intensified.

Conflict of Interest

There is no conflict of interest.

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