Ministry of Agriculture and Animal Resources
Republic of Rwanda

Enabling Self Sufficiency and Competitiveness of Rwanda Rice

Issues and Policy Options

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5/7/2010

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Executive Summary

Rice has become a major food crop in Rwanda. In the past 10 years, the total rice production has increased by 6-fold from 11,949 tons in 2000 to 72,000 tons in 2009. This increase is mainly due to a parallel increase in rice area under cultivation. Due to rising incomes and changing lifestyles of the growing population however, the demand for rice consumption has outstripped the local production.

To cope with the demand, the country has been importing an average of 21,340 tons per year mainly from countries such as Tanzania, Pakistan, Uganda and Vietnam. The distribution of imported rice is mainly concentrated in the mainstream markets where the locally produced rice grains suffer from poor marketability. The locally produced grains are mostly used for subsistence living of farmers themselves and/or sold through the local markets. Due to differences in quality of the produce, the price of locally produced rice endures lower prices (up to 25%) than that of imported rice.

Thus the rice sub-sector in Rwanda faces two challenges – insufficiency (volume) and inappropriateness (value). Self sufficiency in rice production shall be achieved by (a) rising the productivity of existing lands and (b) by further expanding the area under rice cultivation. The quality of locally produced grains on the other hand, needs to be improved through (i) handling and (ii) efficient processing of the harvest. This report analyzes the issues faced by farmers in these regards, and suggests policy options that could improve production and competitiveness of rice in Rwanda.

Rice is almost exclusively grown in marshlands in Rwanda. Owing to a considerable demographic pressure, it is largely cultivated in small holder farms of about 5 ares where the scope for raising productivity is often limited. The government shall prevent further defragmentation of rice farms and promote consolidation of land holdings where in cooperative farming shall be envisioned. The individual farmers shall become shareholders and employees of a larger farm. The country shall produce more rice by diversifying the rice ecosystem whereby upland rice and rain fed rice can be grown in gentle slopes and valleys where water is scarce.

Seed is an essential facet of agriculture determining crop productivity. Due to rapid intensification of rice cultivation, small holder farmers find difficulties in accessing sufficient quantities of good quality seeds in a timely fashion. The farmers are also faced with fewer varietal options that show low adaptability to the diverse microclimatic conditions of marshlands in Rwanda. The government should insist on institutions to invigorate the breeding program for high yielding varieties, to enlist the varietal characteristics of released varieties, and to attend maintenance breeding so that purity of seeds is constantly maintained in the seed production system. Privatization of seed industry shall bring in more varieties and more seeds in the market place, and establish stronger links with farmers.

The flow of eroded soil from hills and the associated slopes of marshlands into rice fields constantly threaten the fertility status of soil. Given the variability in soil fertility amongst the marshlands, Rwanda should immediately shift from blanket recommendations to site-specific recommendations of fertilizers. The government shall continue price support for fertilizers by covering the overhead costs on imported fertilizers. Through various programs and projects, the government shall persuade

farmers to use organic manures and composts, and dissuade farmers from practices such as burning of rice straws in the fields.

The growing pressure from pests and diseases are seriously threatening the viability of rice production in marshlands. The government shall raise the awareness and preparedness of small holder farmers in combating the pests and diseases by appointing a 'monitoring and forecasting committee' comprised of the members of lead farmers' network from each marshland in each season. The government shall also place regulatory controls over the validity and safety of pesticides imported and distributed to the farmers by various institutions and programs/projects.

Post harvest handling and storage of grains are important factors influencing the quality of cereal grains and by products. Lack of awareness on grain moisture content, storage conditions, packing, and modes of transportation is causing serious reduction in prices. This requires sensitization of farmers by the stakeholders (millers, traders and bureaus of standards) and transfer of the necessary technologies. Price incentives for farmers bringing in harvest of appropriate moisture content (14%), good quality and purity shall be implemented in all marshlands.

The traders procuring paddy grains from farmers are far too fragmented and less efficient in stabilizing the quality of local rice outputs. However, the delay in getting the payments from farmers' cooperatives and lower prices force farmers to sell the paddy to such traders. To improve transparency, all traders collecting paddy from individual farmers and farmers' cooperatives should be registered. The government shall establish at least one cooperative with good storage facilities and access to road in each sector as 'paddy collection centre'. The government shall make 'suggested minimal price' for paddy available to farmers in each season that could be used as a benchmark as in further bidding of their grains based on quality and purity. The government shall also introduce 'delivery contracts at predetermined prices' between collection centres/cooperatives/farmers and millers/traders. Metal roads along the marshlands that can facilitate transportation of rice from the fields/collection centres will also improve the price and volumes of trading.

Sub-standard processing of paddy grains is a major factor affecting the quality of locally produced rice. Most of the small and medium sized mills in the marshlands are ill-equipped and poorly maintained. The government shall forbid such inefficient mills and enforce that the mills should have de-husker, paddy separator, de-stoners, polishers and length graders. Rwanda Bureau of Standards should routinely inspect the quality of machines and operations, and shall set Grade 2 as the most acceptable standard for head rice and/or blended rice that are produced upon milling. The mills should also actively undertake rice residue management (husk, bran, brewer rice). The wholesale distributors of rice needs to be registered and allowed to buy rice only from the government approved mills. Small scale industries that could efficiently use broken rice grains/residues in developing value added products shall be encouraged through concessions and financial support.

The government shall declare rice as a sensitive good and constantly watch out for any changes in local policy environments, macroeconomic conditions, regional policies and global rice trade to tap further dividends from its initial investments in marshlands and rice schemes.

1. Background

Rwanda has an estimated population of 10,185,435 in 2009[1]. The population is expected to rise further to 14 million by 2020[2] (FAO, 2005). Providing food security for the growing mass from a limited arable land imposes serious challenges. Agriculture provides livelihood for 84% of the population in the country and contributes 34% of the gross domestic production[3] (GDP). Since the introduction of rice for cultivation in 1960s, rice has become one of the major food crops grown in Rwanda. The fertile soil, favourable weather, natural water resources, and efficient manpower make Rwanda highly suitable for rice cultivation. Furthermore, owing to the advantages of rice grains such as long shelf-life, ease of cooking and transportation, and less requirement of cooking fuel (compared to traditional food such as potato), rice has become a popular choice of food in schools, homes, restaurants, and public programs in Rwanda. The raising incomes, growing urban population, and changing lifestyles have further aggravated the demand for rice.

In response to this growing trend, Government of Rwanda has identified rice as a priority crop since 2002. Subsequently the Ministry of Agriculture and Animal Resources has invested tremendous amount of resources into the development of rice sub-sector in the country. As a result, the total domestic rice production increased by 32-fold in the last decade (Table. 1), the highest amongst East African Community[4] (EAC).

Table 1. Total Milled Rice Production ('000 t)

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	213.0295	199	475	1394	7646	9927.03

The significant increase in rice production is mainly due to the several initiatives taken by the Ministry of Agriculture (MINAGRI) through a number of high profile agricultural development projects and modest research and development outputs.

In more recent years the Government's investment efforts have been directed towards the reclamation of vast areas of inland valleys swamps (marshlands), construction of several small dams in the valleys, organization of farmers' co-operatives, privatization of rice mills, farm mechanization and facilitation of the supply of inputs such as seeds, fertilizers, and pesticides. As a result, the total area under rice cultivation has increased dramatically from 3,549 Ha in 2000 to 13,000 Ha in 2009. In parallel, the total milled rice production has also increased by 6-fold from 5,975 tonnes in 2000 to an estimated 36,000 tonnes in 2009 (Fig. 1).

