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Adoption and Introduction of Rice in Rwanda

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1. INTRODUCTION: EMPIRICAL RESEARCHES

Van den Ban and Hawkins (1988) conducted a study on adoption and diffusion of intervention, the study intended to investigate decision making pathways that individuals follow when making decision on whether or not to adopt an innovation; important sources of information and differences among people who adopt innovations quickly or slowly and characteristics of innovations that affect the rate of adoption as well as the way potential users share information about innovations the way innovation diffuse through a society over time. To date a lot of empirical researches have been conducted on adoption of innovations and differences have been established between adopters based on personal, social and cultural characteristics [2]. However, there was no consensus on key factors which favor or hinder adoption decision at a particular place and time. Therefore, empirical review of literature helps to assess the current state of art of the adoption process and to discuss findings and results of investigation [4].

[6] studied banana farming system in Rwanda, and agricultural innovations related to banana plantation. Banana is cultivated by a large number of smallholders in Rwanda and has multiple functions as food and cash crop; but it is also useful in preventing erosion and ensuring soil fertilization. Semi-structured interviews were conducted with farmers living in Gatore sector (Kirehe district) in the Eastern province of Rwanda. The sample included traditional farmers and innovative farmers and reasons behind their cultivation practices as well as challenges they face in adopting new agricultural practices. Traditionally, banana plantation in the Great Lakes region consists of mixed cropping whereby banana groves intercropped with food crops like beans. There are three types of banana: the beer banana, the cooking banana, and the dessert banana.

2. RICE DEVELOPMENT RESEARCH AND DIFFUSION

Researches on rice development and diffusion are mainly conducted by International Rice Research Institute (IRRI) a non-profit organization established in 1960 by the Ford and Rockefeller Foundations. The institute is among 16 nonprofit international research centers sponsored by the Consultative Group on International Agricultural Research (CGIAR) which is also cosponsored by the Food and Agriculture Organization of the United Nations (FAO) and the International Bank for Reconstruction and Development (World Bank), the United Nations Development Programmed (UNDP), and the United Nations Environment Programme (UNEP) [8].

IRRI scientists developed short stiff-straw rice varieties that are well adapted to fertilizer applications and most of tropical rice varieties were tall and tended to fall over when fertilizer was applied. IRRI breeders also introduced semi-dwarfism into indica rices. In most Asian countries they have established national breeding programmes; countries like China and Japan recognized the importance of rice and rice related research even before the current development in genetic engineering [10].

Genetic improvement of rice in Africa can be traced back to mid – 1930s with the Rokupr Research Station in Sierra Leone for regional mangrove improvement [13]. In China, breakthroughs in varietal improvement and technological progress happened much earlier than in other Asian nations. The first semi-dwarf rice variety was bred in 1957, and by 1965 almost all of the early-season rice area was sown to high-yielding varieties in Guangdong Province, Research on hybrid rice was also initiated in China, and the breakthrough was made in 1974. The potential 15-20% yield advantage of hybrid rice over conventional high-yielding varieties caused a rapid expansion of area under hybrid rice for indica varieties (to 41% of the total rice area by late 1980s), which was the main factor behind the expansion of rice yield since 1976. The development of seed production capacity in the public sector was the main factor contributing to rapid expansion of hybrid rice production in China [8]. The following table depicts the milestones of green revolution and improvement in rice cropping.

Table 2. 1 Milestones of green revolution and rice cropping improvement

Phases	Improved seed and increased input use
Phase I	IR8 and the beginning of high yielding varieties
	Investment in irrigation
	Policies to support inputs of nutrients and pesticides
	Seed multiplication infrastructures and seed distribution by extension systems
	Training of rice scientists
	Rice genetic resources collected and conserved
Phase II	**Increased input use intensity**
	Shorter duration, photoperiod-insensitive rice cultivars
	Protecting yield gains from pests
	Increased mechanization for land preparation and threshing
	Introduction of the farming systems methodology
	International sharing and testing of rice germplasm
Phase III	**Shifting the yield frontier, input efficiency, and sustainability**
	Requirements of new green revolution

Source: (Pingali & Hossain, 1998)

For the phase I, rice research leading to the green revolution is well known. It was characterized by a focus on increasing the "pile of rice" through shifting the yield frontier of rice in the tropics, providing irrigation infrastructure and inputs of nutrient and pesticides, and training local extension technicians in the ways of the new generation of rice production technologies.

