Impact of Technology Innovation on Rice Yield Gap in Asia and West Africa: Technology Transfer Issues

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Abstract

This paper examines the impact of technology innovation on rice yield gap in Asia and West Africa countries. This is based on the premise that rice now accounts for the 22 percent of world's caloric intake and the significant role played in Asia Green revolution as well as the potential role in the expected Africa Green revolution. International, regional and national research organizations have collaborated research efforts in the last decade for increasing rice production, productivity and adaptation to marginal areas. Despite the volume of research and collaboration, the problem of wide gap between potential and actual yield persists. Yield gap has been attributed to biophysical, socioeconomic, institutional, policy and technology transfer and linkage factors. Reducing yield gap will increase rice productivity, improves land and labour use, reduces production costs and increases sustainability. Data collected on the technology transfer and linkage factors operationalised as the extension activities of Japan, Thailand , Nigeria and Ghana were regressed on rice yield gap from 1980 – 2002. The yield gap was determined as the difference between the potential yields and the actual yield. In some cases the gap was taken to be the difference between maximum attainable and the farm level yields. Important predictors of rice yield gap for each country were identified. These include extension agent, farmer ratio, extension funding, extension intensity, ratio of demonstration center to farmers and the ratio of subject matter specialists to extension agents. These factors have implications for the appropriateness of technology to the farmers' environment and the effective transfer of technology and knowledge to the farmers. The paper concludes with pragmatic steps of how the identified factors can be incorporated into the sustainable increase of rice productivity.

2 Introduction

Rice as a crop was originally cultivated in the foothills of the Himalayas, the northern border between Thailand and Myanmar and the border between Viet Nam and China and has fed humankind for 10, 000 years (CHANG, 1985 AND MATSUO, 1997). The Asian region produces and consumes more than 90% of the world's rice. Over 3 billion Asians obtain about 27% of their caloric intake, 20% of dietary protein and 3% of dietary fat from rice and its derived products (KENNEDY ET AL., 2004). The Green Revolution benefited many Asian countries and helped avoid periods of potential starvation; and ameliorated rural and urban poverty by reducing the cost of production by 30% due to technical improvements and decreasing the price of rice by 40%, resulting from sizeable gains in global production through the late 1990s (RAP, 2003). Recently, the popularity of rice as food has increased in a number of countries in Africa, America, and Europe where rice is not traditionally a major food crop. In 2002, more than half of the world's population depended on rice as their major daily source of calories and protein.

Rice as a unique crop in the West African food systems is experiencing rapid growth in per-capita consumption triggered by constraints in the supply of traditional cereals since the early 1970s (WARDA 1997). This impressive growth has largely been due to increasing urbanization, where rice has a comparative advantage in terms of ease of cooking and caloric value. Rice is also unique as a large proportion of its supply depends on imports as a result of an increasing gap between local supply and demand. The consumption of traditional cereals, mainly sorghum and millet, has fallen by 12 kg per capita, and their share in cereals used as food decreased from 61% in the early 1970s to 49% in the early 90s. In contrast, the share of rice in cereals consumed has grown from 15% to 26% over the same period. Growth in regional rice consumption remains high, the FAO projects the annual growth rate to be 4.5% through the year 2000. This means that the total volume of rice consumed in West Africa is likely to increase by 70% over this decade (RICE WEB 2001).Rice production in this region has also marked a high growth rate relative to other cereals, but the gap between regional supply and demand for rice has been increasing. As a result, rice imports reached an average of 2.6 million tons in the early 1990s. During the last decade, local production satisfied an average of 50% of the total demand, whereas the figure is above 75% and close to 95% for other staple crops. There is therefore the need to reduce this food dependency and to accelerate the growth of local rice production.