[1] Press Release, 26 March 2010, National Institute of Statistics of Rwanda
[2] Country Report – Rwanda (2005), Food and Agriculture Organization (FAO)
[3] National Agricultural Survey (2008), National Institute of Statistics of Rwanda
[4] EAC Rice import tariffs and food security (2010) USDA Foreign Agricultural Service

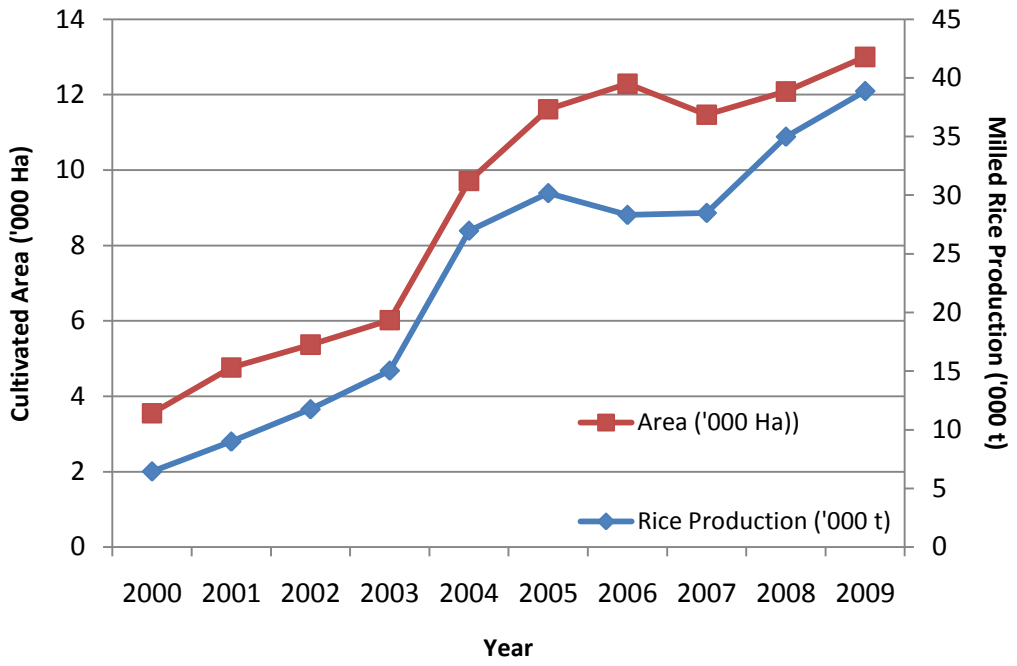


Fig.1. Recent trends in area under rice cultivation and production[5] in Rwanda.

However the demand for consumption has also been surging during these years. The local markets responded to the increase in demand mainly by importing milled rice grains (Table. 2) from countries such as Tanzania, Pakistan, Vietnam, and Uganda. Rwanda, in accordance with its EAC membership, currently administers a tariff free rice imports from EAC countries and imposes a common external tariff for rice imported from outside EAC. The leading rice stores in urban areas largely sell the imported rice grains, whereas the stores in rural areas and in other unorganized markets sell predominantly the locally produced rice grains.

Table 2. Trends in rice supply and demand in Rwanda[6]

Year	Imports ('000 t)	Domestic Production ('000 t)	Consumption ('000 t)	Value* of Imports ($)
2005	17.306	30.176	47.48	6,528,852
2006	16.662	28.320	44.98	5,973,459
2007	22.887	28.488	51.38	8,435,205
2008	17.924	34.989	52.91	6,702,790
2009	31.921	38.880	70.80	11,776,198

There are two types of rice grains that are produced in Rwanda – (i) short and bold (japonica type) and (ii) long and medium/slender types (indica type). Almost all the imported rice grains in Rwanda

[5] The milled rice production was calculated by first subtracting 10% of paddy production (reported by RADA, 2010) for seed/feed/losses and then multiplying the remainder by a milling ratio of 0.60

[6] Source: Trade Section, MINICOM

are of the indica type. For both these types, Rwanda Bureau of Standards (RBS), in alignment with that of EAC standards, classifies milled rice grains into three grades: Grade 1 with a presence of up to 10% broken grains, Grade 2 with up to 25% broken grains and Grade 3 with up to 50% broken grains.

The acceptance of rice quality is generally determined by the consumers based on physical and cooking characteristics. Consumers in mainstream markets in Rwanda generally prefer the long and medium/slender types of rice grains. However, the domestic rice markets differentially price the locally produced rice grains over the imported ones[7]. The long rice grains produced in Rwanda fetches lower price than that of the imported (Table 3). This is mainly due to a perceived consensus amongst traders and consumers that the locally produced rice grains are milled poorly. As a result, the locally produced grains suffer from poor marketability in mainstream markets. Having recognized this trend, the Government has recently approved only seven mills (Kabuye, Bugesera-Ruhuha, Rwamagana, Gikonko, Bugarama, CODERVAM (Nyagatare), and Base) to operate in the country.

Table 3. Retail Market Prices of rice[7] (FRW/Kg)

Year	Local Rice	Imported Rice	Price Difference (%)
2000	226	258	14.2
2001	239	254	6.3
2002	219	258	17.8
2003	290	328	13.1
2004	338	360	6.5
2005	357	451	26.3
2006	361	426	18.0
2007	412	513	24.5

Given the rising demand for rice consumption in Rwanda, the present levels of production and competency of locally produced rice grains, if left unattended, could prove detrimental to the rice sub-sector in the country by;

- submitting the national food security to become more dependent on rice imports and thereby to external factors influencing global rice supply-demand dynamics
- putting more pressure on the prices of locally produced rice and thereby the profitability of rice growers in the country
- affecting the branding of other premium rice that could be produced from special niches such as Bugarama
- weakening country's economic growth through trade imbalance and loss of revenues on tariff free/less importation of rice grains from other countries, and
- missing the opportunity of not tapping the export potential (and the associated socio-economic rewards) of Rwanda rice to regional and international markets

[7] Rwanda in Statistics and Figures (2008), National Institute of Statistics of Rwanda

It is nevertheless conceivable, from the rice supply and demand dynamics, that if Rwanda could scale up the local rice production, the country shall eliminate the need for imports and thereby attain self-sufficiency. In addition, if the quality of locally produced rice grains can be enhanced, the profitability of rice growers and thereby the livelihoods that depend on rice farming can be substantially improved. Thus the current trend in rice sub-sector brings two burning questions into focus: (i) how the gaps in supply-demand dynamics shall be bridged by raising the productivity levels? and (ii) how to improve the competitiveness (quality features) of locally produced grains in a market where the consumers generally prefer imported rice grains. This report aims to analyze these issues and proposes policy options to address the issues.

2. National Context

The performance of the economy and the development of agricultural sector are closely linked. Therefore the strategic interventions and policies governing rice sub-sector in the country should be consistent with its national and regional framework of strategies.

2.1. Vision 2020

The government of Rwanda intends to become middle income economy (with a per capita income of 900 USD), decrease the poverty to 30%, and increase the average life expectancy to 55 years by the year 2020. The government seeks to accomplish this vision by transforming agriculture into a productive, high value, market oriented sector, with forward linkages to other sectors. The government recognizes the need to devise ways and means to promote development of industrial scale agro-processing industries by developing an efficient private sector that is driven by the spirits of competitiveness and entrepreneurship. Therefore the initiatives on increasing production and quality of rice grains are in consistence with the overarching goals set by the nation.

2.2. Economic Development and Poverty Reduction Strategies (EDPRS)

Setting the framework for the medium term (2008-2012), the EDPRS seeks to raise agricultural productivity and improve security. EDPRS plans to expand marshlands for rice crop by increasing the area of reclaimed marshland to 16,442 hectares. EDPRS acknowledges that the low level of agricultural productivity in Rwanda is due to the low level of agricultural technology. EDPRS also intends to assign a greater role in policy implementation to markets and the private sector. To promote commodity chains and support the development of agribusiness, EDPRS intends to subsidize the acquisition of key inputs by farmers' cooperatives. Under EDPRS, public investments are being directed into the construction and rehabilitation of feeder roads.

2.3. National Agricultural Policy

National Agricultural Policy (NAP) identifies rice as one of the priority agricultural commodities. It proposes that appropriate technological packages need to be developed for the sector to improve its commodity chain. NAP recognizes that rice offers a potential market in the country and in the EAC region. NAP also envisages development of improved post-harvest technologies to enhance quality and value of rice commodity.

2.4. Strategic Plan for the Transformation of Agriculture in Rwanda – Phase II (PSTA-II)

The PSTAII plan acknowledges that rice is one of the value crops in the country. PSTAII includes rice as one of the cereal commodity chains that will serve as a major source of internal agricultural markets in Rwanda. Under Program 1, the strategic plan intends to intensify production of rice in Rwanda. Through various sub programs, it aims to improve the efficiency of use of inputs such as seeds, fertilizers, soil and water. Under sub program 1.3, it intends to develop marshlands and raise the total area under rice cultivation. It intends to reduce the importation of rice in the country. PSTAII seeks to energize activities to improve the production and productivity of rice crop.

3. Regional/International Context

Sustainable agriculture is one of the major approaches of Millennium Development Goals (MDG) to remove property and improve quality of rural livelihoods. The national issues related to agricultural revitalization and its implications on national economic development are reflected also under MDG. It also includes food security, quality improvement and competitiveness. MDG envisages improvement of rural livelihood by raising the value of key agriculture commodities. MDG emphasizes that increase in food production through development and rehabilitation of cultivable land, irrigation facilities, post harvest mechanization are the proposed strategies.