For the second phase II, this phase concentrated on reducing the growing period of cultivars. A consequence of the crop improvement process to increase yields and to develop cultivars that were photoperiod-insensitive (i.e., broadly adopted over large areas) was a shortening of the duration of the crop. The variety IR8 showed advantages over many traditional rice varieties in shorter growth duration (130 vs 160-170 d to maturity); it was photoperiod-insensitive and produced about 70 kg of rice per day. Later IR varieties, such as IR36, IR64, and IR72, which are now widely grown, are also photoperiod-insensitive, mature in 100d, and produce about 90 kg/day [8].

Despite all reported potentialities and achievements, rice demand growth outpaces rice economic production and requires development of HYVs with different characteristics such as flood and droughts resistance, The rice yield of the irrigated ecosystem should increase of about 8.0t/ ha by the year 2025 [8]. The context for agricultural research has been changing over time due to emergence of new technologies, advancement of scientific knowledge, biotechnological development as well as advances in understanding of biological processes. Other dynamics include changing legal views of intellectual property rights. Also more investments have been poured into agricultural research by different institution to ensure advances in biotechnology [10].

Sub-Saharan Africa are also involved in monitoring the adoption. Different varieties of rice from Asia have been adopted in Africa, especially the semi-dwarf, short-duration high yielding varieties of rice [13]. Globally. The rice development brings an opportunity to address and alleviate by half food-insecure people estimated at around 860 million, in line with the Millennium Development Goal which aims at eradicating poverty and hunger [3].

3. INTRODUCTION OF RICE IN RWANDA

Rice started being cultivated in Rwanda around 1950s introduced by the Chinese, during the "Formose" mission in Bugarama in Cyangugu and Kabuye regions. Later on, several rice diffusion schemes were spread in different parts of the country [5]. During the 1970s, the Chinese government continued to support rice production in Rwanda. A Chinese rice variety known as Keng Diao 3 was diffused in the country until 1980s when rice blust attacked and infected this rice variety causing a lot of damage to Rwanda rice production causing testing and introducing new rice cultivars from Madagascar, Cameroon, Korea, Japan, and other Chinese varieties. New varieties introduced were Xinan (Xinun) 175, YunKeng136, and Yunertian01 selected for their high yields. Yun Keng 136 and Yunertian 01. These varieties were derived from Xinan175. Xinan 175 was also derived from Japonica varieties developed by Taiwan's Xinan Agricultural Research Institute during 1950's. Basmati rice were

grown in 1980s, and varieties of long-grain rice from some areas of Western Africa were introduced to Rwanda [13].

4. ADOPTION OF RICE IN RWANDA

Rice was adopted in Rwanda following exploitation of marshland ecosystems. The Rwandan marshlands have altitude ranges varying from 1,000 m to more than 1,700 m above mean sea level (MSL). Marshlands in Rwanda are also characterized by high relative humidity, cool night temperatures (10 to 15ºC), warm day temperatures (20 to 30ºC), and frequent rainfalls. The climatology of Rwanda includes two rainy seasons from September to November (Planting season A) and from March to April (Planting season B). Rice is planted during the season A and B. Although rice has been adopted from outside Rwanda, it has become a popular choice for food in schools, homes, restaurants, and public ceremonies. Factors such as rise in income levels, growing urban population, and changing lifestyles have also influenced rice consumption (MINAGRI, 2013).

The government of Rwanda has recognized the importance of rice and has made it a priority under Rwanda agriculture sector development [7]. Also the Government of Rwanda introduced the Strategic Plan for Agricultural Transformation (PSTA) and the framework for enhancing agricultural development, with their goals aligned with achievements on the goals of Rwanda's Vision 2020 and medium-term strategies, such as Economic Development and Poverty Reduction Strategy [1].