Research activities on rice has recorded the contribution and collaboration of several organizations such as SATMACI, SODERIZ, RIZ NORD, GIDT, GIVC, JIRCAS, ORSTOM, IITA, IRRI, CIRAD, JICA, JADEA, IRAT, WARDA, and CORAF. Research on rice in West Africa has been the exclusive preserves of National programs, Research institutions from developed countries,(CIRAD and ORSTOM) and International Agricultural Research Centers,(WARDA, IITA, and IRRI) (VIRMANI ET AL, 1978). During the period 1980 to 1992, rice researchers from CIRAD covered Cote de voire, Nigeria, Burkina Faso, Came Ghana, Guinea, Madagascar, Mali, Niger, and Senegal, while, ORSTOM covered Cote de Ivoire and Senegal. IITA in Nigeria conducted a full range of research on rice in upland, hydromorphic, rain-fed, and irrigated lowland ecosystems until 1990 (MATLON ET AL 1998).

WARDA currently conducts the largest program of variety generation. Upland rice breeding activities are centered in Cote de Ivoire and breeding for lowland rice in Nigeria on IITA’s main research station. The primary locus of variety improvement research for the mangrove swamp environment has been the Rice Research Station at Rokupr, Sierra Leone, where British and Sierra Leonean scientists have worked since the 1930s, and where WARDA was based from 1977 until 1993. The initial strategy was to select from among introductions and regional varieties that showed good adaptation to the hydrology and adverse soils of this ecosystem. In the early 1960s, the Sierra Leone national program also began a program of hybridization, which was reinforced by WARDA after 1976 (MATLON ET AL, 1998). DALTON AND GUEI (2003) noted that regional collaboration has produced a considerable number of new varieties for two ecologies: the mangrove swamps and irrigated lands. The CGIAR, IRAT and Rokupr Rice Research Station have produced considerable number of improved varieties. The Asian national programs have also introduced many varieties to West Africa. An important source of released varieties is traditional varieties introduced from one nation to another within the region.

TRAN AND NGUYEN (2000) reported that after decades of remarkable rice production, growth has slowed in Asia; DALTON AND GUEI (2003) also reported that in West Africa, after 20 years of continuous efforts and investment in the intensification of rice-based systems, the rice deficit stabilized at around 50% of the total rice consumption, but the success of capital-intensive rice technologies was very unequal and did not meet expectations in that the gap between farmers’ fields and the potential yield has not been reduced. The Expert Consultation on Yield Gap and Productivity Decline in Rice Production, convened by FAO in Rome in 2000, recognized that there is a sizeable yield gap between attainable and farm-level yields across the ecologies, the regions, within ecologies and the crop seasons in many rice growing countries. The yield gap between attainable and farm-level yields ranges from 10 to 60 percent. Rainfed, flood-prone and problem soil ecologies have the highest yield gaps, but these tend also to be the least exploitable gaps.

FAO, (2000) reported that the causes of yield gaps can be classified according to their nature and the degree to which they contribute to the gaps. These include Biophysical factors such as climate/weather, soils, water, pest pressure, weeds and Technical/management factors which comprises of tillage, variety/seed selection, water, nutrients, weeds, pests, and post-harvest management. Others are socio-economic factors (socio-economic status, farmer's traditions and knowledge, family size, household income/expenses/investment) and Institutional/policy factors in terms of government policy, rice prices, credit, input supply, land tenure, market, research, development, extension; as well as Technology transfer and linkages factors that consist of the competence and facilities of extension staff; integration among research, development and extension; farmers' resistance to new technology; knowledge and skills; weak linkages among public, private and non-governmental extension staffs.

GOMEZ ET AL., 1979 identified two types of yield gaps between experiment station and farmers' fields, depicted as Gap 1 and 2. Gap 1 is attributed to environmental differences and referred to as "non—transferable technology" while Gap 2, is the difference between potential and actual farmer yields, which constitutes the true research—extension gap due to combinations of biological, technical, and socioeconomic constraints. EVENSON, (1997) described three types of yield gaps namely extension gap- the difference between best practice (BP) and average (A) yields; the research gap is the difference between research potential (RP) yields and best practice (BP) yields and science gap exists between science potential (SP) and research potential (RP) yields. LIN AND SHEN (1995) reported two kinds of yield gaps. Yield gap I is the difference between the maximum yield obtained on an experiment station and the potential average yield that may be achieved under favorable farm conditions in a region while Yield gap 11 is the difference between average farm yields and yields attainable under favorable conditions for all farm-controlled varieties. All the authors generally reported that Extension and applied research programmes are designed to reduce the different types of yield gaps.