Agriculture is stated as 'the engine' of inspired growth by the New Partnership for Africa's Development (NEPAD). NEPAD declares growth in production of food crops one of its main priorities. It emphasizes three aspects: improving the livelihoods of people in rural areas; achieving food security; and increasing exports of agricultural products. NEPAD envisages that agricultural development should be driven by technologies. NEPAD intends to bring in changes in strategy and policy reforms to promote modernization and diversification of agricultural production and exports.

4. Rice Development in Rwanda

4.1. Introduction of Rice in Rwanda

Rice was introduced in Rwanda in 1950s through various missions from China and Korea. After the initial success of growing rice in the valleys near Kigali and in the Southern province, a number of varieties became popular in 1960s. These varieties collectively referred to as Kigoli, are of short and bold type. In Bugarama, government introduced rice varieties from India such as Basmati 370 in 1980s. In 2001-02, the national agricultural research institution, Institut des Sciences Agronomiques du Rwanda (ISAR), in collaboration with West Africa Rice Development Association (WARDA) evaluated a total of 990 rice accessions in farmers' field through a participatory approach in 4 marshland areas. Farmers selected 24 rice varieties based on tillering ability, early maturity, erect flag leaf, panicle length, big and heavy panicles, long and slender grains, awning, general disease occurrence, and grain yield. These varieties were subsequently introduced for cultivation in different marshland areas in the country in 2002. The new varieties are of long and slender type and generally yield higher than Kigoli varieties. However, the varieties are not as widely adapted as the Kigoli varieties in Rwanda.

4.2. Rice Farming Systems

Although rice is not a traditional crop, it has emerged as the most suitable crop for marshlands and inland valleys in the recent years. Several reasons justify this recent shift in cultivation. Soil erosion in the hills and the associated slopes due to intensive cultivation of traditional crops such as banana, cassava, beans and potato has diminished the sustainability of farming in the uplands. Rice is the only crop that thrives well and produces better yield than any other traditional crops especially during rainy season. The recently introduced varieties can yield up to 7 t/Ha. Thus rice provides a viable alternate for millions of resource-poor rural farm families in Rwanda.

4.3. Marshland Development

Due to the mountainous nature of Rwandan geography, rice is grown mostly in swampy inland valleys that are referred to as marshlands. The top soil in marshlands is more heterogeneous and constantly changing. This is due to the various degrees of erosion of soil from the associated hills into the marshlands. Under marshlands, rice is grown in puddled soil in two seasons a year. During the wet season (January through June), the soil is constantly moist due to rains and the occasional flooding. In 2009, rice was grown in about 12,000 Ha of marshlands. Although water is increasingly becoming a constraint during the dry season, some marshlands in the country are comparable to the favourable lowland rain fed environment.

Marshland ecosystem is comparable to lowland irrigated ecosystems in Asia except that marshlands are prone to occasional flooding particularly during the wet season. Marshlands in Rwanda can be found at various altitudes ranging from 1000 m above mean sea level (MSL) to >1700 m MSL. High relative humidity, cool night temperatures (10 to 15 degrees Celsius), warm day temperatures (20 to 30 degrees Celsius), and frequent rains are the salient features of marshlands. During the dry season (July through December) however, the soil moisture content drops significantly in marshlands. The inconsistent rains during the dry season can even expose rice crop to short periods of drought stress. Government spends enormous amount of resources in reclaiming swamps and developing marshlands for rice cultivation in the country.

4.4. Value Chain Analyses

The current trends in rice production and marketing in Rwanda point to the need for improvement of (i) volume (quantity) and (ii) value (quality) of locally produced grains. While the lack of local supply prompts the market to import additional volumes of rice from other countries, the lack of quality causes differential pricing of local rice grains in the market. This section examines the underlying issues of these two challenges.

4.4.1. Productivity

Since the adoption of new varieties in 2002, farmers were able to increase their yield[8]. Farmers' yield has increased over the last 10 years at a moderate slope of 0.15 (t/Ha) over the past 10 years (Fig. 2). And the yield gaps between progressive farmers and national average remains very high. This suggests that there is room for substantial improvement of the current productivity levels.

[8] From the data records of Rice Unit, RADA (2010)

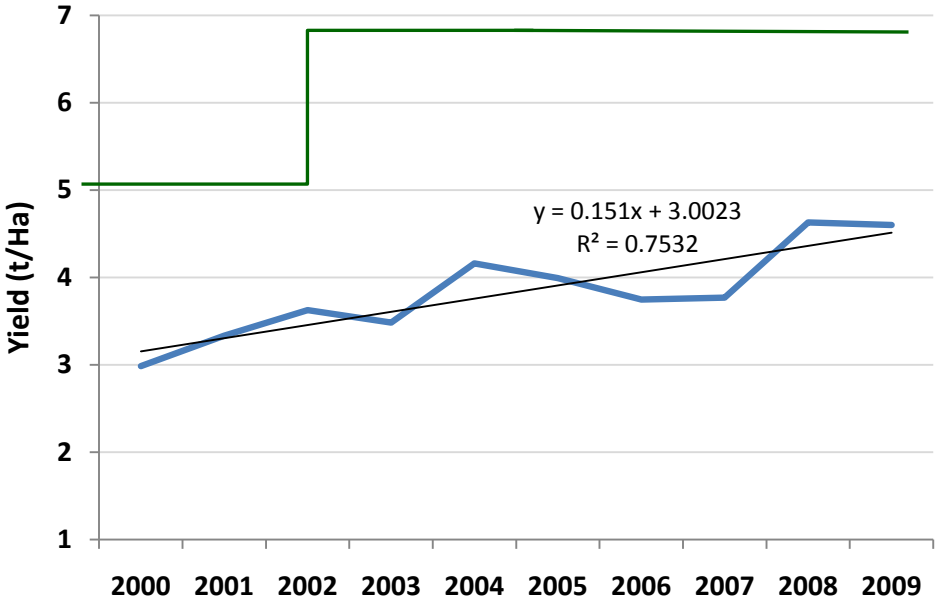


Fig.2. Average yield trends in Rwanda. The average maximum yield obtained by progressive farmers for the top 3 varieties[8] is shown as solid green line.

The demographic pressure has led to land fragmentation into smaller plots of rice cultivation. The smallholder rice farming in Rwanda is constrained and characterized by unsustainable agricultural practices such as mono cropping, inefficient inputs, inferior seeds, improper control of pests and diseases, and inappropriate soil and water management. An appraisal from the rice growers in 12 marshlands across the country identified problems faced by farmers in raising the productivity of rice crops[9]. Farmers feel that access to seed and water are the two most limiting factors in rising productivity from their rice crop (Fig. 3).

4.4.1.1. Seeds

Rice farmers in most parts of Rwanda find it difficult to access sufficient amounts of good quality rice seeds. In old marshlands where rice has been grown over the past few years, the quality of seeds limits the productivity. This is mainly due to the absence of an efficient public seed production network in the country. Furthermore, the characteristic features of already released rice varieties are not made available to the farmers and other stakeholders to verify the description of the varieties. Progressive farmers also feel that the varietal options need to be broadened through research and development. In new marshlands however, the quantity and the type (variety) of seeds cause greater concerns. Due to a rapid expansion of area under cultivation and the poor capacity of seed production and distribution system in the country, seeds of improved varieties could not be supplied to new marshlands. Farmers in such marshlands usually grow varieties of short- and bold type for which the marketability is low.

[9] http://rada.gov.rw/IMG/pdf/RADA_RSSP_Rice_TechReport_1.pdf, Increasing rice productivity through input management (2008)