5. ADOPTION OF RICE IN KIREHE DISTRICT

Kirehe possesses the second largest marshlands area of 9,457 ha after Bugesera which holds marshlands covering 13,644 ha (MINAGRI, 2013), due to agricultural development projects taking place in Rwanda, several marshlands have been rendered to farmers for rice plantation [1]. Kirehe District, alongside Gatsibo, Nyagatare, and Bugesera have allocated larger land to rice cropping compared to the rest of the country. Kirehe also counts a great number of low-input and low-risk smallholders abundant in rice farming (SFSA, 2012). The government of Rwanda has provided more inputs for agriculture such as high yielding seeds varieties, pesticides, fertilizers. Also some international research collaborations have contributed modestly to the improving rice production in marshlands [1]. The adoption of rice production owes also to the enhancement of food security as staple food and its commercial viability (KirehеDistrict , 2015).

A project known as The Kirehe Watershed Management Project (KWAMP) is among the projects designed to ensure agricultural production. Those projects are part of the Government's program to improve agricultural investment in line with national development [1]

6. RICE INTENSIFICATION IN RWANDA

Rice productivity in Rwanda, like that of other crops is enhanced by agricultural development strategies and policies. Agricultural development emphasized on efficient use of arable land by village community through "Imidugudu" policy which consisted in changing settlement patterns of farmers from scattered to grouped settlements along roads side. Also the crop intensification program consisting of changing cultivation pattern from farming any crop to cultivating crop purposely designated for a particular area by prohibiting mixed plantation or intercropping, to achieve modern mono-cropping cultivation. These programs have considerably changed the rural landscape. Also the agricultural intensification programs have led to maintenance of marshland and improvement of irrigation schemes and drainage systems, as well as improved fertilizer supply [9].

To nurture rice productivity, the sustainable management of the watersheds is meant to take into account an upstream to downstream response that equally takes into account the wetlands. Towards this end, the PAPSTA and KWAMP projects adopted the Intensive Rice Cultivation System (IRPS) for the sustainable development of wetlands. The Intensification of Rice Production System is a rice production process which combines different techniques that helps in ensuring (i) an intensive, (ii) sustainable production (iii) at minimal costs. The formation of this triptych is made possible through the combination of the following complementary techniques: (i) seed preparation, (ii) preparation of paddy-fields, (iii) sowing, (iv) transplanting, (v) water management, (vii) weekly weeding, (viii) fertilizer application, (ix) disease and pest control (insects, weeds), (x) paddy-field security (xi) harvest. The mastery and application of these additional farming techniques helps in increasing the yield to between

6 and 8 tons per hectare (as opposed to between 2 and 3 tons for the traditional rice production system) with much less labor, seed quantity and water consumption. The Sustainable Rice Intensification (SRI) therefore allows the enhancement of the wetlands through sustainable intensification of rice production (Derrahi, 2014). The National Rice Production Program (2006-2016) had the goal of increasing rice production to 170,000 MT by the end of 2016 (Promar Consulting , 2012). The NRDS aims at reaching the self-sufficiency level in terms of rice production by 2018, and to considerably improve the competitiveness and performance of rice produced in Rwanda in both local and regional markets. This approach is likely to raise the productivity level from 5.72 t/ Ha in 2012 to 7.0 t/ Ha by 2018 and will help in expanding cultivated area to 28,500 by 2018. Using the this integrated approach which intervene in sub sectors which compose the rice value chain helps to achieve higher productivity and sustainability. These approaches and strategies are in line with the overall national, regional and global goals concerning economic growth and poverty alleviation (MINAGRI, 2013).