Narrowing yield gaps not only increases rice yield and production, but also improves the efficiency of land and labour use, reduces production costs and increases sustainability. Exploitable yield gaps in rice can be improved effectively through adopting participatory and holistic approaches to activities and actions and through government attention. An integrated programme approach is essential. The narrowing of the yield gap is not static but dynamic, and includes technological developments in rice production because gaps tend to expand when the yield potential of rice varieties is improved. While efforts are made to raise the yield ceiling, there is an even more pressing need to address the yield gap (DUWARI, TRAN AND NGUYEN, 1998). A yield gap reduction can be seen as the local solution to a global problem. It can lead to increased production with the additional incentives of cost reduction, poverty alleviation, social justice, and equity. While no major breakthrough is expected immediately, reducing the yield gap alone could supply 60 percent of the increased annual rice demand by the year 2025 (FAO 2004).

Several studies have examined how the biophysical, socio-economic, technical/management, and institutional/policy factors cause the yield gaps with little emphasis on the technology transfer and linkages. To supplement the biological, socioeconomic, institutional and policy studies an investigation into the effectiveness of technology transfer and linkage mechanism is of vital importance. The technology transfer and linkages constraints may explain why the interface expected among the factors causing yield gap is not functional. Based on the above scenarios, the objective of this study is to determine the impact of extension services on rice yield gap in Nigeria Ghana Japan and Thailand. The specific objectives are: To compare the management style of extension delivery systems and determine the influence of extension services indicators on rice yield gap in the countries under study

3 Methods and Data

This study covers four countries namely Japan, Thailand, Nigeria, and Ghana. These countries were selected based on collaborative research work on rice production between these countries and the ensuing scenarios with respect to the effectiveness of the national extension system to efficiently scale- up the innovation uptake towards ensuring food security. The differences in terms of the level of institutions, infrastructure, and economic development were recognized and standardized. Technological break-through of the Green revolution period increased the potential yield to 5-7t/ha and in the late 1980s it became 10-11t/ha in the Asian region (FAO 2004). Similarly, the activities of WARDA in the introduction and adaptation of new varieties brought significant increase in the potential yields of rice in West Africa from 4 in the 1980s to 6 t/ha in the early 1990s. The yield represents the average for all ecologies (WARDA 1997).

Ghana is at the lowest level of in terms of rice production, therefore yield gap is determined as On farm adaptive research yield – actual farmers yield. A yield of 5.2 t/ha and 3.3t/ha were reported for on -farm trials for rice in irrigated and rain fed lowland ecologies. Nigeria and has enjoyed some form of prominence in rice research such that yield gap is depicted as (EVENSON 1997) Best practice, Best infrastructure yield – actual yield. The Best practice, Best infrastructure yield is in turn defined as the average of the yield potential range as some farmers sometimes attain best practice yield. It then implies that 2 becomes (EVENSON,1997). Average of yield potential range – actual yield. Japan and Thailand have the favourable and enabling environment for the full realization of the research potential yield of rice. They have also benefited from the Green Revolution of the Asia world. Yield gap is thus calculated as Research potential/expected yield – actual yield.

This study use secondary data to explain the influence of extension service indicators on rice yield gap. The empirical analysis adopted the multiple regression equation using the linear function. EVENSON, (1997) reported that extension variables (although not specific to rice) have impact on farm productivity in 7 African, 8 Asian and 3 Latin American countries using a production function of **Z = a + bEXT + cSCH + d(EXT)(SCH) + eRES + f(EXT)(RES)**. Where Z is defined as the farm productivity, extension (EXT), schooling (SCH), and research (RES).