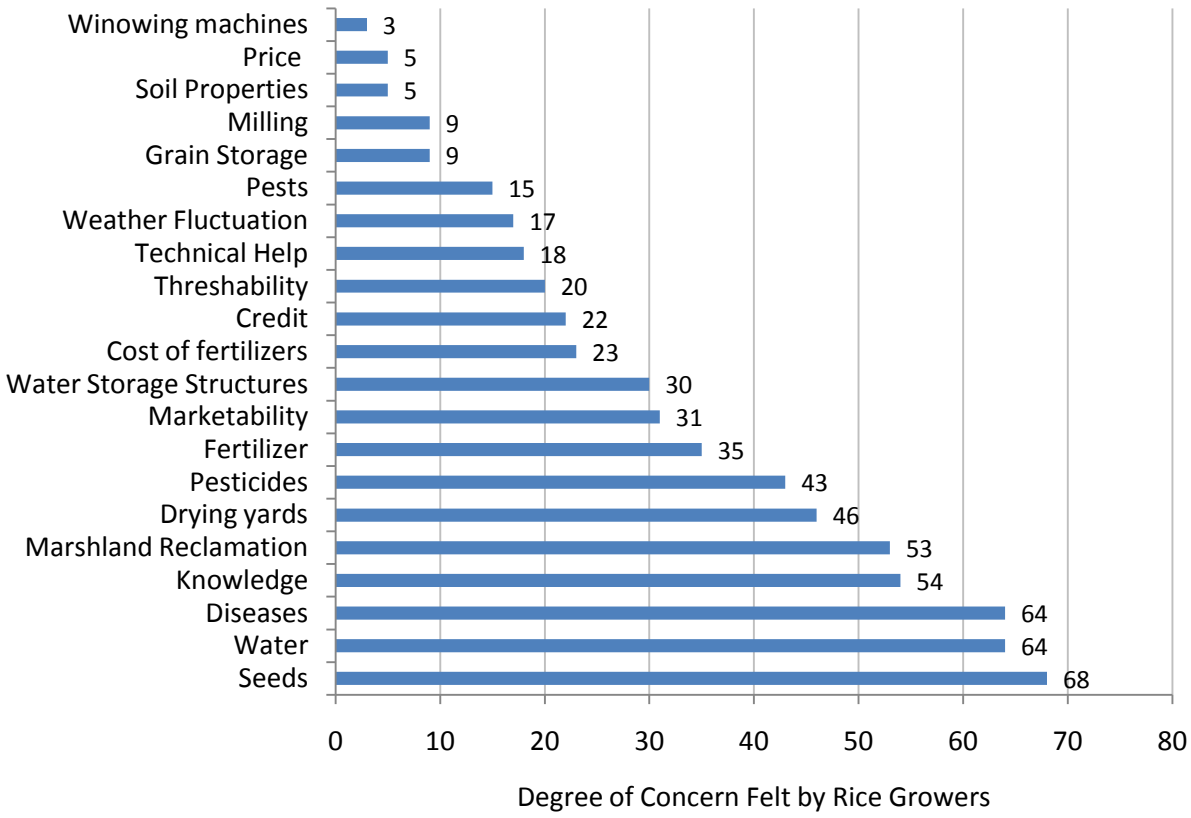


Fig.3. Farmers' constraints in raising the current productivity levels of rice crop in marshlands.

4.4.1.2. Access to water

Rice is widely grown as an irrigated crop in Rwanda. Water becomes scarce especially during the dry season in most of the marshlands where rice is grown. This scarcity is due to either (i) water availability and/or (ii) inequitable distribution of available water. In old marshlands the water availability is felt as a common problem. Due to poor maintenance, weeds and soils clog the irrigation canals. In new marshlands, the water equity, especially for rice fields in the tail ends of the water channels is perceived as a major concern by rice growers. Here the sequential cropping of rice and the general attitude of farmers towards rice as the water loving crop raises the demand for water. In new marshlands, the water is available in enough quantities as the residual moisture and the water supply are fresh. However the equitable distribution of water is a major constraint here. Water equity is often the most fundamental cause of frictions amongst the rice farmers in marshlands.

4.4.1.3. Pests and Diseases

The intensive mono cropping of rice has gradually built up the pressure of pests and diseases to alarming levels in several marshlands. Lack of knowledge on appropriate control measures against pests and diseases amongst farmers is a major impediment in raising the productivity levels. The limited choices of rice cultivars and access to pesticides also affect the readiness of farmers against the most common epidemics of blast and Diopsis in the marshlands. The pesticides used by farmers

are not properly regulated leading to pollution of drinking water and raising health risks of farmers and farm families in marshlands.

4.4.1.4. Soil management

Use of inorganic fertilizer is one of the major factors that catalyzed the rice green revolution in Asia. The low input intensive mono cropping pattern in the marshlands is constantly depleting the soil and water reserves. The lack of suitable fertilizer recommendations and the high fertilizer cost are the two major reasons for the poor nutrient management in rice fields. Farmers generally manage the crop residues such as straws by burning them instead of effectively recycling the nutrients stored in the residues through decomposition. Such practices further worsen the hidden nutrient imbalances in some of the marshlands. Erosion of top soil from the hills and the associated slopes into marshlands cause accumulation of silt. The lack of availability and the slow rate of decomposition of organic residues lead to low usage of organic manures in marshlands. Hence the texture and nutrient profile of the top soil in marshlands are constantly changing in marshlands. The soil fertility is highly variable amongst marshlands, and in some cases within a given marshlands. Soil fertility thus remains a constant threat to sustainability of rice cultivation in marshlands.

4.4.1.5. Infrastructure

Rice cultivation is a resource intensive enterprise. Synchronized planting of rice in a given marshland often requires planning of resources such as labour, thrashing- and drying yards, and storage. More importantly timely availability of these resources also inherently linked to the quality of rice produced in marshlands. Small holder farmers often find organizing these resources difficult and perceive it as a constraint in raising the productivity and profitability.

4.4.1.6. Extension services

In general, farmers in Rwanda learn rice cultivation from each other and from across other marshlands. The lack of human capacity has weakened the extension system in the country. The system is currently struggling to raise its technical capacity on effective and timely dissemination of improved soil, water and crop management practices that have been shown elsewhere to increase the productivity of rice production.

4.4.2. Quality of locally produced rice grains

The importance of post harvest technologies on efficient processing and its effect on prices is generally not recognized and/or ignored by the rice farmers in Rwanda. Until recently, the milling in Rwanda remained an informal business activity in rural areas. Farmers retain and hand pound a portion of their harvested grains for subsistence living. The remaining harvest is sold to farmers' cooperatives and/or rural traders. The rice is generally milled either in small private mills or mills owned by cooperatives. The mills owned by private and cooperatives generally produce Grade 3 rice. When proper care is taken, all the locally produced rice cultivars can be milled to Grade 1. This is mainly due to absence of a linkage along the continuum of production, processing and marketing. The locally produced rice loses its quality because of poor handling at harvest, post-harvest stages, storage and inefficient milling.

4.4.2.1. Harvesting

Rice plants require proper draining of fields to allow uniform maturity of spikelets. Due to prolonged maturity of the varieties, non-synchronized planting, lack of awareness, and labour availability, farmers in marshlands often harvest the rice under wet conditions and/or during rainy days. Farmers/Labours also tend to stack the harvest on wet surfaces (often in the wet field itself), and do not thresh the harvest immediately after cutting due to lack of access to threshing floors. Since threshing is done manually by beating against drums/wood, the high moisture content of grains and straws at harvesting stage reduces the output (yield).

4.4.2.2. Drying

The grains are generally sun dried by farmers in Rwanda. The grains are not turned properly while drying. Since the harvest is done under wet conditions and often before the grains reach physiological maturity, the uneven moisture content of grains pose additional challenge at drying stage. The duration of drying is arbitrarily determined by the farmer or the family member. The weather fluctuations and unpredictable clouding pattern does not allow uniform drying of the harvested lot. Hence the grains are not often dried to a prescribed moisture content of <14%. The higher moisture content affects storage life and milling ability of rice grains.

4.4.2.3. Rural Trading

Rice farmers in Rwanda sell a significant portion of their harvest themselves to the traders and/or rice mills located in the vicinity where they can get cash for their produce. The marketplace for rice trading is generally not transparent and often fraught with imperfections. In the absence of a guiding value, the traders purchase the grains from the farmers often at lower prices. Due to the fragmented nature of rural trading, the rice farmers lack skills in collective buying power.

The mills owned by farmers' co-operatives collect rice from farmers but generally take time before they pay the cash to farmers. This is mainly because the farmers' co-operative committee needs to voluntarily ask for bids (after collecting a significant amount of paddy from farmers in the area) from a few traders to whom they can sell the milled rice. The trader(s) also buys non-milled rice directly from farmers at the doorsteps of co-operatives at a slightly higher cost. This extra cost compensates the secondary transportation of harvest from farmers' fields. Farmers tend to prefer this route for they (i) get immediate cash and (ii) the price increment.

4.4.2.4. Milling

Farmers hand pound (by battering with wood/stone) the remaining portion of the harvest themselves. The hand pounding generally produces Grade 3 rice by breaking the integrity of most of the rice grains (25-50%). Farmers use the hand pounded rice for subsistence living and/or directly sell to the retailers in the rural markets.

Most of the small private huller mills (200 Kg/hour), which have recently been banned by the government, are largely incompetent. The rice mills owned by most of the co-operatives on the other hand are not well managed, heterogeneous, ill equipped and obsolete. Due to the lack of competitiveness, the milled rice grains from such mills often enter into unorganized rural markets where they are subjected to price pressures.

There are no clear written regulations on milling operations. The mills are not routinely checked for the standards of operations and outputs. Thus milling remains largely as an informal

industry in Rwanda. This has led to serious reduction in quality of locally produced rice. Most of the milled rice from rural mills is used for subsistence living and/or sold to consumers in rural markets.