7. DEVELOPMENT OF RICE VARIETIES IN RWANDA

The first rice varieties introduced in Rwanda were of Chinese origin during the 1960s when the government adopted the large-scale rice production. Later on, other varieties were also introduced such as Basmati, BG, IITA, IRON and FAC. Some of these rice varieties are in high demand due to their qualities which include attributes such as quality of the grain, smell, grain length, disease resistance and yield [5]. The rice farmers do not have wide option to choose among seeds varieties. In marshlands, farmers prefer to grow long and slender type (indica) varieties over the short and bold type (japonica) because of seed supply shortage. Considering the market preference, consumers are more inclined to indica rice. However, because of limited choice of varieties, rice cultivation face vulnerability due to an ecosystem under pressure. Development of new rice varieties in Rwanda should be encouraged through research activities and strategies introduced through test of rice varieties originating from other areas. These researches should take into consideration microclimatic variations in marshlands by breeding and selecting varieties that accommodate the local ecosystem [7]. In 2002, ISAR and WARDA found that there were 24 rice varieties[9]. (See the main varieties are listed in the table 4.2 in appendix)

Since then ISAR and WARDA tested around 900 rice varieties to assess their suitability to the Rwandan microclimate. It was observed that WAT rice variety has proven to be resistant and well adapted to Rwanda's cold weather and diseases and is able to yield up to 10 tons/ha. Rwanda Agricultural Board (RAB) recommended the rice varieties adapted to different altitude: IR 64, WAT 54, BASMATI 137 and IR 65192 -4B-17-3 were recommended for low altitudes, they are suited for places like Bugarama; Other varieties such as Gakire (Tox 4331 Wat 91-3-1-1-1), Instinzi (Tox 4331 Wat 86-3-4-2-2-1), Instindagirabigega (Wat 1395-B-24-2), WAB 543-45-2, were also recommended for medium elevation areas. These recommended varieties are being promoted by RAB and they are given local names such as *Ga*kire which means rich, Intsinzi meaning victory and Intsindagirabigega meaning full storage in order to promote their cultivation (Promar Consulting , 2012). The government of Rwanda has been interested in deregulation of seed industry in order to promote private investments and increase activities of seed companies in the region such as import, produce and disseminate seeds to local producers. RAB is involved in supply and distribution of improved rice varieties seeds through private entrepreneurs and farmer cooperatives. However, implementation of seed production is still facing challenges such as absence of training programs for seed multipliers and supervision of seed production practices. These challenges are caused by inadequate human capacity and technical support (MINAGRI, 2013). The NRDS is committed to expansion of rice cultivated area in order to increase rice production from 66,000 MT of rice produced to 369,000 MT/year for 2018. To reach this target seed supply systems in Rwanda have to be strengthened and a clear logical framework should be designed showing inputs, activities and outputs (MINAGRI, 2013, p. 22).

8. INTENSIFICATION OF RICE SECTOR IN RWANDA WETLANDS

Rwandan marshlands offer opportunity to grow rice since rice is the only crop that is well adapted to marshlands. Estimates at national level reveal that in 2008 the yield of rice in Rwanda was 3.354 tons per Ha on average, the highest yield among the member states of East African Community (EAC) [7]. This high production of rice made the Government of Rwanda to declare rice priority crop in 2002 (MINAGRI, 2013, pp. 9 - 10). In the following year there were about seven formally approved rice-producing schemes in Rwanda (Jagwe *et al* , 2003, p. 12).

Table 2. 2 The Rice growing Schemes in Rwanda by 2003

Scheme	Rice grown by area (ha)	Altitude	Edaphic conditions
Bugarama	830	Low altitude <1,200 M	Alluvial and clay soils
Butare	1,239	Mid altitude1,200 – 1,700 M	Low organic matter content; High risk of iron toxicity
Mukunguri	240	Mid altitude 1,200 – 1,700 M	Sandy soil with eroded material
Rwamagana	670	Mid altitude 1,200 – 1,700 M	Well maintained organic material content in soils
Mutara	280	Mid altitude 1,200 – 1,700 M	Alluvial soils with vertisols that break down in dry season
Bugesera	200	Mid altitude 1,200 – 1,700 M	Low organic matter content
Kabuye	230	Mid altitude 1,200 – 1,700 M	Well maintained organic material content in soils

Source: (Jagwe, Okoboi, Hakizimana, Tuyisinge, & Rucibigango, 2003, p. 12)

In 2003, rice schemes extended to a marshland area of about 4,000 hectares catering for the needs of rapidly increasing population especially in urban areas. Other 1,500 hectares were grown in out grower fields and in total about 5,500 hectares were used to grow rice in Rwanda.