Data from 1980 -2002 were obtained on the following extension variables: use of Information communication technology, type of extension system, provision of feedback and strength of linkage between research, extension, and farmers. Others are number of farmers, ratio of extension agents to farmers, number of subject matter specialists, number of extension office/center, number of extension agents/advisor, ratio of extension center to farmers, number of demonstration plots established, extension funding and the ratio of extension funding to the national budget (Extension intensity). In order to overcome the problem of multicollinearity, 4 out of the variables were fixed into the regression equation to determine yield gap (YGAP). These are ratio of extension agent to farmers (EAF), ratio of subject matter specialist to extension agents (SMSEA), ratio of extension center to farmers (CENF) and extension intensity (EI). The equation is stated as $YGAP = bo + b_1EAF + b_2SMSEA + b_3CENF + b_4EI + U_1$

4 Results and Discussions

Table 1 presents the result of the multiple regression analysis of the impact of extension services on rice yield gap in Nigeria and Japan. Significant relationships were recorded between the extension service indicators and rice yield gap.

Table 1: Influence of extension services indicators on rice yield gap

	Nigeria	Japan	Thailand	Ghana
Constant	-3.06 (-0.15)	0.26 (0.28)	2.96(3.10***)	5.21(6.69***)
EAF	- 16.95 (-2.82**)	62.52 (0.61)	0.10(2.84***)	0.31(1.47*)
SMSEA	18.95 (0.07)	38.89 (2.60**)	3.17(0.69)	0.22(4.22***)
CENF	25319.31 (1.04*)	627.57 (2.43**)	0.03(0.65)	0.03(1.03)
EI	350.16 (2.95***)	54548.2(1.26)	0.45(5.55***)	0.08(3.35***)
R^2	0.86	0.73	0.61	0.80
Adjusted R^2	0.66	0.67	0.59	0.78
F	9.77	11.89	57.37	36.68
SE	0.93	0.74	1.01	0.82
DW	1.25	1.35	1.22	1.63
Observations (n)	23	23	23	23

Data in parentheses are associated t values; *** 1% significance, ** 5% significance, * 10% significance.

The ratio of extension agents to farmers shows significant impact of rice yield gap in Nigeria, Thailand and Ghana. . This implies that farmers can reduce rice yield gap by a decrease in the ratio of extension agents and farmers. However in Japan, the ratio of extension agents to farmers has no effect on the rice yield gap. This may be attributed to a low ratio of extension advisors to rice farmers that already existed. The ratio of subject matter specialists to extension agents show significant impact in Japan and Ghana. This stresses the fact that as more technical knowledge and information are transferred by the subject matter specialists, the rice yield gap will be greatly reduced. In Nigeria and Thailand however, the ratio of subject matter specialists to extension agents has no impact on the rice yield gap.

For Nigeria and Japan, the ratio of extension center/office to farmers show significant effect on the reduction of rice yield gap, with Japan showing a stronger impact than Nigeria due to significance levels of 5 and 10 percent respectively. This result underscores the importance of extension centers as the hub of extension activities in the localities such that their number should be increased and activities enhanced more for greater effectiveness in the two countries. Extension intensity, which is a measure of the funding of extension activities, shows significant impact on the reduction of rice yield gap in Nigeria, Thailand and Ghana. This result may be due to the fact that the effectiveness and efficiency of extension activities strongly revolves round the available funds for such activities, which has been a limiting factor in the developing countries to which these countries belong. The non-significance of the influence of extension funding on rice yield gap in Japan emphasizes the timeliness and adequacy of funds release for extension activities by the national and the prefecture governments.

5 Conclusion

This study adds to the literature on reduction of rice yield gap by showing the Technology transfer and linkages factors that influence rice yield gap for Japan, Nigeria, Thailand and Ghana.. It has been able to empirically provide insights in to the impacts of extension service indicators on the reduction of rice yield gap. The study has also paved ways into which different perspective to explaining rice yield gap from technology transfer issues could be examined. From the model applied in this paper, the result has shown that important variables that stimulate yield increase could turn around to cause yield gap. It is therefore important that technology transfer issues should not be neglected or treated as an appendage of research efforts to overcome the problems of yield gap and declining productivity.

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