A recent survey conducted by the Government in Rusizi District[10] reveals that out of 25 mills scrutinized for the standards of milled rice, only 2 mills produced Grade 2 (Table 4). Out of the 5 mills administered by co-operatives, 3 mills failed to pass their rice through standard grading.

Table 4. Summary of Performance of Rice mills in Rusizi District[10]	
Number of Mills tested	25
Number of small private mills	20
Number of mills administered by farmers co-operative	5
Number of non-functional mills	7 (7 private; 0 co-operative)
Number of mills producing Grade 2 rice	2 (2 private; 0 co-operative)
Number of mills producing Grade 3 rice	12 (10 private; 2 co-operative)
Number of mills producing failed grades of rice	4 (1 private; 3 co-operative)

In addition, the private and co-operative mills could not also efficiently manage the by-products (husk, bran, brewer rice) of milled rice. Thus it is becoming clear that such mills have thus far substantially extended the loss of quality (competitiveness) and quantity of rice produced in Rwanda at the milling stage.

5. National Rice Policy

The analyses of the problems in rice sub-sector inspire interventions aimed at (i) enhancing the productivity levels and (ii) raising the standards of post-harvest processing of rice. It is also evident that most of the problems leading to lack of competitiveness of rice in Rwanda are from within the sub-sector (internal). Hence the issues can be addressed through development and implementation of policies that insist on clear rules and procedures for programs, institutions and budgets that direct conduct in rice sub-sector. The following policy options are recommended to augment production and competitiveness of rice produced in Rwanda.

6. Vision

It is envisaged that Rwanda will attain self-sufficiency in rice production in the next 10 years, and will be well-positioned to compete local and regional markets with significant improvements in quality and value.

6.1. Objectives

The policies recommended in this report aims to attain the following objectives;

i. consolidate and efficiently use the land and water to improve productivity of existing rice cultivars in marshlands
ii. expand the area under rice cultivation by developing new marshlands and by diversifying the ecosystems under which rice is grown

[10] Compiled from the reports of MINICOM, RBS and MINAGRI (2010)

iii. improve the access to and distribution of inputs such as seeds, fertilizers and pesticides to smallholder rice growers
iv. enhance the quality of rice grains through improved management practices of harvesting, drying and storage of rice grains
v. introduce efficient and effective regulations on trading of rice grains in rural areas
vi. raise the standards of milling operations and thereby improve the quality and competitiveness of locally produced rice grains

6.2. Strategic Axes of Intervention

To accomplish the above mentioned objectives, interventions are necessary along the supply and value chains of rice sub-sector. The following policy options are recommended to improve productivity and quality of rice produced in Rwanda.

6.2.1. Productivity

6.2.1.1. Consolidation of land holdings to promote efficiency gains

Since rice cultivation in Rwanda is carried out by small holder farmers with an average of 5 ares, the productivity of rice farming can be enhanced by prevention of further defragmentation of land, consolidation of land holdings to a minimum of 5 ares or more, and giving options for farmers to become shareholders of a larger farm (co-operative farming; where individual farmers' families attend farm chores). Land consolidation is one of the fundamental reasons for high productivity in South Africa and other western countries.

6.2.1.2. Identify new areas/lands for rice intensification

To fill the gaps in supply of rice in domestic markets, the country needs to produce more rice. Besides raising the productivity of the existing rice farms, this goal can be achieved by extending the area under rice cultivation. Identification of new marshlands and other marginal lands for rice cultivation should become the additional focus of rice intensification policy. 'Upland rice' and 'Rain fed rice' that can be grown on gentle slopes, marginal lands and valleys in higher attitudes should be actively explored. A significant amount of exported rice from Thailand and Vietnam is produced from such marginal lands.

6.2.1.3. Special Zones or Granaries for rice

Special niches such as Bugarama can be designated as special zones or rice granary. The climatic conditions in Bugarama for example, suit production of premium long grain rice that can be exported. A handful of varieties such as Basmati 370, Nerica 9, WAT 9 that show good adaptation can be selectively grown in Bugarama. Such exclusive zoning of rice has benefited export of Basmati and special trades with EU in India.

6.2.1.4. Co-operatives as energized input delivery points

The institutional policies should target effective delivery of inputs such as seeds, fertilizers, insecticides, irrigation, and farm tools at individual farmer levels. Since the farmers' co-operatives have close links with individual farmers, the co-operatives shall be treated as input delivery points for the farmers. Instead of involving private entrepreneurship for such services, the co-operatives shall be actively engaged and monitored for their delivery at suggested prices. By covering the overhead

costs, especially the transport along the diffusion channels, the government can subsidize the market prices for inputs such as seeds, fertilizers, and pesticides.

The trend of distributing the inputs on credit at the start of the season and recovering the payments (cash or grains) at the end of the season gives more strength to the community. To encourage farmers from paying the credit back to the co-operatives at the end of the season, the parties need to enter into a legal agreement whereby bad debts can be settled through local courts, seizure of land holdings for instance.

6.2.1.5. Investments in Irrigation

Water management committee of each marshland shall include field engineers and agronomists. Water distribution in marshlands should be coherent with crop calendar. The water management committee should ensure adequate water supply in the dry season through water conservation during the wet season and rain water harvesting.

In marshlands where water is limiting in the dry season, rain water can be supplemented with bore well irrigation. The government shall encourage investments in rigging of wells. The government shall also facilitate equitable water distribution by encouraging motorized (2-5 HP) pumping of water to areas that are topographically not inclined to receive water from the common irrigation channels in the marshlands.

Additional investments in maintenance of marshlands (especially for clearing the irrigation canals) and new infrastructures for areas in the tail ends with poor reach-ability of water from the main source (dam) are important.

6.2.1.6. Fertilizer recommendations

Given the variability in varietal performance in marshlands, the research (ISAR) and development (RADA) institutions should immediately shift from blanket recommendations to site-specific recommendations of fertilizers. The government shall continue to support the pricing of fertilizers at least until small holder farmers become accustomed to the usage of fertilizers.

The government shall also actively dissuade farmers from burning rice straws in the field through development projects.

6.2.1.7. Seeds

Timely availability of sufficient amounts of good quality is imperative in raising productivity levels of rice farming in Rwanda.

6.2.1.7.1. Boosting of research

After the introduction of rice varieties in 2002, the outputs of rice research in Rwanda has been nominal. The sustainability of the rice sub-sector can be ensured only through active persuasion of research on development of new varieties and control measures of pest and diseases. The current yield levels will plateau unless new pest and disease resistant, high yielding varieties are constantly put on the pipeline for future release. After the green revolution in 1980s, the rice growing countries in Asia have reaped several benefits by investing in research to an extent that these countries are not dependent on international institutions for developing varieties and crop management.

6.2.1.7.2. Varietal regulations

The government should insist on the institutions to enlist the phenotypic characteristics of all the released rice varieties in Rwanda and on dissemination of this information to farmers and seed producers. The research institutions should also assume the responsibilities of maintenance breeding by constantly multiplying small amounts of nucleus seeds of these varieties in smaller plots under rigorous procedures.

6.2.1.7.3. Privatization of seed production and marketing

Given the capacity and budget constraints, privatization of seed production will bring in more quality seeds to the market and distribute to rice farmers on a self-financing basis. A commercially oriented seed industry might bring in new high yielding rice varieties (including hybrid rice varieties) and establish stronger links with rice farmers. The privatization of seed sector shall be given concessions that are tied to meeting the real needs of farmers on value basis (pest and disease resistant varieties for example). The cost-benefit ratio of a moderate increase in seed price to productivity has been shown to be high by farmers in many developing countries such as India where privatization in other sectors is still fraught with fears.

6.2.1.8. Pest and Disease Monitoring Committee

The government shall form a 'monitoring and forecasting' committee comprised of members from the Lead Farmers Network for rice and agronomists from projects and institutions. This committee shall constantly monitor the outbreak of major pests and diseases that affect productivity in rice. Through consultations, the committee will raise awareness on the usage of pesticides and preparedness of handling the pest and disease pressure amongst all stakeholders. This should prove useful in a policy environment where the government enforces synchronized seasonal plantings (with a narrow window of 2 weeks) in all the marshlands where rice is grown.

6.2.2. Improving the quality and competitiveness of rice

The value and hence the competitiveness of rice grains produced in Rwanda will greatly depend on how the grains are handled from harvest through milling stages. Interventions that are required in these stages are recommended below:

6.2.2.1. Sensitization of farmers

The millers in conjunction with rice traders and the government should raise awareness of the rice growers on the importance of moisture content, storage conditions, packing, grading and modes of transportation and their impact on market prices through workshops, training, media and publications. The government shall also encourage price increments to farmers who bring the grains of proper moisture content (14%) and purity at all the mills.