To improve rice production People's Republic of Korea and American government through a non-profit organization known as ACDI / VOCA made considerable financial contribution to establish infrastructure related to hydro agriculture to support rice production schemes [5].

Different projects were adopted to support rural development. These included Rural Sector Support Project (RSSP) which lasted from 2001-2008 and RSSP II which started in 2008 and ended in 2011. These projects contributed to development of irrigation system for 6,000 hectares of marshland areas. Other programs included ADB-funded irrigation proposed in order to develop irrigation systems for an area of 1,500 hectares in Bugesera while IFAD-funded projects supported irrigation systems repair for 200 hectares of marshland areas in Kirehe district [9].

Table 2. 3 Distribution of marshlands along the three major rivers in different districts of Rwanda

Nº	Akagera river		Akanyaru river		Nyabarongo river	
	District	Area (ha)	District	Area (ha)	District	Area (ha)
1	Bugesera	13,644	Gisagara	5,372	Karongi	163
2	Kicukiro	1,989	Nyanza	1,848	Gakenke	557
3	Nyarugenge	609	Ruhango	415	Ngorero	568
4	Rwamagana	777	Kamonyi	1,524	Nyarugenge	1,348
5	Ngoma	7,428	Bugesera	1,821	Ruhango	236
6	Kirehe	9,457			Muhango	849
7					Kamonyi	1,548
8					Rulindo	298
Total	**6**	**33,904**	**5**	**10,980**	**8**	**5,567**

Source: MINAGRI (2013)

It was observed that the price of rice is an incentive for the rice production in different areas. Another incentive is the government policy which support industrialization as a means of supporting rice production. This encouraged rice production which in 2009 reached 110,000 tons but slightly declined in 2010. Although irrigation systems and rainfalls are practiced regularly yet rice production volumes are still fluctuating [9]. The intervention of

the Government of Rwanda to regulate the prices fertilizer has helped farmers and cooperatives to have access to inputs [12].

9. COMMODITY CHAIN DEVELOPMENT OF RICE IN RWANDA

The rice development projects developed by the Government of Rwanda helped to boost rice production. This has led to increase of rice production 32-fold which is the highest increase amongst the member states of the East African Community (EAC). This performance was achieved due to marshland delivery to farmers and facilitation of access to agricultural inputs (MINAGRI, 2013, pp. 9 - 10).

Table 2. 4 Comparative table of milled rice in EAC from 1970s to 2000s ('000t)

Decade	Rwanda	Burundi	Kenya	Uganda	Tanzania	EAC
1970s	1.85	4.44	24.56	12.4	184.05	227.3
1980s	4.64	15.41	30.19	17.29	329.54	397.07
1990s	6.53	29.75	31.58	54.47	446.29	568.62
2000s	213.03	199	475	1394	7646	9927.03

Source: (MINAGRI, 2013, p. 10)

It was observed that the increase in rice production was accompanied by the increase in demand by rice consumers in Rwanda. Since the demand did not match the rice production, the country had to import rice from neighbouring countries such as Tanzania and Uganda, as well as from Asian countries such as Pakistan and Vietnam (MINAGRI, 2013, p. 10). The Coalition for Africa Rice Development (CARD) has continued to support development of a strategic framework for rice production initiatives in Rwanda.

The National Rice Development Strategies (NRDS) lay emphasis on the following approaches: *"facilitation of research for development of rice value chain; expansion and diversification of land area under rice cultivation; improvement in productivity of small holder farms through efficient distribution and use of inputs; establishment of new- and rehabilitation/maintenance of old infrastructures in marshlands; enhancement of quality and competitiveness of locally produced grains in domestic and regional markets; and creation of favorable environments for the sustenance of rice sub-sector through effective policy and regulatory frameworks"* [7]

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