6.2.2.2. Organizing Farm laborers

One of the challenges in adhering to crop calendar involves careful planning for labor availability. The government shall encourage registered labor contractors who can mobilize laborers from far and near the marshlands to perform seasonal chores such as planting, weeding and harvesting in small holder farms.

To complement the labor power, contractors for mechanical tools shall also be encouraged in performing field operations such as tilling of soil, harvesting, threshing and drying of rice grains.

Power tillers of 10-15 HP shall be engaged in field operations such as land preparation, puddling and land leveling. Because of its relatively low capital (about $1400), compact size and the scope of generating additional revenues through transportation and hiring services, power tillers might find several ownerships. Mechanization of operations in post harvest handling can reduce the losses and improve the quality of harvested grains. Hence concessions on service tax and removal of duty for farm machineries shall be offered to farmers and service providers.

6.2.2.3. Transparency in rural markets

The government shall endorse select farmers' co-operatives with good storage structures and accessibility as "collection centers/marketing clusters" for each sector. RBS should impose rigorous standards (structure, ventilation, stacking, and protection from moisture, pests and rodents). RBS should also routinely examine the maintenance and hygiene of the collection centers.

Taking trade forecasts in EAC region into considerations, the government shall make available a 'suggested minimal collection price for non-milled paddy grains at these collection centers' for 'farmers' in each season. The collection centers and individual farmers can then use this market information as a baseline and bid for higher prices from traders, depending on the quality and purity. The collection centers and individual farmers shall enter into delivery contracts at predetermined prices or down payments to millers and/or traders to avoid delay in payment.

The government shall also improve the transparency of rural trading by authorizing only the registered traders to buy paddy grains in each sector/district. The government shall also forge strong linkage between traders and collection centers by insisting on documentation of bidding, pricing and timely payments. The registered traders shall bring the grains only to any of the government approved mills. Roads along the marshlands must be made suitable for transportation of rice grains in medium sized trucks (>100 t load).

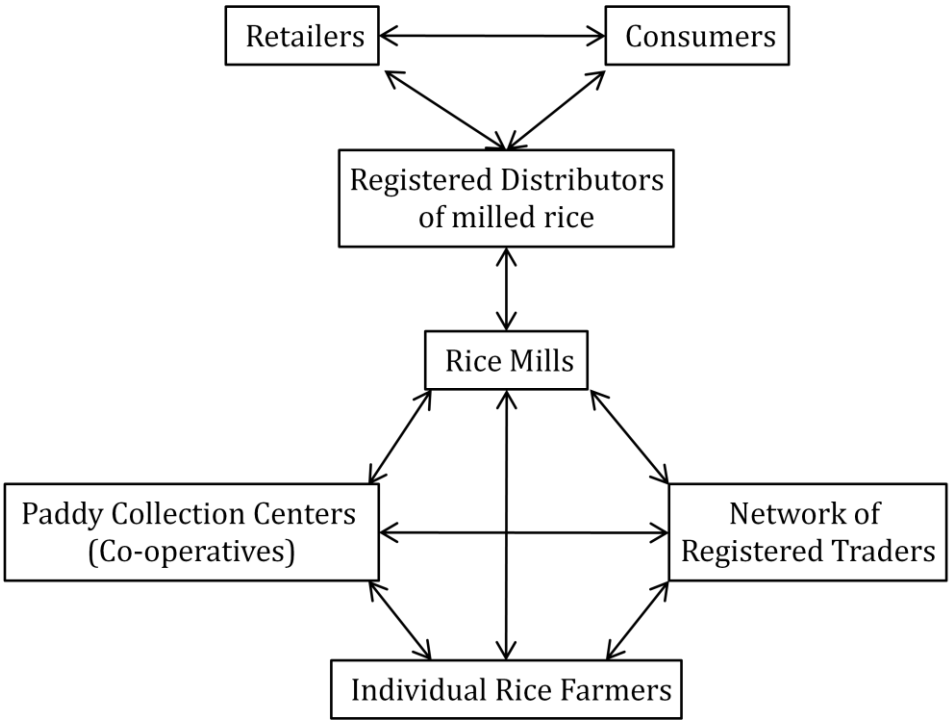


Fig.4. A proposed network of rice trading structure in Rwanda.

6.2.2.4. Milling Regulations

The government shall adhere to its decision of banning the inefficient and ill-equipped rice mills in the country, as they contribute to a great loss of quantity and quality of rice produced in Rwanda. Countries such as India where small mills were encouraged in 1980s are now struggling to reverse legislations to minimize such setbacks in the industry. The government shall instead embark on modernization of existing mills by imposing international standards – the rice mills should undertake de-husking and must have paddy separators, de-stoners, polishers, and length graders. RBS shall regularly verify the standards and maintenance at the mills (Annex 1). Using length graders, all mills should separate milled rice into head rice, large broken and small broken. RBS should set grade 2 as the minimal standard for the head rice at mills.

Mills may also opt for grading the rice to head rice and broken rice (large- and small broken). In these instances, rigorous inspections should also be made for controlling blending of head rice with large/small broken rice at the milling/distribution points. In such cases also, RBS should insist that the blended rice must pass Grade 2. The government should also encourage the millers and other entrepreneurs in turning the rice residues (husk, bran and brewer rice) into economically useful products such as animal feed, fuel energy and oil. The government shall also improve the transparency of trading of milled rice by establishing a network of 'registered distributors and/or retailers' and strengthen the linkage between the network and rice millers to ensure constant feedback on quality and other consumer demands.

6.2.2.5. Promoting private enterprises

The government shall either modernize the closed/existing government mills and/or extend privatization by encouraging a few additional private entities for setting up medium/large scale rice mills in the country. There may also be benefits of price competition, especially in the more productive areas. Small scale industries that can produce value added rice by-products such as rice flours, cookies, crispies (supplemented with protein, iron and vitamins) from broken rice and/or short and bold grains for domestic and regional markets shall be encouraged through microfinance. Such industries shall create a demand for short- and bold rice grains that otherwise suffer from marketability in mainstream markets.

Women entrepreneurs shall be encouraged to start such agro based industries producing value added by-products. Traditional policies such as the registration costs (50,000 RWF + 1.2% of capital with a minimum capital of 500,000 RWF), tax rates and administration can impose a significant fiscal and administrative burden on such enterprises, and therefore shall be either waived or substantially reduced by the government.

6.2.2.6. Coherence of trade policies

Despite an ad valorem tariff of 75% imposed by EAC for all the rice imports from outside the region, the markets continue to receive rice from Pakistan. This is apparently due to a 'side agreement' between Kenya and Pakistan[4]. The government shall ward the local markets off from such hidden competitions by voicing in EAC forums. Yet the duty free imports from within the region are currently to the advantage of Rwanda as it might buffer the pressure on retail price. Therefore the government should treat rice as a 'sensitive good' and constantly monitor changes in regional trade policies and other macro economic conditions.

Table.5. Matrix of Issues and Policy Recommendations

Issues	Policy Options
1. Volume and productivity 1.1. Land Usage	• Consolidation of land holdings • Prevention of further defragmentation • Encourage cooperative farms (farmers become shareholders) • Identification of new areas/marshlands • Diversification of ecosystems (Upland rice, Rain fed rice) • Special Zones or 'Granaries' for premium rice
1.2. Seeds: Timely availability of sufficient quantities of good quality seeds	• Enlisting of the characteristics of all released varieties • Maintenance breeding, High yielding varieties, Hybrid rice • Investment in seed multiplication • Privatization of seed sector
1.3. Water availability and Water Equity during dry season	• Investment in irrigation structures, maintenance of marshlands, bore wells, motorized water distribution • Adherence to crop calendar
1.4. Yields decline due to poor nutrient management	• Site-specific fertilizer recommendations • Continuation of pricing support on fertilizers • Dissuasion of farmers from burning rice straws
1.5. Inputs are not effectively reaching individual farmers	• Energizing the system of cooperatives as input delivery points • Covering overhead costs on transportation
1.6. Seasonal pests and diseases puts pressure on crop yield	• Commission monitoring and forecasting of outbreaks • Awareness on preparedness and usage of pesticides
1.7. Labor availability to carry out farm operations	• Encourage Labor contractors • Encouraging Machinery sub-contractors • Concessions on servicing
2.0. Value and Competitiveness 2.1. Farmers ignore/lack awareness on the quality	• Engagement of stakeholders on sensitization of farmers • Price incentives for farmers at all mills
2.2. Imperfections in rural trading of paddy grains	• Market information on 'suggested minimal paddy price' • Establishment of 'collection centers/marketing clusters' • Registration of traders network • Metal roads along the marshlands for transportation • Transparent bidding of paddy • Delivery contracts at predetermined prices
2.3. Milling industry remains informal and lacks regulations	• Forbidding of inefficient mills • Modernization and privatization of existing mills • Routine inspection of standards of storage and milling • Grade 2 as the acceptable standard for head and blended rice • Transparency in distribution of milled rice • Small scale industries for value added rice by-products • Concessions and financial support for entrepreneurs on residue management and value addition
2.4. Ineffective trade policies for rice imported from outside EAC	• Declaration of rice as a 'sensitive good' • Monitoring of implementation of EAC trade policies and macroeconomic conditions on global rice trade

7. Conclusions

Analyses of supply-demand trends suggest that rice production in Rwanda confronts two challenges (i) inadequate supply and (ii) sub-standard quality of locally processed rice. The productivity of rice crop is affected by lack of timely supply of good quality seeds, lack of varietal choices, less efficient input delivery systems, water availability and equity, pressure from pests and diseases, and inept soil management practices. Rice produced in Rwanda suffers from poor marketability. This is mainly due to the problems that occur along the continuum of production to processing. The farmers are not aware and/or ignore the causal link between the quality of their harvest and quality of milled rice. Improper harvesting, threshing, drying and storage practices lead to significant losses at milling stages. Mills owned by farmers' co-operatives are obsolete and ill maintained. Most of the milling has until recently been done by small mills that do not adhere to good standards. Outputs from these mills are of poor quality (Grade 3; up to 50% broken) and hence suffer poor marketability.

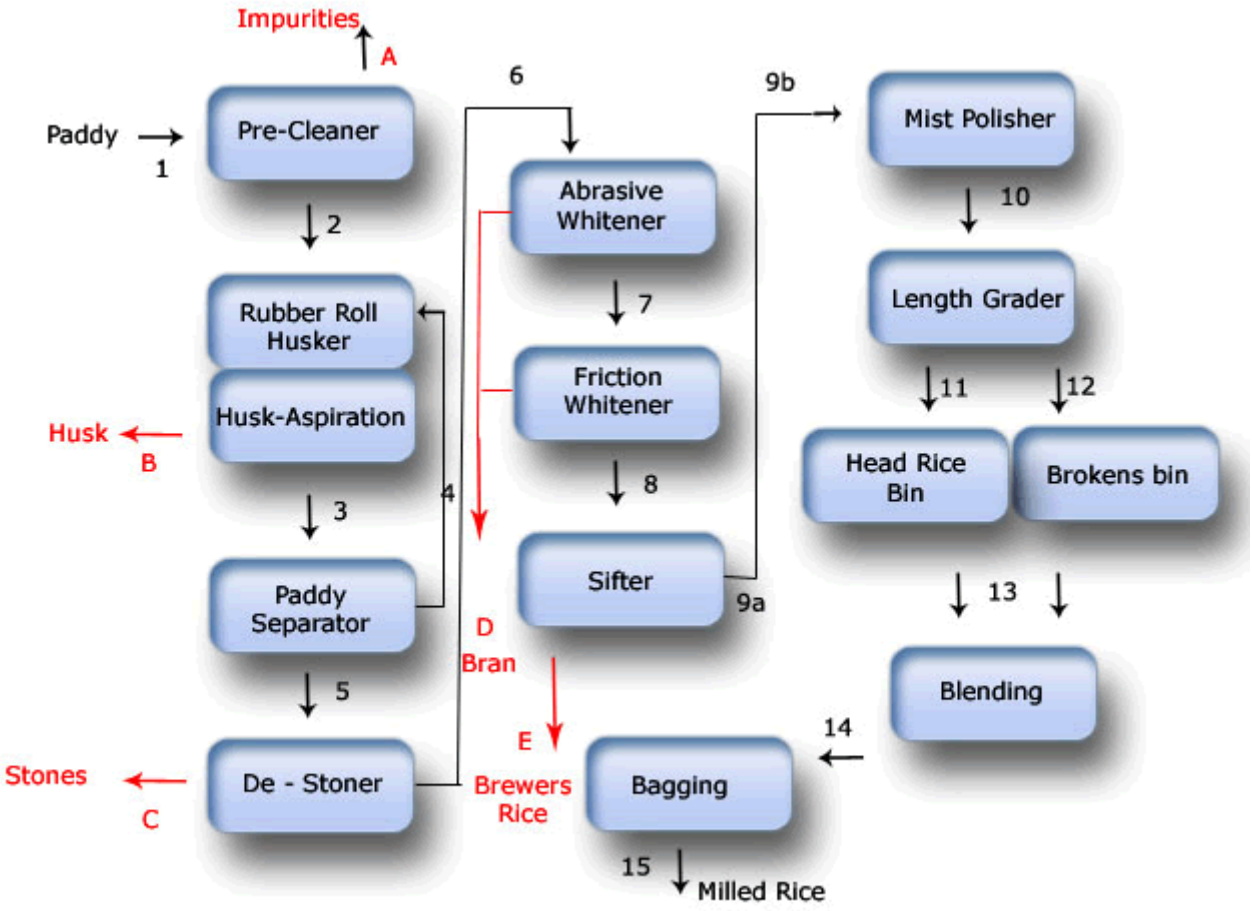
Productivity can be enhanced through policy reforms that are responsive to the needs of small holder farmers in Rwanda. Effective delivery of inputs such as seeds, varieties, fertilizers and pesticides requires further emphasis. Diversification of rice production into new ecosystems such as uplands and rain fed lands that will increase total rice production should be explored. Privatization of the seed industry shall improve the production and marketing of seeds to the farmers. The preparedness of farmers in combating pests and disease needs to be improved through active monitoring and forecasting. Organization of labor with supplementary mechanization activities shall be made contractual.

Farmers need to be sensitized on the relationship between the handling of harvest and the quality of milled rice through awareness programs and incentive pricing of the paddy grains. Farmers' cooperatives with good storage facilities and accessibility in each sector shall be made as 'collection centers/marketing clusters'. Registered traders and Mills shall collect paddy from such centers and individual farmers at suggested minimal price by the government. Forbidding of inefficient mills and further privatization/modernization of existing mills shall be embarked. RBS should routinely inspect and insist on standards of mills and residue management. To enable branding of locally produced rice, RBS shall set Grade 2 as the most acceptable grade for head rice and blended rice. Small scale industries that utilizes broken rice and/or short and bold grains in producing and marketing value added rice by-products should be encouraged. The government shall also ensure coherence of its rice policy with any changes in regional policies and country's macroeconomic environments.

Annexes

Annex 1. Proposed Standards for Machineries used in Rice Mill

The flow of operations that requires to be followed in a typical modern rice mill is shown below:



1 - paddy is dumped in the intake pit feeding the pre-cleaner, 2 - pre-cleaned paddy moves to the rubber roll husker, 3 - mixture of brown rice and un husked paddy moves to the separator, 4 - unhusked paddy is separated and returned to the rubber roll husker, 5 – brown rice moves to the destoner, 6 - de-stoned, brown rice moves to the 1st stage (abrasive) whitener, 7 - partially milled rice moves to the 2nd stage (friction) whitener, 8 – milled rice moves to the sifter, 9a - (for simple rice mill) ungraded, milled rice moves to bagging station, 9b – (for more sophisticated mill) milled rice moves to the polisher, 10 - Polished rice, will move to length grader, 11 - Head rice moves to head rice bin, 12 – Brokens moves to brokens bin, 13 – Pre-selected amount of head rice and brokens move to blending station, 14 – Custom-made blend of head rice and brokens moves to bagging station, 15 – Bagged Rice moves to the market, A – straw, chaff and empty grains are removed, B - husk removed by the aspirator, C – small stones, mudd balls etc. removed by de-stoner, D - Coarse (from 1st whitener) and fine (from 2nd whitener) bran removed from the rice grain during the whitening process, E - Small brokens/brewer's rice removed by the sifter.

Since there are various suppliers available for manufacturing machineries involved in milling process, the standards proposed here put emphasis on the following:

- criteria for performance;
- classification of rice mill based on method of operation single-pass and multi-pass
- type of huller, the under-runner stone disc and rubber roll type were considered
- requirements for safety was included;
- basic tools, operation and parts

De-stoner:

The De-Stoner should remove 'all' the stones from the rice. The de-stoner should have a vibrating deck and air blower that suspends the grain from the stones. The stones should be thrown off in one end and the brown rice in the other end. De-stoning should be considered as critical control point and should always be monitored on hourly basis in terms of product quality.

A simple pre-cleaner used in rice mills usually shall contain an oscillating double screen bed with an aspirator. The first screen is a scalper that lets through the grain but retains straw. The second screen retains the grains but allows broken grains and small stones or weed seeds to pass through. The air aspirator must suck out dust and the light empty grains. Air dampers shall be provided and must be adjusted to prevent the good grain from being sucked out.

De-husker:

Husking or de-hulling is a process for removing the rice hull from the rough rice. The rubber roll husker is by far the most important technology used today for husking rough rice. Rough rice shall be fed via a hopper and supplied to the two rubber rolls. One roller should rotate clockwise, and the other counter clockwise at a faster speed. This provides a shearing action that strips off the husk while paddy drops between the rollers (see diagram). The rubber on the roles should be flexible and must not crush the grain. Rice husk and broken rice should be removed from the husked material at the winnowing section which is referred to as aspirator. In the aspirator the material should be divided into a mixture of brown rice, un-husked whole grains, and rice husk. The husked material must be taken out by suction of the aspirator fan. After passing through the rubber roll husker, the brown rice and un-husked paddy grain must move to the paddy separator.

Paddy Separator:

It should remove 'all' the paddy mixed in the rice. The paddy should be reprocessed to the husking units. Ideally paddy separators should have shaking tray type separators, which operate at the principle based on differences in specific gravity of rice and paddy as rice is heavier than paddy. The separator shall be composed of several trays with dimples stacked one above the other that is angled forward and sideways from the horizontal plane. The trays should be oscillated from side to side. On the trays, paddy should gather on the lower end, brown rice on the upper end, and with mixtures in between.

Polishers:

Polishing is an essential step in the plant which increases the smoothness and brightness of the rice and gives it a sparkling touch. Rice should be allowed to pass through mist polishers which impart an extremely clean and glossy white appearance to the kernels, a distinct advantage over traditional

milling methods. The result should be a sparkling grain with creamy smoothing touch. This is essential for easy cooking and also enhances aroma.

The abrasive whitener shall be composed of a horizontal cylinder coated with an abrasive material (carborundum, for instance) or rubbers. The abrasive material should peel off the bran layers from the brown rice. The cylinders generally rotate inside a perforated steel plate cylinder. The coarse bran drops through the perforations in the plate. An abrasive whitener that is suitable for Basmati Rice and other long grain varieties shall be used.

The grain should be further processed in a friction whitener. The friction-type whitener is composed of a ribbed steel cylinder rotating inside a perforated steel plate cylinder. The ribs force the grains to rub against each other and against the steel cylinder. The forces of attrition remove the remaining bran layers left by the abrasive whitener, which generates heat and stress in the kernel.

In compact rice mills (such as the private mills in rural areas), both whitening and polishing are often done through a one step process. This generates a lot of heat in the kernel, as grain undergoes friction forces through the effects of scraping. This can lead to build up of heat in the grain, and break grains. This also causes a low milling recovery. Hence one-step process should be monitored for the degree of brokens upon milling.

Length Grader:
After polishing, the milled rice must be separated on the basis of grain size and thickness. The Rotary sieve, length graders and thickness graders performs both thickness and length grading where the broken and shriveled rice is separated from head rice to a very high percentage of accuracy and the result is the product of long uniform length rice available.

It shall consist of a rotating cylinder with cavities (i.e. indents) inside and a catch trough with a screw conveyor. As the indented cylinder rotates, the grains should be caught in the indents and lifted. Head rice should fall on while broken grains shall be elevated to the catch trough. The screw conveyor shall convey the broken outside the cylinder. The entire cylinder must be set at a slight angle. Length graders are usually used in series, with indents of various sizes used for each grading step keeping in view the given specifications.

Maintenance and operation:
Each rice mill shall be provided with at least three (3) pieces of dust masks and the following basic tools: three (3) pieces of different sizes of open wrenches; one (1) piece each Philips and flat screw drivers; and three (3) pieces of different sizes of Allen wrenches.

Performance requirements:
The performance criteria for rice mill shall be as specified in the table below. The specified capacity at the brown rice output of the paddy separator must be attained, with maximum of 10 pieces of paddy per kilogram of brown rice output. There shall be provisions for lubrication of non-sealed type bearings and belt tightening. Provisions for safety of the operator from all moving components of the rice mill such as belt guard or cover shall be included.

Performance Criteria for Rice Mills in Rwanda

Criteria	Performance			
	Single pass		Multi-pass	
	Cono	Rubber Roll	Cono	Rubber Roll
Milling Recovery Index, minimum	0.97	0.98	0.97	0.98
Percent Head Rice Index, minimum	0.9	0.9	0.9	0.9
Hulling Efficiency percent, minimum	80	80	80	80
Noise level, db (A), maximum	92	92	92	92
Milling Degree	Minimum Grade 2	Minimum Grade 2	Minimum Grade 2	Minimum Grade 2

Workmanship and finish:
Rice mill shall be free from manufacturing defects that may be detrimental to its operation. Any uncoated metallic surfaces shall be free from rust and shall be painted properly. Rice mill shall be free from sharp edges and surfaces that may injure the operator.

Warranty for construction and durability
The construction of the rice mill shall be rigid and durable without major breakdown of the hulling, whitening, separating, aspirating, and conveying mechanism within six months. Warranty shall be provided for parts and services within six (6) months after the installation and acceptance by the user, except on easy to wear parts such as belts, rubber rolls, and screens.

Marking and labeling: Each unit of rice mill shall be marked at prominent place with the following information;

- Registered trademark of the manufacturer
- Brand
- Model
- Serial number
- Name and address of the manufacturer
- Name and address of the importer
- Country of manufacture /Made in the Philippines
- Input capacity, t/h
- Power requirement, kW
- Safety/Precautionary markings

Annex 2. Definitions

For the purpose of the proposed standards the following definitions shall apply:

Bran: outer layer of the brown rice consisting of the aleurone cells covering the endosperm of the rice grain

Broken grains: grains that break in the process of milling which have a size of less than eight-tenth (8/10) of the average length of whole grain

Brown rice: dehulled palay (husk/hull removed) with the bran layer still intact

Coefficient of hulling: measure of the ability of the machine to remove the hulls

Coefficient of wholeness: measure of the ability of the machine to remove the hulls without breaking the grain

Head rice: grain or fraction of grain with its length equal to or greater than eight-tenth (8/10) of the average length of the whole grain

Huller: de-huller component of a rice mill that removes the hulls (palea and lemma) from the grains

Hulling efficiency: product of the coefficient of hulling and the coefficient of wholeness of grains, expressed in percent

Input capacity: weight of palay per unit loading time into the hopper/intake pit, expressed in kilogram per hour

Milled rice: grains obtained after the removal of hull and bran

Milling capacity: quantity of palay that the rice mill can process to a specified quality per total milling time, expressed in kilogram per hour

Milling degree: extent or degree by which the bran layer of the brown rice is removed as a result of whitening

Milling recovery: ratio of the weight of milled rice to the total weight of palay, expressed in percent

Milling recovery index: ratio of the milling recovery obtained in actual testing, to the milling recovery obtained from the laboratory test mill

Multi-pass rice mill: rice mill that employs a series of two or more whitening machines

Paddy: rough rice unhulled grain (grain with the hull/husk enclosing the grain)

Percent head rice: ratio of the weight of grains that do not break in the process of milling and with a size of three-fourth (3/4) or more of the whole grain to the total weight of milled rice, expressed in percent

Percent head rice index: ratio of the percent head rice obtained in actual testing, to the percent head rice obtained from the laboratory test mill

Polisher: auxiliary device of a rice mill, which removes the remaining small bran particles on the milled rice and gives it a glossy appearance

Rice hull: outermost rough covering of the palay grain (palea and lemma) consisting of the empty glumes, floral glumes, and awn

Rice mill: machine used to remove the hull and bran of the palay to produce milled rice and consists mainly of hulling and whitening assembly

Cone or "Cono" type: type of rice mill having an under-runner stone disc huller and vertical cone whitener

Rubber roll type: type of rice mill using rubber roll huller and utilizes friction and/or combination of other types of whitener

Single-pass rice mill: rice mill that employs only one whitening machine
Well-milled rice: rice grain from which the hull, the germ, the outer bran layers, and the greater part of the inner bran layer have been removed, but part of the lengthwise streaks of the bran layers may still be present on less than 15% of the sample grains

Whitener: component of a rice mill that removes the bran layer in the brown rice

Abrasive type: type of whitening machine consisting of a cylinder or cone coated with abrasive material such as emery stone or any similar materials enclosed in a perforated steel housing

Friction type: type of whitening machine consisting of a ribbed cylinder enclosed in a perforated steel housing

Material of construction for milling components:
Steel, cast iron or any other suitable materials shall be generally used for the manufacture of the different components of the rice mill.